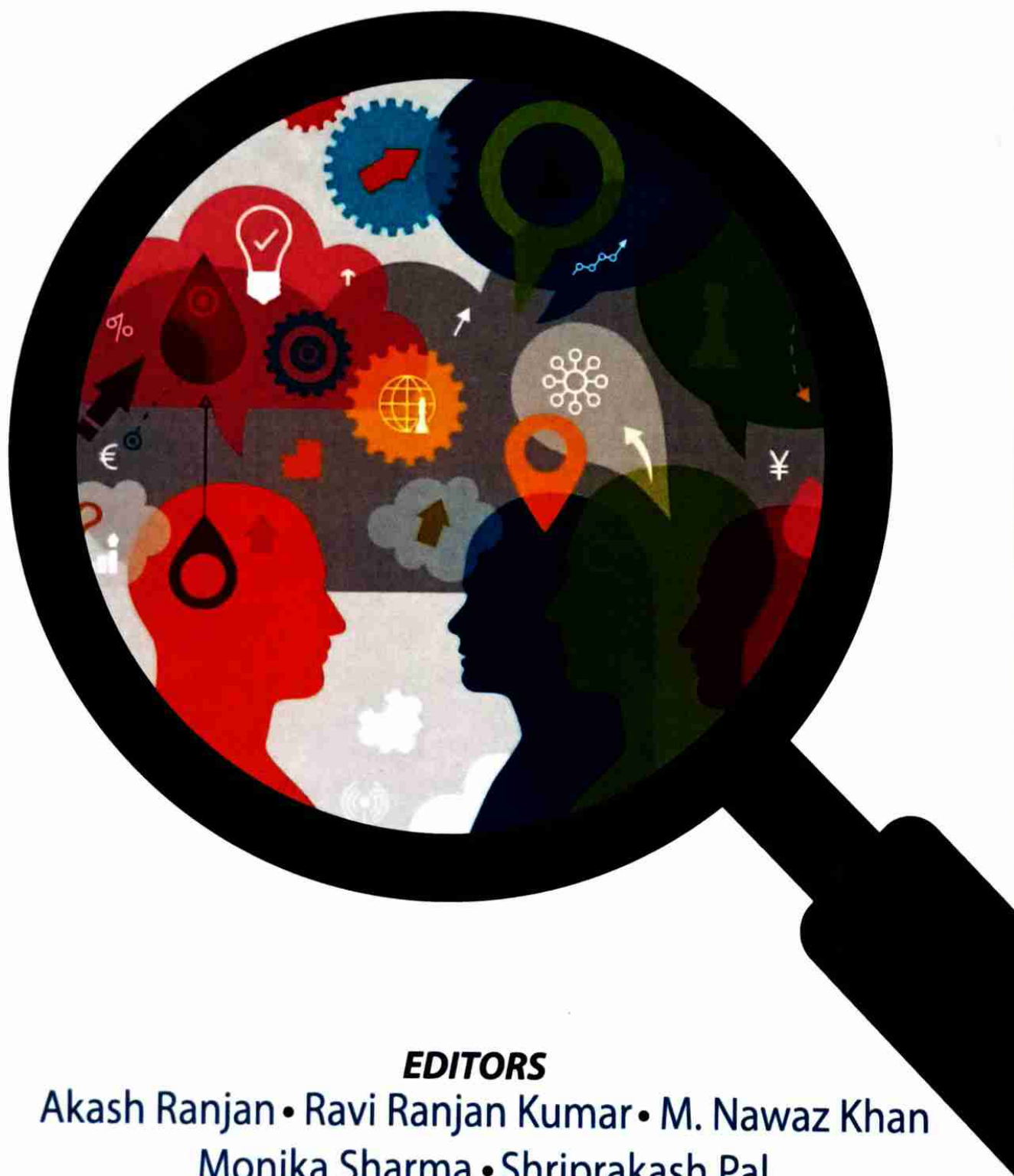


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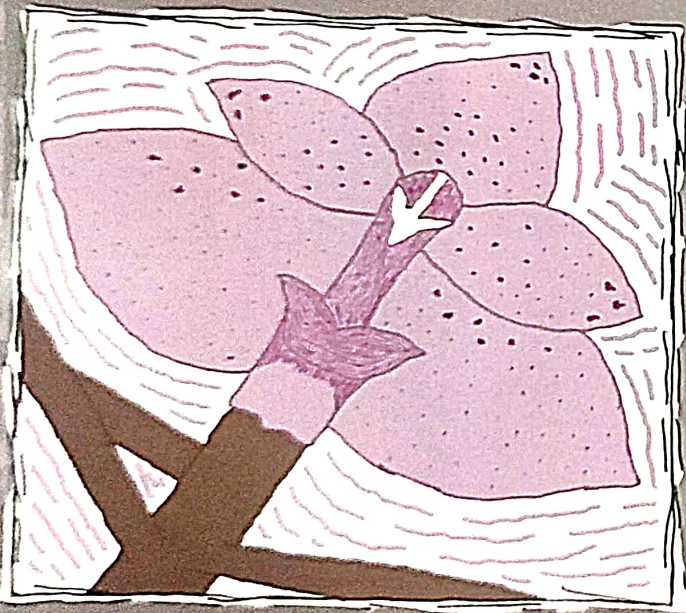
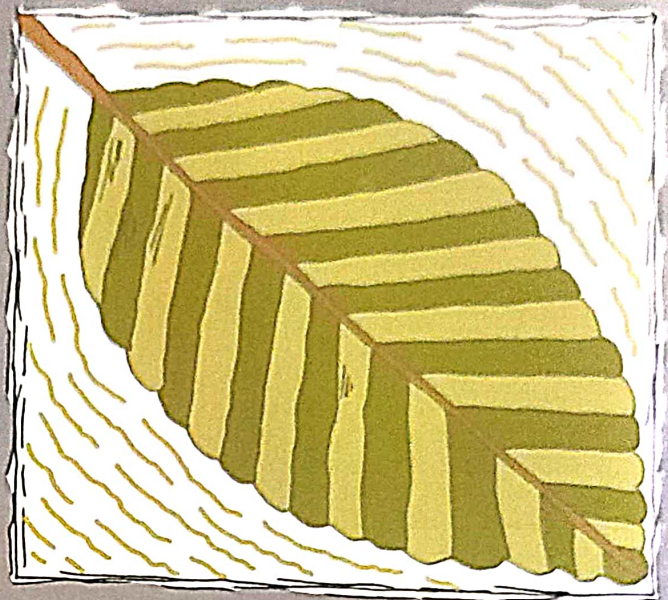
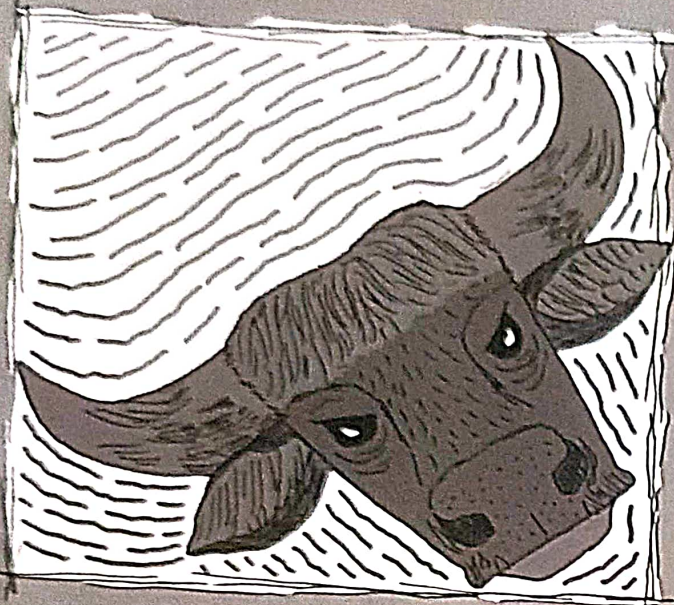
## **21<sup>st</sup> Century Indian Insurance Industry Marching Towards E-insurance: Perspectives, Problems, and Prospects**

**Dr. Vinod Kumar Yadav**  
Assistant Professor  
Department of Commerce,  
Rajiv Gandhi (Central) University,  
Itanagar (Arunachal Pradesh)

### **Introduction -**

Indian insurance industry has a long track record of its origin and development. It originated in the form of private venture and latter converted into the public venture, and now again on the verge of reaching to its original state. Insurance has been an offline i.e. face to face service on the basis of direct interaction between an insurance agent of an insurer and a customer for a long time. However, today Indian insurance industry has moved on the path getting online. The credit for the promotion of direct online sale of insurance policies goes to the privatization of Indian insurance industry led by the introduction of the IRDA Act, 1999. Today online insurance has been possible due to the expansion and outreach of the information and communication technology to the common people. Thus, Indian Insurance Industry has been facing many problems while moving on the way of getting online, however, e-Insurance has potential to multiply the current insurance penetration using available digital resources and current digital awareness.

# MATRIX ANTHOLOGY



Volume-I. 2022.

poems-short stories-essays

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Front cover depicts in clockwise order the State animal Mithun (*Bos frontalis*), leaf of the State tree Hollong (*Dipterocarpus macrocarpus*), State bird hornbill and the State flower foxtail orchid (*Rhynchosstylis retusa*).

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# A LABYRINTH OF THOUGHTS ON THE CROSSROAD

Bompi Riba

≡≡≡

An event that stays in the memory; that evokes a conundrum and enlightens one to see one's culture in a new light is worth documenting. But it is seldom done so when it involves an ordinary person who is but an insignificant member of a community of a prodigious state of a big country. He is but a diminutive voice like a tiny globule of the Universe. His story surely does not affect the course of the Nation's history or even the State's history and remains just 'his' story and fades into oblivion. And his death, whether natural or unnatural is again an insignificant event except for his family members who will gradually recover from that unpleasant experience and move on.

The event that led to the germination of this deep reflection was the death of a tribal man, a Galo to be precise. The mysterious events or just pure imaginations that were associated with the poor man's untimely death

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


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### ABSTRACT

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# SUSTAINABLE AGRICULTURE AND THE ENVIRONMENT



# Abundance, variety, and scope of value-added utilization of agricultural crop residue: emphasizing potential of anaerobic digestion and digestate recycling

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## Abstract

Recycling of agricultural crop residue is a part of agroecological practices that helps in reducing pollution and recovers resources into several value-added products, thereby closing the nutrient loop. However, various intrinsic and extrinsic factors related to farm management, practices, and processing methods influence the successful and optimum utilization of the crop residue. Anaerobic digestion of crop residues is one of the much recognized and well-established biomass conversion processes which can undertake a wide range of crop residues, that results in 'biogas' as the primary product and 'digestate' as the by-products. Considering digestate characteristics that vary with type of crop residues and processing methods, these can be of considerable economic potential for bioenergy production and other value-added applications. This work discusses opportunities and issues for various valorization pathways related to agricultural crop residue-based digestate management to reduce its environmental impact and improve overall economic profitability of anaerobic digestion plants.

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**Keywords:**

Anaerobic digestion; Crop; Crop residue; Digestate; Fertilizer; Soil.

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## 1. Introduction

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### 1.1 Agricultural crop residue: variety, abundance, and scope of value-added utilization

India's economy is mostly focused on agriculture. In its various agroecological regions, a large proportion of land is being used for the cultivation of crops. This results in production of a large proportion of crop residues (Cardoen et al., 2015). Crop residues are noneconomic parts of the crops that are left after the economical part of the crop is harvested. They are readily available, widely distributed, and inexpensive (Ali et al., 2019). A significant quantity of agricultural waste is generated in India, the world's second-largest agricultural economy owing to the country's year-round crop farming (Bhuvaneshwari et al., 2019). India's agriculture area represents around 51% of the country's overall geographical area and 11% of the world's total geographical area (Bimbraw, 2019). The amount of agricultural residue that India produces each year is estimated to be over 500 million tonnes (GOI, 2016). A diverse variety of crops are cultivated which comprises wheat (102.19 Mt), rice (116.42 Mt), maize (27.23 Mt), sugarcane (400.16 Mt), fiber crops (38.48 Mt), pulses (23.40 Mt), and oilseed (32.26 Mt) (Directorate of Economics and Statistics, New Delhi, 2019). These residues have a wide variety of properties and decomposition rates (Lal, 2005). Abundance of the crop residue and its use varies greatly across the world, which depends on the type of crop, intensity of cropping, as well as the productivity (Delgado, 2010). Crop residues are important assets in cropping systems for sustainable management. It has been reported that residues left on the field prevent soil erosion, enhance the physicochemical properties of soil, manage greenhouse gas emissions, maximize infiltration of water into the soil, and thereby decrease the nutrient and/or chemical pollution (eutrophication) of the nearby waterbodies, streams, and rivers (Lal et al., 1999). As a result, effective agricultural residue distribution and integration can greatly benefit to the farmers. Further the residues are also widely used as livestock feed, in mulching of soil, in the processing of organic manure, in thatching of houses, and in the production of household and commercial fuels.

However, after harvesting the economic part of the plant, only a small fraction of residue is used for various purposes, while an enormous portion of the residue is unused and usually burnt in situ on-farm across the country during the sowing of the subsequent crops (Devi et al., 2017; Yadav, 2019). The problem of crop residue burning has intensified in recent years due to the high and futile expense of its removal from field by conventional approaches. In India, a recent report suggests that stubble burning of crop residues generates nearly 150 million tonnes of carbon dioxide, over 9 million tonnes of carbon monoxide, a quarter of a million tonnes of sulfur oxides, 1 million tonnes of particulate matter, and more than half a million tonnes of black carbon (Porichha et al., 2021). The Indian government has made several efforts to address this issue, including campaigns and initiatives aimed at promoting sustainable management practices for transforming agricultural leftovers into a useable form

of resources (Bhuvaneshwari et al., 2019). A wide range of alternative uses for crop residues, such as livestock feed, manure compost, rural roofing, bioenergy, and packaging materials such as paper, may be found for crop wastes which should be promoted further to reduce the environmental implications of stubble burning.

The rapid increase in biomass energy utilization is attributed to its reliability, availability, and environmental cleanliness. These conversion processes offer significant scope to expand biomass use by tapping unused residues and wastes which are with reliable availability with wide geographic distribution and cost-effective and do not compete with resources like food, water, and land. Because crop residues consist of high proportion of biodegradable components, anaerobic digestion (AD) is an effective and eco-friendly approach and a viable choice for generating bioenergy from these and recycling the residue to crop field effectively (Bhuvaneshwari et al., 2019). Rice straw, Cotton stalk, Gram stover, Pigeon pea stalk, Soybean stalk, Mustard stalk, Castor stick, Maize stalk, Millet straw, and Groundnut shell are suitable crop residues for bioenergy generation. Valorizing crop residue for energy recovery can prove to be a potential solution to reduce the wastage of residues and curb huge environmental implications of stubble burning as well as would enhance the energy security of the country. The present work assesses how the crop residue can be turned to a clean energy source by the process of AD and how the nutrient loop can be closed by recycling the digested crop residue into agricultural fields.

### 1.1.1 Variety of crop residues

Globally, several crops generate large amounts of residue each year. Straws, stalks, stover, bagasse, leaves, seed coats, shells, and husks are the most common agricultural crop residues (Ali et al., 2019; Go et al., 2019). Residue Production Ratio (RPR) is the ratio of the amount of residue to the amount of the main product. The major crop residues of India and their physical properties including particle size, diameter, density, and flexibility are as follows.

**Straw:** The stems and leaves of cereals are termed as straw. It accounts for almost half of cereal crop yields such as barley, oats, rice, rye, and wheat. Straws are flexible with bulk density ranging from 30 to 60 kg/m<sup>3</sup> (Baruah and Jain, 1998). It can be used as animal fodder and bedding, as a raw material for board and paper production, and as a construction material. In many Asian countries, rice straw is used as a domestic fuel and the ash from burnt paddy straw is used as an organic fertilizer. The RPR values of the paddy straw may range between 0.416 and 3.96 (Koopmans and Koppejan, 1997). Strict environmental laws, as well as the progress in straw treatment to increase digestibility, are reducing the in situ straw burning in field in majority of industrialized nations, where it is now either fed to animals or utilized for industrial reasons (Suttie, 2000).

**Stalk:** Stalks are crop stems that are relatively more rigid than straw. Stalk diameters are more than straw. The density is about 50 kg/m<sup>3</sup>; however, some stalks may be woody with a higher density of 160–180 kg/m<sup>3</sup> (Baruah and Jain, 1998). Woody stalk residues are used as a fuel in areas with fuelwood scarce and have an RPR value ranging from 1.25 to 2.8 (Baruah and Jain, 1998). Crop leaves along with the rejected stalk parts may be left in the field or used as fuelwood. These residues are suitable alternative as fuelwood.

**Bagasse:** Bagasse is the dry pulpy fibrous residue that remains after crushing sugarcane, and it is one of the most abundant crop residues globally. It has a density of about 80–120 kg/m<sup>3</sup> (Danianto et al., 2015). The sugarcane produces a comparatively high dry



matter yield per unit area of land. Whereas bagasse is the key energy source for the generation of steam in various factories, it is also used as a raw material for making paper and board. It has an average RPR value of 0.29 (Baruah and Jain, 1998).

**Cob:** It is a by-product of the production of maize kernels and is a portion of the ear on which the kernels are located. Corn cob is often burnt on farms in developed nations in order to prepare for the next growing season. The cob of maize has a bulk density of around 100 kg/m<sup>3</sup> and an RPR value of about 0.2 (Baruah and Jain, 1998). Corn cobs are presently utilized for heating in certain areas of Europe, while in the United States, significant amounts of cobs are processed as basic substrate in various industries (Pennington, 2020). It has direct energy potential due to its density and uniformity, high energy content, and low sulfur and nitrogen contents (Anukam et al., 2017).

**Husk:** Husk is the dry outer covering of some fruits or seeds. It is available at the processing (husking) site and has a smaller particle size with a bulk density of about 100 kg/m<sup>3</sup> and an RPR value of about 0.2 (Baruah and Jain, 1998). In most cases, following the conventional grain processing, the paddy husks are often burnt in most of the rice mills. However, in some places it is used for the generation of power in large rice mills, or in brick industries. RPR values for rice husk may range from 0.2 to 0.33 (Bhattacharya et al. 1993).

**Shells:** It has a bulk density of about 80 kg/m<sup>3</sup> and an RPR value of 0.477 (Baruah and Jain, 1998). Groundnut shells can be used to make biodiesel, bioethanol, and nanosheets and have applications in production of enzyme and hydrogen, degradation of dye and heavy metal, etc. (Duc et al., 2019). The shells of the groundnuts are sold in the market; thus, normally it is no longer available as fuel.

**Tops/leaves:** Just like bagasse, the tops and leaves of sugarcane and most of the crops account for a major share of crop residue. They generally serve as cattle fodder or are traditionally burned in the field.

**Stover:** The field residues of large cereals, such as maize and sorghum, soybean, and grams are termed as stover. These are typically left in a field after the grain has been harvested for use as mulch.

### **1.1.2 Abundance of the agricultural residue in the Indian context**

Kharif (monsoon crops) and Rabi (winter crops) are the two main cropping seasons in India; however, advancement of irrigation and climate condition led to multiple cropping practices. The cereals are dominant in the Indian cropping system, which accounts for about 40% of the cropping area, followed by pulses, oilseeds, sugarcane, and other crops. With a 2.53% yearly growth rate, agricultural residue production in India is on the rise (Devi et al., 2017). Particularly rice, maize, and wheat are commonly consumed crops in India, accounting for a significant share of the overall production of crop residue (Devi et al., 2017). Asia alone contributes 47% of the crop residues produced in the entire world. Based on the crops planted, intensity of cropping, and productivity, the distribution and utilization of crop residue varies significantly across the country. The residues of cotton, rice, sugarcane, and wheat are the most dominant, accounting for about 66% of total produced residue. In 2016, the Annual report of the Govt. of India estimated the crop residue to be 500 Metric tons, with rice, maize, wheat, and millets contributing 70% of crop residue, followed by fiber crops contributing only 13% of the produced residue. In India, the production also displayed broad geographical variation, with Uttar Pradesh sharing the biggest residue generation of 60 Mt; it was followed

by Punjab and Maharashtra. The crops such as oilseeds (29 Mt), pulse (13 Mt), cereals (352 Mt), fibers (66 Mt), and sugarcane (12 Mt) produced the greater part of residue in India (NPMCR, 2019). To quantify crop residue, crop harvest is multiplied by residue-to-crop ratios (Hiloidhari et al., 2014).

The management of crop residues is highly variable depending on a variety of factors such as competing uses, weather and climatic conditions, soil qualities, and crop rotations (Einarsson and Persson, 2017). Crop residues' traditional utility varies by region and is determined by their versatility in applications, biochemical content, and calorific and nutritional values. A large amount of agricultural residue is used as feed, fuel, and other residential and industrial purposes. There have been multiple reports of surplus residues being burned at farms, which is amounting about 92 Mt per year (NPMCR, 2019). Thus, the volume of crop residues burnt as agriculture waste in India is much larger than the other countries. However, whole quantity of crop residues may not be ideally or cannot be sustainably removed from the fields if soil organic matter is to be preserved. The crop residue plays an important role in the cycling of nutrients in soil. For instance, after the harvesting of rice, the amounts of nutrients removed are reported as N (about 7 kg), P (about 0.9 kg), K (about 15 kg), S (about 0.7 kg), Ca (about 3.5 kg), Mg (about 2 kg), and Si (about 50 kg) per ton of straw (dry weight) (Dobermann and Witt, 2000). However, the concentration of nutrients usually depends on the physicochemical property of soil and the variety of crops. Despite the dominance of chemical fertilizers in agricultural productivity, agricultural crop residues continue to play an essential role in cycling of nutrients. Traditionally crop residues have numerous uses. The following are some of the major conventional utility of crop residues:

**Livestock feed and bedding material:** In rural India, the predominant use of some ligneous crop residues is as livestock fodder. Crop residues of rice, wheat, millets, sugarcane tops, sorghum, and oilseeds are the most important source of livestock feed. These residues are an important resource, providing feed for livestock, especially in the dry winter months, when other options are limited (Valbuena et al., 2015). In a common practice in India, cows are often deployed in the fields after the harvest to graze on the residue. Crop residues are also extensively used as bedding for livestock. Wheat and rice straw and coconut fronds are commonly used for thatching.

**Building materials:** Making walls out of bricks made of mixture of straw and clay is an age-old technique used in the building of houses and sheds. The cereal straws on the other hand are primarily used in the roofing of rural houses. According to Guna et al. (2019), the reuse of crop residues as building materials could be appealing from both an economic and an environmental perspective as an alternative to cement.

**Compost:** The crop residues have historically been used to make compost. Leguminous nonwoody residues are preferred in the preparation of compost. Production of compost from crop residues is one of the most accepted ways to add value to crop waste. Recycling the nitrogen-rich crop waste mixture via compost formation may be a critical component of organic waste coutilization (Brown and Cotton 2011). In addition to soil amendment, fertilization, restoration, landfill cover, landscape gardening, soilless (substrate) cultivation, and plant disease prevention, compost made from a wide range of organic wastes may be used in a variety of ways (Becker et al., 2010).

**Household fuel:** Ligneous and hard residues of crops such as rice husk, maize cobs, cotton stalks, and coconut fronds and shells are largely used as generation of household fuel,

alternative to fuelwood. Even though the energy content of crop residues is lower than conventional wood, they are still an important source of fuel in most of the deforested localities of Asia and Africa. In India, other than its use as household fuel, the residues (straw and husk) of rice are used in boilers for parboiling of paddy grains. In addition, the woody portion of cotton, pulses, and soybean wastes are primarily used as domestic fuel. Groundnut residues are burned as fuel in kilns. The shells of coconut stalks or mustard and rapeseed, jute, and sunflower are used as domestic fuel.

### 1.1.3 Value-added service and applications

Crop residue is now being recognized as a significant resource with outstanding economic potential. Crop residue's development as a valuable resource has progressed to the point where there are competing applications for it. The following are some of the major value-added services and applications delivered by crop residues:

**Modern construction materials:** Crop residues have a range of commercial applications in various stages of production. It can be used as a raw material for construction goods, namely, fiberboard, paper, and liquid fuels (Pandey and Sujatha, 2009). Several technology and commercial products of hybrid green composite particle or fiberboards have sprung up in recent years. These cost-effective biocomposites are further treated for extending longevity and protection from termite and corrosion. For the building industry, jute–coir composite is a cost-effective alternative to wood. Again, jute–ply boards are composite boards that can be used replacing plywood, and natural fiber reinforced boards made of jute–coir can be used to replace MDF boards (Fahmy et al., 2017). Other applications for crop residue–based products include geotextiles, floor coverings, and polymers made from plants and biocomposites. Crop residue is converted into briquettes for the construction of houses, which is lightweight and hence suitable for use in earthquake-prone areas. Crop residues are an essential source of pulp for papermaking. In terms of quality, straw pulps are comparable to fiber of hardwood, but they need fewer pulping chemicals which are beneficial for industries.

**Bioenergy generation:** Crop residue has been proven to be a valuable energy source, and it is gaining popularity around the world because of its cost-effectiveness, energy efficiency, and environmental friendliness (Hiloidhari et al., 2014). Crop residues have been increasingly used for energy production in recent years, and they may be a safer alternative to fossil fuels. However, the residues availability, costs of transportation, and infrastructural settings are some of the major disadvantages of using residues as bioenergy. Lignocellulosic biomass such as agricultural residues, wood, and grass are promising sources of alternative energy (Hu and Ragauskas, 2012). Based on crop data from 2003/04 to 2007/08 and literature heat values for each crop, Hiloidhari et al. (2014) estimated the energy content of surplus agricultural residue (ca. 235 million tww) at 4,150,000 TJ yr<sup>-1</sup> after excluding known competitive applications.

**Liquid biofuel:** The abundant availability of lignocellulosic crop residues as a raw material for the biofuel production is making it a valuable commodity (Bhuvaneshwari et al., 2019). Crop residues (corn grain or cob, straw of wheat and rice, sugarcane bagasse, and sawdust) are commonly regarded as a major source of cellulosic ethanol (Wilhelm et al., 2004; Mirza et al., 2008; Liu et al., 2008). During the process, the cellulose in straw is enzymatically digested into its sugar components, which are further fermented to ethanol. Because of its enhanced energy balance and lower carbon emissions, cellulosic ethanol has been

considered a superior alternative to corn or any other ethanol. However, the process has high processing expenses.

**Biopower:** It is the process of converting biomass into electricity. It can be achieved by combustion, gasification, biomethanation, and pyrolysis. During combustion, the crop residue alone (or with coal) is burned to produce steam, which drives a turbine to generate electricity. Gasification involves heating straw in the presence of limited oxygen to create a synthesis gas (comprises  $N_2$ ,  $H_2$ ,  $CO$ , and  $CO_2$ ). Other than producing electricity, this synthesis gas can be used for the manufacture of chemicals, ethanol, gasoline, and diesel. Whereas, pyrolysis can be used to generate bio-oil from crop residues, which involves raising the temperature of the biomass to 400–500°C to convert the residues to condensable vapors. When the condensate is rapidly cooled, it is transformed into a sticky liquid commonly known as bio-oil (calorific value = 16–20 MJ kg<sup>-1</sup>), which also has several value-added applications.

**Biochar:** Biochar is fine-grained charcoal, which is a high-carbon material made from crop residues via the process known as pyrolysis. In this process, the crop residues are burnt at 300–600°C at partial or complete exclusion of  $O_2$ . The process generates noncondensable gases ( $H_2$ ,  $CH_4$ ,  $CO$ ,  $CO_2$ , and  $N$ ) as primary products (Di Blasi et al., 1999). Biochar has been shown to play a significant role in long-term carbon sequestration in soil and can be used to improve the functions of soil and increase crop yields (Marousek et al., 2014). It improves soil characteristics and reduces greenhouse gas emissions, as well as provides an adsorption surface for agrochemicals and improves key nutrient dynamics. Crop residues offer abundantly available inexpensive source of biochar production (Wang et al., 2013).

**Biogas:** Biomethanation or AD is the microbiologic conversion of organic substances to biogas in anaerobic environment, an established technology under the biochemical bioenergy conversion route (Angelidaki et al., 2011). In this method, the high-quality fuel gas is extracted from the agricultural crop residues. The process produces methane-rich biogas as primary product from organic residues under microbial action, which mainly consists of  $CH_4$  (~60%) and  $CO_2$  (~40%) (Kataki et al., 2017; Bhuvaneshwari et al., 2019). It is a commercially proven matured technology, is widely used for recycling and treating wet biodegradable organic waste, and is one of the best suited options for producing heat and electricity from biomass and for recycling of the nutrients from residue by-product (digestate) to the agricultural sector (Al Seadi, 2001). AD degrades organic matter by 60%–70%, yielding biogas as the main product and digestate as a by-product, which is nutrient rich. The following sections will discuss the prospects of crop residue based on AD in detail.

**BioCNG:** BioCNG is the purified and processed form of biogas, which is similar to conventional natural gas in terms of composition and properties and energy potential (Shah et al., 2017). BioCNG can be a perfect fuel and power source due to its high methane content, high calorific value, low moisture content, low cost, low emission level, and low impurity (Sahu et al., 2020). This technology has enormous potential for usage in commercial, industrial, and automotive applications. Following biogas production from organic waste, purification of biogas is carried out in order to produce highly pure biomethane by removal of  $CO_2$  and  $H_2S$  by using several technologies such as scrubbing, chemical absorption, pressure swing adsorption, membrane purification, cryogenic separation, and biological filtration (Kumar et al., 2018; Sahu et al., 2020). The purified biomethane which contains more than 95% pure methane so produced is then pressurized and filled in high-pressure cylinders (0.45 kg of bioCNG can be produced per m<sup>3</sup> of biogas). BioCNG has been reported to be

much cheaper than CNG and other fuels, as the production cost of bioCNG is 20%–50% lower than the other fuels such as CNG and other petroleum products. As compared to calorific value of biogas (19500 kJ/kg), bioCNG has a calorific value of 52,000 kJ/kg (Sahu et al., 2020).

Particularly for countries like India with enormous biomass resources, it needs to promote bioCNG to tackle stubble burning, boost rural economy, for resource development, lessen the petroleum demand, and advance energy security (Kumar et al., 2018). However, the potential of bioCNG has not yet been fully realized and marketed. There exist several challenges such as appropriate purification technologies, upgradation of equipment and the associated cost, lack of skilled man power, and refueling infrastructure (Shah et al., 2017).

**Biojet:** In order to comply to the global efforts on carbon emission reduction, the aviation sector has also committed to reduce carbon emissions by 50% from their 2005 level by 2050, for which blending of low carbon fuel with fossil jet fuel will be essential (IEA, 2019). It has been predicted that jet fuel made from renewable resources (biojet fuel or also known as sustainable aviation fuel (SAF)) has the potential to significantly lower lifecycle emissions by 20%–95% compared to petroleum-derived jet fuel, depending on feedstock source and fuel conversion technology (Cremonez et al., 2015; Bosch et al., 2017; Klein et al., 2018).

Agricultural residues can be a sustainable feedstock for producing SAF. For instance, lignocellulosic feedstock can be processed into liquid fuel by pyrolysis, further necessitating hydrogenation for improvement, or by gasification and Fischer–Tropsch synthesis (Bosch et al., 2017). Alcohols may also be produced from starch and sugar crops, which can subsequently be transformed into oligomers and dehydrated. Oil-rich agroforestry residues can be potential SAF feedstocks (Doliente et al., 2020). To reduce aviation emissions, agrowastes may be a cost-effective choice than dedicated feedstocks, if the quantity of resources required to purify and upgrade wastes into jet fuel is less than that required for cultivated feedstocks (Doliente et al., 2020). Despite the immense promise of these fuels, new manufacturing techniques, especially ones with lower production costs, are urgently needed. Because of the high prices, investor uncertainty, and lack of policy knowledge, biojet fuel is still in its infancy in most parts of the world, which can be alleviated with clear and stable policy (Deane and Pye, 2018). Additionally, NO<sub>x</sub> emissions, considerable agricultural land use, and high water consumption may have an impact on the environment as a result of the manufacturing of the raw materials required to create these biofuels (Cremonez et al., 2015; Klein et al., 2018).

**Biohydrogen:** Hydrogen is used for range of application and is produced through number of technologies. However, sustainable sources of hydrogen production are vital for long-term energy strategy and sustainable development. The energy ratio and GHG emissions of biohydrogen are better than fossil fuel–based hydrogen (Djomo and Blumberga, 2011). Dark fermentation, photo-fermentation, direct algal bio-photolysis, and indirect cyanobacterial bio-photolysis are significant biohydrogen production processes (Balaji et al., 2020). Dark fermentation's high output rates and easy reactor architecture make it a suitable conversion process. Dark fermentation uses carbohydrate-rich substrates such as lignocellulosic biomass, including agricultural residues and food waste, and utilizes cellulose and hemicellulose while avoiding lignin in the presence of dark fermentative bacteria. Previous studies have used rice straw, corn straw, banana waste, apple waste, sunflower straw, wheat straw, palm oil mill, maize, rye, oat, sunflower, rape, etc., as biohydrogen substrates (Singh and Das, 2019). However, most of the research work focuses on lab-scale biological hydrogen generation. It was

calculated that about 10.56 (in 2013) and 15.5 (in 2030) Mt of biohydrogen could be obtained globally from agricultural residues (Alavijeh et al., 2020). When it comes to commercialization and development of biohydrogen economy, low conversion efficiencies; infrastructure, storage, and transportation costs; and lack of large-scale production, cell stabilization, continuous production, appropriate pretreatment conditions, and microbial strain, purification techniques are subjects of future research (Singh and Das, 2019; Singh and Sarma, 2022).

## 1.2 Crop residue–based anaerobic digestion

Crop residues are mostly lignocellulosic biomass rich in cellulose and hemicellulose, which serves as a great potential for AD (Sawatdeenarunat et al., 2015). AD is one of the mature processes that can undertake wide range organic waste (organic manure, crop residue, agroprocessing residues). These conversion processes offer significant scope to expand biomass use by tapping unused residues and wastes which are widely available and cost-effective and do not directly compete with food resources, or water or land.

Energy crops such as maize, wheat, sorghum, sunflower, and grass are reported to have a biomethanation potential of 291–338 L kg<sup>-1</sup> VS, 351–378 L kg<sup>-1</sup> VS, 286–319 L kg<sup>-1</sup> VS, 231–297 L kg<sup>-1</sup> VS, and 286–324 L kg<sup>-1</sup> VS, respectively (Weiland, 2010). Previous work reported methane potential of wheat straw in the range of 0.145 m<sup>3</sup> kg<sup>-1</sup> to 0.390 m<sup>3</sup> kg<sup>-1</sup> for dry organic mass (Sharma et al., 1988; Moller et al., 2004). The biochemical methane production from sugarcane biomass varies from 0.266 to 0.314 m<sup>3</sup> kg<sup>-1</sup> (Deren and Snyder, 1991). As per the study of Deublein and Steinhauser (2011), rice straw biomass has a biogas generation capacity of approximately 0.550–0.620 m<sup>3</sup> kg<sup>-1</sup> with a methane content of around 50%. Biomethane potentials of some relatively less explored crop residues such as coffee husk, corn cob, and oat straw have been reported as 0.20, 0.35, and 0.32 m<sup>3</sup> kg<sup>-1</sup> volatile solid (Paul and Dutta, 2018; Deepanraj et al., 2014; Hidayat et al., 2020). Suhartini et al. (2021), while comparing specific methane potential of fruit-based agro-industrial waste to that of agricultural crop residues (rice straw, vegetable waste, maize straw, coffee husk, and oil palm empty fruit bunches), reported higher methane potential of fruit-based waste than crop residues, except for vegetable waste that showed highest potential (0.420 m<sup>3</sup> kg<sup>-1</sup> VS).

However, many times it is seen that AD implementation at large scale faces several challenges. Unrealistic input feedstock estimation and quality assumptions, incomprehensive understanding of the complexities of the feedstock supply chain, inappropriate AD designs, and overestimation of economic benefits from biogas and digestate are the main causes of these problems (Breitenmoser et al., 2019). Further, net economic potential for AD is often much lower due to the spatial distribution of biomass and variation in seasonal availability (Rao et al., 2010; Bochmann and Montgomery, 2013). Furthermore, crop residues are often high in lignocellulosic matter (high C:N ratio, contains 10%–25% lignin) with a high total solid content due to which they are not degraded easily in AD systems (Bochmann and Montgomery, 2013; Einarsson and Persson, 2017). Most of the plants (crop residues) are composed of three major components, namely, cellulose (38%–50%), hemicellulose (23%–32%), and lignin (10%–25%) (Sawatdeenarunat et al., 2015). The high carbon to nitrogen ratio (C/N) of lignocellulosic biomass (recalcitrance) is reported to be the major limiting factor for a higher biogas yield (Hu and Ragauskas, 2012). Consequently, the ability to generate biogas from

agricultural residues is highly dependent on the ability to overcome obstacles associated with these substrates via advancement of biogas technology (Einarsson and Persson, 2017).

The complex structure of lignocellulosic biomass may be overcome by incorporation of appropriate pretreatment of feedstock and its codigestion with other feedstock (Yang et al., 2017). Cellulose content, hemicellulose content, and C/N ratio of rice straw, wheat straw, corn stover, and switchgrass are 32%, 24%, and 47; 38%, 21%, and 60; 37%, 22%, and 63; and 38%, 26%, and 93, respectively (Karthikeyan and Visvanathan, 2013), which have high potential for biogas production with codigestion of other suitable substrates. But their high value of C/N ratio and complexity of biomass structure (contains >10%–25% lignin) hinders faster AD process when it is used for monodigestion (Sawatdeenarunat et al., 2015). The synergistic integration of high C/N ratio lignocellulosic biomass with low C/N ratio biomass such as animal manure in an AD system appears to be a logical option to enhance biogas yield of such recalcitrant residues (Ye et al., 2013). Codigestion of lignocellulosic biomass with animal waste can balance carbon and nitrogen ratio to optimize biogas production because monodigestion produces low biogas for digester instability (Abouelenien et al., 2014). Table 9.1 shows the biochemical composition of some common agro-residues.

Previous works clearly show codigestion as a method to improve the digestibility of crop residues in AD. Zhu et al. (2014) tested codigestion of hay with soybean processing waste at 25:75 ratio in a solid-state AD process and found that it yielded 258 Lkg<sup>-1</sup> VS methane output

TABLE 9.1 Biochemical composition of some common agro-residues.

Crop residue	Lignin (%)	Hemicelluloses (%)	Cellulose (%)	Ash (%)
Miscanthus	24–25	18–24	38–40	5.5
Bamboo	20.81	19.49	39.80	1.21
Corn leaves	15.81	13.27	26.93	10.95
Corn cobs	14–15	35–39	42–45	3.53
Rice husk	26–31	18–21	25–35	17.27
Wheat straw	17–19	26–32	33–38	3.74
Rice straw	12–14	23–28	28–36	19.8
Corn stover	7–19	24–26	38–40	6.8
Barley straw	14–19	27–38	31–45	–
Sweet sorghum bagasse	14–21	18–27	34–45	–
Rye straw	16–19	27–30	33–35	–
Oats straw	16–19	27–38	31–37	–
Switchgrass	10–40	30–50	5–20	5–6
Hazelnut shell	42.1	28.2	25.2	1.4

Sources: Paul, S., Dutta, A. 2018. Challenges and opportunities of lignocellulosic biomass for anaerobic digestion. *Resour. Conserv. Recycl.* 130, 164–174; Praspaliauskas, M., Pedišius, N., Čepauskienė, D., Valantinavičius, M. 2020. Study of chemical composition of agricultural residues from various agro-mass types. *Biomass Convers. Bioref.* 10 (4), 937–948; Phyllis2 database.

after fermentation. Codigestion increased biogas production by 50% and 148%, respectively, as compared to using just hay or only soybean processing waste individually. In another study by Xu and Li (2012), the authors showed that using maize stover and dog food (expired) in an equal ratio (1:1) may provide a methane production of 304.4 kg kg<sup>-1</sup> of dry matter, which is an increase of 129% compared to corn stover alone and 9% compared to dog food digestion alone, respectively. Recent research reported methane outputs ranging between 101 and 286 NL CH<sub>4</sub> kgVS<sup>-1</sup> from AD of mixed agricultural biowastes rice and wheat straw (Breitenmoser et al., 2019). Keeping the C/N ratio at 20, Wu et al. (2010) were able to maximize biogas production from swine dung by codigesting it with three lignocellulosic biomasses, such as maize stalks, wheat straw, and oat straw. The authors attributed the increase in biogas yield to the enhancement of volatile matter in substrate.

There are various pretreatment methods that are being explored to enhance the degradability of crop residue biomass prior to AD. In order to liberate degradable cellulose and hemicellulose from lignocellulosic material when utilized in AD, it must be pretreated physically, chemically, or biologically (Mosier et al., 2005; Bochmann et al., 2013). Given the large amounts of agricultural biowastes available, the quest for cost-effective pretreatments will drive research in low- and middle-income countries (Mittal et al., 2017; Kamusoko et al., 2019). A universal pretreatment method for all lignocellulosic biomass is not available. Various pretreatment methods can be broadly classified as physical, chemical, and biological (Amin et al., 2017). Various physical methods such as milling, microwave, and mechanical extrusion can be used to increase the pore size and surface area of biomass and decrease cellulose crystallinity and degree of polymerization. Under chemical pretreatment various acids and alkali, ionic liquids, and other chemical agents are used for lignocellulosic biomass degradation. Biological pretreatment requires living microorganism for the degradation of lignocellulosic biomass (Baruah et al., 2018). Various microorganisms such as fungus (white rot, soft rot, and brown fungi) and microaerophilic bacteria are used in this purpose. Hydrothermal pretreatment of lignocellulosic biomass is another promising approach to increase biogas production in AD (Paul and Dutta, 2018).

Further, it is necessary to develop techniques to evaluate the feasibility and sustainability of crop residue-based AD plant by spatial tools and decision support system to aid decision-makers in selecting the proper feedstock for biomethanation, determining the best site for a biogas facility, as well as determining the optimal plant capacity, supply chain and related risks, and costs for the project's implementation (Escalante et al., 2016). Though, the use of larger amounts of crop residues in the feedstock is favorable from an energy management viewpoint, its spatial projection on resource logistics and its significance on biogas plant selection are less investigated (Soha et al., 2021).

### 1.3 Digestate, the inevitable commodities of anaerobic digestion: need of its management and scope of digestate utilization in agriculture

During the AD process, apart from the primary energy from biogas, the process generates anaerobic digestate as the by-product. Remaining digestate from the AD process might range from 5% to 80% of the initial feedstock, depending on the kind of feedstock used. Due to the fact that by-products are an essential part of the bioenergy generating process, their use directly influences the efficacy and adoption of the technology. As a result, while building



a bioenergy plan, it is essential to maximize the usage of the digestate by-product. Digestate typically has high levels of refractory chemicals and nutrients relative to the source feedstock and is biologically stable in comparison to that feed (Holm-Nielsen et al., 2009). There may be a lot of value-added uses for digestate because of its characteristics.

AD is highly adaptable to a variety of feedstocks, resulting in by-products with varied physicochemical properties (Abubaker et al., 2012). However, digestate retains enough nutrient and carbon from the original feedstock that can be utilized as fertilizer (Gell et al., 2011). The increased bioavailability of plant nutrients without significant variation from input feedstock makes recycling AD digestate in agriculture a viable alternative for sustainable use. Several studies have shown that biogas digestate improves crop and soil health compared to unfertilized and chemically fertilized controls (Vaneckhaute et al., 2013; Riva et al., 2016; Bartóg et al., 2020; Panuccio et al., 2021). In places like India, where nutrient and energy insufficiency is a problem, the potential of using alternative fertilizer supplies is highly relevant, since there has been a focus on increasing nutrients inputs for crop productivity and also on the development of bioenergy. Considering the abundant crop residues available in these areas, there is ample scope of utilization of these resources for both energy generation and fertilizer application. The continuous development of the bioenergy industry has increased interest in understanding soil and crop behavior after using digestate. The main aspects to be taken care of while considering application of, particularly, the digestate as fertilizer are the nutrient profile, transportation distance to the place of utilization, cost associated with digestate treatment and processing, optimum route and time of application to ensure maximum crop benefit, and also acceptance by the end users. All types of digestates as a plant nutrient source are not recommended because of some feedstock-derived properties (heavy metals, imbalanced nutrient status, biological security, phytotoxicity) that may not be favorable for crops despite reports of beneficial effects of digestate recycling (Gell et al., 2011; Przygocka-Cyna and Grzebisz., 2018; Panuccio et al., 2021). Due to the difficulties connected with digestate bulk handling, most of the time, digestate use is restricted. Adding water to digestate lowers its value for the producer by increasing the cost of transporting, managing, and treating it. Because of inappropriate application and storage (via an unlined earthen drain and pit), excess nutrients may leak into groundwater (Sharpley and Moyer, 2020).

## 2. Variation in digestate characteristics with respect to different crop residues

AD can take up a wide range of organic sources belonging to categories such as crop residues, animal waste, urine and manure, vegetable waste, organic wastes from food industries, organic fraction of municipal waste, sewage sludge, etc. The nutrient composition of digestate varies depending on the parent substrate or feedstock, type of digester, and the method of energy production (de Groot and Bogdanski, 2013). About 25%–30% of the total dry matter of organic feedstock is converted into biogas during digestion and remaining 70%–75% comes out as the by-product of biogas digestate (Gurung, 1997). In general, digestate contains 0.7%–20% of dry matter, of which volatile matter accounts for 1.4%–76%. AD results in 60%–75% reduction of total solid of feedstock (Alfa et al., 2014). During AD, the quantities of nutrients in the feedstock are conserved, but their availability is enhanced

due to chemical change during digestion process (Lukehurst et al., 2010). Digestate is characterized by increased pH, due to volatile fatty acid production during AD (Gómez et al., 2007). The characteristics of digestates are similar to feedstock, except they have a higher pH,  $\text{NH}_4^+$  content, and  $\text{NH}_4^+$ : total N ratio than undigested feedstock (Fouda et al., 2013). Generally, digestates include nutrients with increased bioavailability (60%–80% total nitrogen mineralized, plus phosphorus and potassium) (Tambone et al., 2009; Garfi et al., 2011; Makádi et al., 2012). Characteristics of digestates concerning its fertilizer value from farm and agro-industrial residue, maize silage, sugar beet pulp, and fruit marc were shown to be a property of feedstock.

Fertilizer property of digestate is mainly attributed to its high TN content and N in mineralized form (Gell et al., 2011; Teglia et al., 2011). N is generally reported to be conserved under anaerobic condition; hence digestates represented higher TN as a consequence of the N concentration effect from carbon degradation and N preservation during AD (Tambone et al., 2010; Massaccesi et al., 2013). The most significant property of the digestates is the occurrence of 70% and 39%–61% of total N (on mass basis) in inorganic  $\text{NH}_4^+$ -N forms (Alburquerque et al., 2012). Compared to undigested feedstock, where predominant form of N was organic bound N, anaerobic materials were characterized by  $\text{NH}_4^+$ -N concentrations (50%–75% of total N) due to formation of ammonium during anaerobic decomposition (Kirchmann and Witter, 1992; Tambone et al., 2010).  $\text{P}_2\text{O}_5$  content of digestates was reported to be similar to that of undigested feedstock in maize silage and rice residues based digestates (Tambone et al., 2010). However, there are reports on losses of S as  $\text{H}_2\text{S}$ , Mg (due to precipitation as struvite), Cd, and Zn (due to precipitation as sulfides) in digestates following AD from maize silage (Zirkler et al., 2014). Compared to undigested counterpart, digestates had lower TOC and VS due to mineralization of organic matter. Spectroscopic characterization using Fourier Transform Infrared Spectroscopy (FTIR) and nuclear magnetic resonance (NMR) of digestates shows clear transformation of organic content between undigested and digested fraction. The spectra of undigested feedstock were reported to be dominated by carbohydrate (hemicelluloses, celluloses, and simple sugars). As AD proceeds through degradation of the labile organic molecules, FTIR spectra of digestates showed drastic reduction in aliphatic structures (Tambone et al., 2013; Provenzano et al., 2014). On the other hand, characteristic of digestate spectra is increase of the peak in the aromatic region due to concentration of chemically recalcitrant molecules (lignin, complex lipids, and steroids) (Tambone et al., 2009). Physicochemical characteristics of some crop residue–based digestates are shown in Table 9.2.

Due to the potential risk of metal interaction with the food chain, knowledge on heavy metals in digestates is necessary. The heavy metals which are of particular concern in digestate to understand their fertilizer application are Cd, Cr, Hg, Pb, Cu, Ni, and Zn (Tampio et al., 2016). Concentration and availability of heavy metals in digestates were reported to depend on their initial concentrations in raw feedstock and conditions of digestion and storage (Chen et al., 2014). However, concentration of heavy metals in digestates were reported to be lower than the limit, set under regulation related to digestate utilization in different countries. Digestates were reported to meet quality standard in respect to heavy metals as reported by Pokoj et al. (2015) in crop silage digestates (Polish limits for organic fertilizers) and Alburquerque et al. (2012) in farm and agro-industrial residue–based digestates (Spanish legislation and the quality protocols for the production and use of digestates).

**TABLE 9.2** Physicochemical characteristics of some crop residue–based digestates as reported in literature.

Source	Rice straw	Cattle slurry and maize	Maize silage
TS	20.9%	5.7%–6.5%	3.39%
VS	75.2% TS	–	–
TSS	–	–	–
TOC	41.7% TS	36.8%–39.5%	76.2% TS
Ash	–	–	–
pH	–	8–8.2	9.96
EC	–	–	9.7 mS cm <sup>-1</sup>
Water-soluble C	–	–	–
TN	3.7 g kg <sup>-1</sup>	55.9–64.2 g kg <sup>-1</sup> TS	4.1% TS
Ammonia-N	0.076 g kg <sup>-1</sup>	25.5–32 g kg <sup>-1</sup> TS	–
C:N	–	–	–
P <sub>2</sub> O <sub>5</sub>	6.68 mg kg <sup>-1</sup> TS	–	3.48% TS
K <sub>2</sub> O	28.91 g kg <sup>-1</sup> TS	–	0.59% TS
CaO	24.06 mg kg <sup>-1</sup> TS	–	0.37% TS
MgO	7.08 mg kg <sup>-1</sup> TS	–	3.62% TS
Na	1.34 mg kg <sup>-1</sup> TS	–	–
Fe	1.12 mg kg <sup>-1</sup> TS	–	–
Ref	Chen et al. (2014)	Cavalli et al. (2016)	Albuquerque et al. (2012); Nabel et al. (2014)

### 3. Effect of digestate application on soil fertility

Digestates are reported to be rich in plant nutrients as they retain nutrients from input raw material and hence could be used in agriculture as soil amendment or fertilizer. In general, high concentration of total nitrogen and presence of 60%–80% of it in mineralized form along with higher phosphorus and potassium make digestate suitable consideration as soil applicant (Tambone et al., 2009). The performance of digestate as soil applicant is found to be encouraging, though there are variations in their performance depending upon quality and nutritional status. Soil carbon, nitrogen dynamics, microbial content, emission, soil nutrients, soil structure, carbon sequestration potential, etc., are the parameters evaluated to understand effect of digestate application on soil. Literature on digestate effect on soil mainly focuses on dynamics and fate of digestate-N fraction in relation with its characteristics and soil properties to understand the potential mineralization/immobilization turnover in soils.

The results depend on the source of digestate, digestate processing, method of application, type of soil, and application dose. Application of agricultural waste–based digestate is reported to decrease soil bulk density and increase saturated hydraulic conductivity and moisture retention capacity indicating better aeration, better drainage in soil, and subsequently better crop growth (Garg et al., 2005). It has been reported that status of digestate organic carbon, dissolved organic carbon, biochemical oxygen demand, and their proportion with respect to TN are reliable parameters to predict C and N dynamics in the soil and hence the N-fertilizer potential of the digested materials (Alburquerque et al., 2012). On the other hand, application of digestates with less biodegradable organic fraction, availability of plant available N is ensured as ammonium is rapidly nitrified in soil. Available fraction of soil K and P were also reported to increase from digestate application depending upon type of soil and soil layer (Baryga et al., 2021). However, sometimes digestate is unable to compensate for nutritional deficiencies for elements such as potassium, magnesium, iron, and zinc that occur in intensively farmed soil (Baryga et al., 2021). Heavy metal accumulation from digestate use is reported to vary with respect to type of soil and source of digestate. Accumulation of Cu in digestate (feedstock: mixture of pig manure, maize silage, biological waste) applied soil at a concentration higher than Flemish environmental quality standard was reported by Vaneckhaute et al. (2013). However, amounts of As, Cd, Cr, Hg, Pb, Ni, and Zn were lower than the environmental quality standard. In a recent study by Aso (2020) digestates from Cassava peeling residue has been recommended for direct application for agronomic uses.

#### 4. Effect of digestate application on crop growth and nutrient uptake

Digestates from several feedstocks have been investigated for fertilization potential using a range of test crops and cropping systems, using different methods and timing of application, as well as in different application phase through digestate processing. Performances of anaerobic digestates on crops can be analyzed with respect to three types of control: (a) unfertilized control, (b) undigested feedstock, and (c) mineral fertilizers. Considering the crop yield, application of digestate has been proved to be beneficial than using no fertilizer.

While comparing the effect of digestate with chemical fertilizer, a range of studies reported no statistical difference in crop yield between digestates and mineral fertilizer application. Losak et al. (2014) recommend the use of digestate as a fertilizer for wheat and kohlrabi as it results in comparable or better yield compared with mineral fertilizers. Riva et al. (2016) suggested possible substitution of chemical fertilizer by digestate from silage maize without reducing crop yields of wheat and corn. Digestate was reported as a better fertilizer than mineral fertilizer resulting in higher crop yield in other studies (Gnanamani and Kasturi Bai 1992; Chantigny et al., 2008). On the other hand, Gnanamani and Kasturi Bai (1992) and Abubaker et al. (2015) reported combined application of synthetic fertilizer along with digestate to perform better than separated application of digestate. However, positive effects of digestate were shown to depend on the type of digestate, type of crop, and dose of digestate. Alburquerque et al. (2012) reported comparable yields to the mineral fertilization for summer horticultural (watermelon) crops, while for winter crops (cauliflower), yield was lower. Barbosa

et al. (2014) reported similar positive effect of biogas digestate from maize silage and chicken manure with chemical fertilizer on biomass production of *Sida hermaphrodita*, *Zea mays* L., and *Medicago sativa* L. However, the higher dose of digestate may have a negative impact. In relation to its undigested counterpart, digestate applications were found to be better in terms of crop yield mainly because of improved N nutrition of the crops (Loria et al., 2007; de Boer et al., 2008).

Several previous works have shown application of digestate to enhance crop nutrient content and quality. It has been reported that, compared to undigested feedstock, the fraction of plant available N is higher in digested form, hence, if it might be lost through emission ( $\text{NH}_3$ ) and leaching ( $\text{NO}_3^-$ ) could be minimized through proper timing and method of application, an immediate and higher N uptake can be ensured from digestate application (Loria et al., 2007; Chantigny et al., 2008). Digestate application may enhance protein, amino acid content, and nutrients content (C, N, P, S, and Na) of crop significantly compared to control or at par with that under chemical fertilizer treatment (Barbosa et al., 2014). Leaf quality of alfalfa grown under the treatment of digestate agricultural residue was also found to improve in terms of macrolelements content as reported by Koszel et al. (2015). In a study by Massa et al. (2017), digestates were also found to be effective in enhancing biochemical composition of microalgae species (*Arthrospira maxima* and *Tetradesmus obliquus*) increasing lipid, carbohydrates, and ash content. There are many reports discussing N uptake, N use efficiency, following digestate application.

AD digestate often has to be posttreated before use in order to minimize moisture, volatile fatty acid content, and/or pathogens in order to produce a marketable product that is simpler to transport (Kothari et al., 2014; Garcia-Pena et al., 2011; Breitenmoser et al., 2019). To allow better nutrient management, digestate processing into different processed products is an attractive option (Al Seadi et al., 2012). There are some processing methods such as dewatering, solid liquid separation, and stabilization (composting) that have been proposed to obtain products suitable for different uses (Balsari et al., 2010; Teglia et al., 2011). Though digestate processing helps in their management in a better way, however, understanding on quality, characterization, and distribution of nutrients with respect to varied feedstock and processing method are required to be understood for their appropriate and selective use. Digestates can be directly utilized in agriculture or its processed application can be employed through solid liquid separation, composting, drying, dilution, and ammonia stripping. The purposes of adopting digestate processing are to reduce volume for improved handling and management and/or to concentrate the nutrients present. Solid–liquid separation is the most adopted digestate separation technique. A more efficient transportation and hence enhanced nutrient recycling opportunities and efficient redistribution of digestate could be ensured from separation of the liquid and solid fractions of digestates. Effect on soil and crop from processed application in solid and liquid form were found to depend on the source of digestate, the type of processed phase, and the concentration used. It was reported that fertilizing vegetables, fruits, and grass separately with solid and liquid fraction of digestates led to comparable or higher yield under liquid digestates treatment than commercial fertilizer (Lield et al., 2006). No significant difference in yield as well as soil quality than mineral fertilizers was reported by Sigurnjaka et al. (2016) in production of *Lactuca sativa* L., by application of separated liquid digestate generated from mixed feedstock (animal manure, maize, and biological waste of food industry). In another study by Muscolo et al. (2017) discussing separate application of

agricultural residue and manure-based digestates, authors found solid fractions to increase soil stability and humification rates and suitable application of liquid fractions as irrigation water was indicated.

Evaluation of toxicity and phytotoxicity of digestate is an important concern while investigating its potential value as fertilizer. Recycling in agriculture might be restricted by heavy metal contents, salinity, biodegradability, phytotoxicity, and hygiene characteristics (Albuquerque et al., 2012). Digestate originating from industrial waste streams, waste sludge may substantially contain high metal load, aromatic and aliphatic hydrocarbons, and organic acid which may inhibit crop growth; however, crop residue-based digestate may not be phytotoxic in comparison to municipal sludge, industrial sludge based, or animal manure based digestates. Phytotoxicity effect of digestate which was mostly assessed using a germination index has been reported to be dependent on type of feedstock, type of crop, and dose of digestate (Panuccio et al., 2016). In a study by Teglia et al. (2011), ray grass showed phytotoxic effect against digestates from wastewater treatment sludge and source-selected organic fraction of municipal solid, while food-processing wastes and agricultural solid wastes based digestates showed phytotoxicity toward cress. Degree of phytotoxicity was also found to be dose dependent (Bustos et al., 2014). Bustos et al. (2014) recommended an application of anaerobic digestate concentrations lower than 10% to have no phytotoxic effect over lettuce seeds. In literature the toxicity incurred from digestate application was attributed to various factors. Elevated levels of organic acid or fatty acids may hinder germination, which may damage proteins and lipids in the cellular membranes of plant roots, impairing the plant's ability to uptake and retain nutrients (Abdullahi et al., 2008). A number of studies reported salinity or concentration of soluble salts to affect (McLachlan et al., 2004). Massacesia et al. (2013) digestate immaturity, i.e., lack of degradation of organic compounds to be the reason of digestate's phytotoxic effect. Phytotoxic effects may also be exerted by heavy metal contents, total nitrogen, phosphate, phenol, chemical oxygen demand, K, S, Zn, and Cl (McLachlan et al., 2004; Insam et al., 2015). Phytotoxicity potential of digestates can be addressed by incorporating aerobic decomposition or maturation phase following AD to further stabilize the organic matter of the digestate Abdullahi et al. (2008) [10, 35, 71]. Alternatively, lower or diluted application of digestate can be employed or direct contact with germinating seeds may be avoided (Abdullahi et al., 2008; Lencioni et al., 2016).

## 5. Use of digestate for vermicompost production

Digestate can present characteristics which would limit its recycling by direct use in agricultural soils sometimes due to improper digestion or degree of maturity (Salminen et al., 2001; Insam et al., 2015). Sometimes digestates in their basic form are not suitable for direct application to agricultural soils since they usually possess undesirable characteristics, such as odor, viscosity, high humidity, and a high content of volatile fatty acids, which are phytotoxic (Abdullahi et al., 2008; Abubaker et al., 2012). Further, there may be possible risk of pathogens if the digestion process is conducted under mesophilic conditions (Zhao and Liu, 2019). Therefore, it is desirable to refine or stabilize the digestate obtained after the AD. Composting can be a feasible treatment to stabilize digestate and thus, to improve its properties

for using as a soil conditioner (Czekała et al., 2017). Solid fraction of digestate is suitable substrate for composting. Composting can constitute a suitable postprocessing method to stabilize digestate not only for the management of these materials but also for improving the quality of the end-product by reducing the odor emission by decreasing the concentration of volatile compounds, moisture content, potential phytotoxicity and also contributing to the elimination of pathogens (Zeng et al., 2016, 2018).

Suthar (2010) illustrates the potential of digestate in vermicompost production by mixing it with crop residues in different ratios. The authors reported increase in total N, available P, and exchangeable K in all types of compost produced. Bustamante et al. (2013) and Zeng et al. (2016) in their studies showed need of appropriate bulking agent in digestate composting. Several crop residues such as wheat straw, vine shoot prunings, and pepper plant prunings were suggested as suitable bulking agent. The digestate-derived composts were reported to have desirable degree of stability and maturity, and the final properties were influenced by the bulking agent strongly. While conducting composting process with and without bulking agent (Vine shoot pruning) using solid fraction of a digestate from codigestion of cattle slurry and silage, Bustamante et al. (2013) reported positive effects of bulking agent by reduction in electrical conductivity, N losses during process, and also dilution of heavy metal contents of products. Tambone et al. (2010) investigated the characteristics of the solid fractions of digestate from pig slurry, energy crops and agro-industrial residues, their compostability, and compost quality, where they observed composting could not further bring about any significant change in compost quality than that of digestate, as AD itself brought upon high biological stability of biomasses. Further, the composts obtained fully complied to the legal limits for high-quality compost of Italy. In their study Cucina et al. (2017) reported production of organic amendment rich in macronutrients (27.1, 6.2, and 17.8 g kg<sup>-1</sup> of total N, P, and K, respectively) and compatible with the Italian legislation from digestate from organic waste codigested with agricultural by-products.

## 6. Use of digestate in algal cultivation

In recent times, potential of algae as renewable energy resource is being explored for production of a range of biofuels due to their favorable characteristics such as high productivity, nutrient removal efficiency, and ability to grow under varying environment. However, commercial exploitation of algae is limited for issues related to feedstock production, quality, and cost. Substantial supply of nutrient as growth supplement is critical for efficient production of algae, which is generally supplied through chemical input causing a major share of production cost. In this context, digestate, the by-product of AD, can be considered favorable that would offer efficient means to produce valuable biomass (Stiles et al., 2018; Chong et al., 2022). Previous studies reported a digestate concentration in the range of 30%–50% as optimum for microalgae above which can be toxic (Prajapati et al., 2014; Ayre et al., 2017). Considering the abundant crop residues and weed biomass available in India, there is ample scope of utilization of these resources for both energy generation and subsequent application of resultant digestate for algae production. Alternatively, microalgae can efficiently remove the nutrients from digestate while producing high-value biomass that can be used to produce

biochemicals and biofuels. However, there is limited study that has reported crop residue–based digestate in algae growth. [Silkina et al. \(2017\)](#) utilized digestate from agricultural origin for the growth and product formation of single cell algal cultures (*Nannochloropsis oceanica*, *Scenedesmus quadricauda*, and *Schizochytrium limacinum*) in heterotrophic and autotrophic conditions. The authors reported satisfactory product formation simultaneously achieving significant levels of bioremediation of digestate. The authors reported *N. oceanica* and *S. quadricauda* are ideal for digestate remediation (achieving ammonia and phosphate reductions of more than 60%), while *S. limacinum* SR21 serves as an ideal production medium for lipids and biomass, reaching 16.70 w/w % and 1.42 g L<sup>-1</sup> correspondingly. [Yang et al. \(2017\)](#) used diluted anaerobically digested effluents from grass as the substitute medium to cultivate *Scenedesmus* sp. A 1:3 ratio of unsterilized grass digestate:tap water was found to be the best proportion for the growth and nitrogen and phosphorus removal. The dry weight obtained for algae was 3.2 g L<sup>-1</sup>, and the total fat, carbohydrate, and protein contents in algae were 34%, 30%, and 16%, respectively. Total N, ammonia nitrogen, P, and selected heavy metal removal efficiencies were also satisfactory. From the perspective of successful process scale-up in this area, it is necessary to find efficient algae strain with capability of sustaining efficiently, optimal digestate loading considering inhibition from disproportionate digestate use, effect of digestate on quality of algae as energy feedstock, and bioremediation potential of algae through nutrient removal of growth medium, which are the novel areas of research requiring attention with a more holistic approach ([Stiles et al., 2018](#); [Chong et al., 2022](#)).

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## 7. Conclusion

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Crop residues, the noneconomic parts of the crop, are one of the most valuable resources with ready availability, wide distribution, and inexpensive resources, but need adequate management strategy. Crop leftovers may be valorized into valuable products such as compost, organic manure, biochar, or through biomass conversion technologies which can be used as a renewable fuel for power production or as a soil supplement to increase soil health and fertility. Even after fulfilling the competitive uses, these residues are of magnificent value if processed through appropriate conversion technology. AD presents such a robust technology that offers significant scope to expand the biomass use for bioenergy generation by tapping unutilized crop residues and wastes which are with reliable availability with wide geographic distribution. Crop residue valorization for energy recovery by AD has the potential to be a viable option for reducing the environmental consequences of stubble burning while also enhancing the country's energy security and would help to close the nutrient loop by recycling the by-product (digestate) into agricultural fields. Data concerning the effect of digestate on crop productivity vary with respect to test crop, type of soil, and growing conditions; however, if digestate is used appropriately, encouraging results can be attained under widely differing local conditions and with a wide variety of crop plants. A deeper understanding of digestates quality is required from range of feedstock, as well as standardized monitoring techniques of digestates, in order to minimize detrimental consequences on soil or plants prior to agricultural application. It would be beneficial to have a thorough understanding of the complete AD chain, from substrate to crops, in order to produce high-quality output, hence increasing the acceptance and marketability of the AD digestate.



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TAXMANN'S

# Accounting for Managers Text & Cases



Sankar Thappa

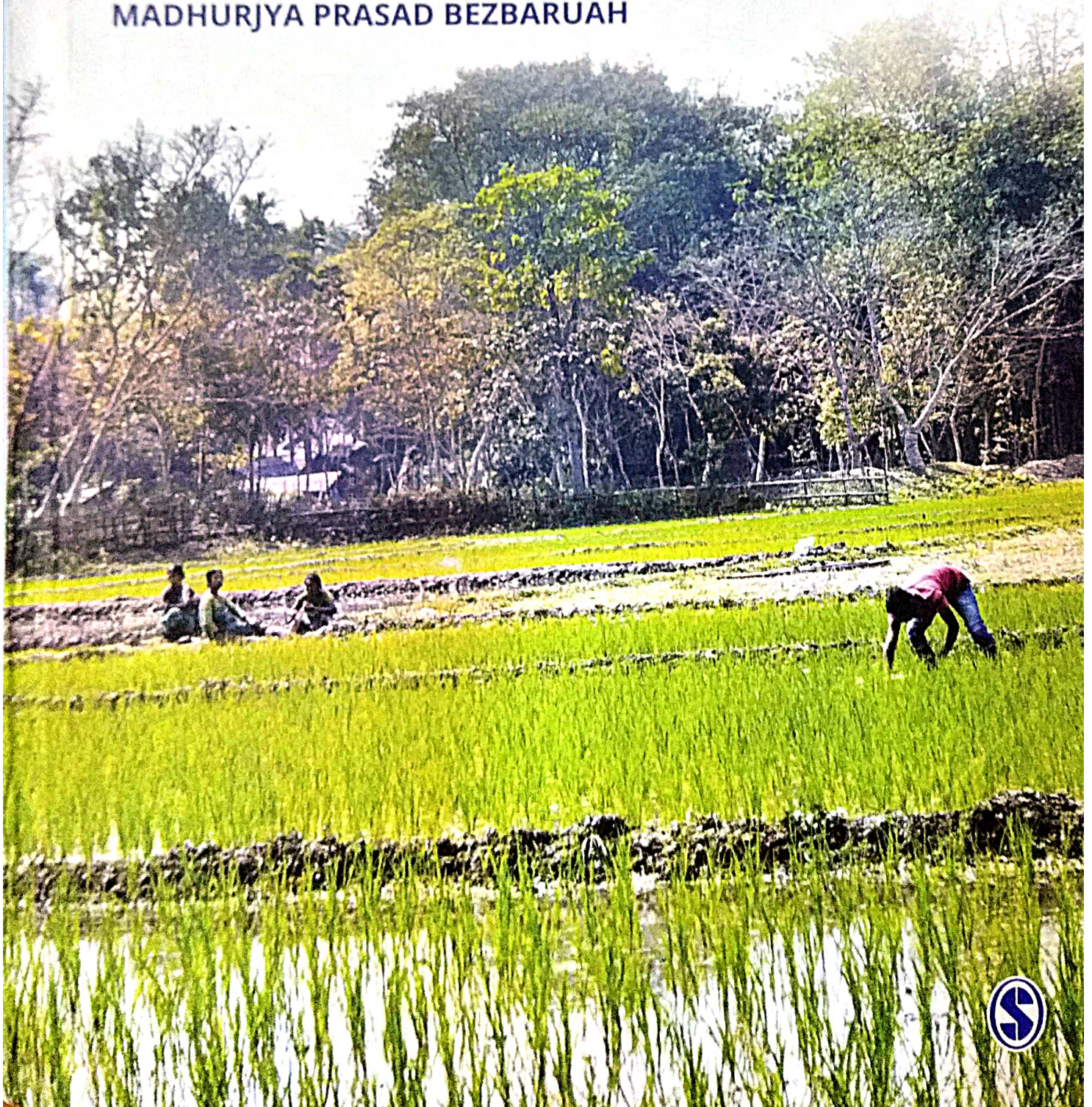


# AGRICULTURAL FACTOR MARKETS AND INDIA'S SMALL FARMERS

EDITED BY

ANUP KUMAR DAS | BINOY GOSWAMI

MADHURJYA PRASAD BEZBARUAH



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## Chapter 8

# Agricultural Credit in India

## The Dominance of Informal Sources

Abhijit Sharma and Prasenjit Bujar Baruah

### 8.1. INTRODUCTION

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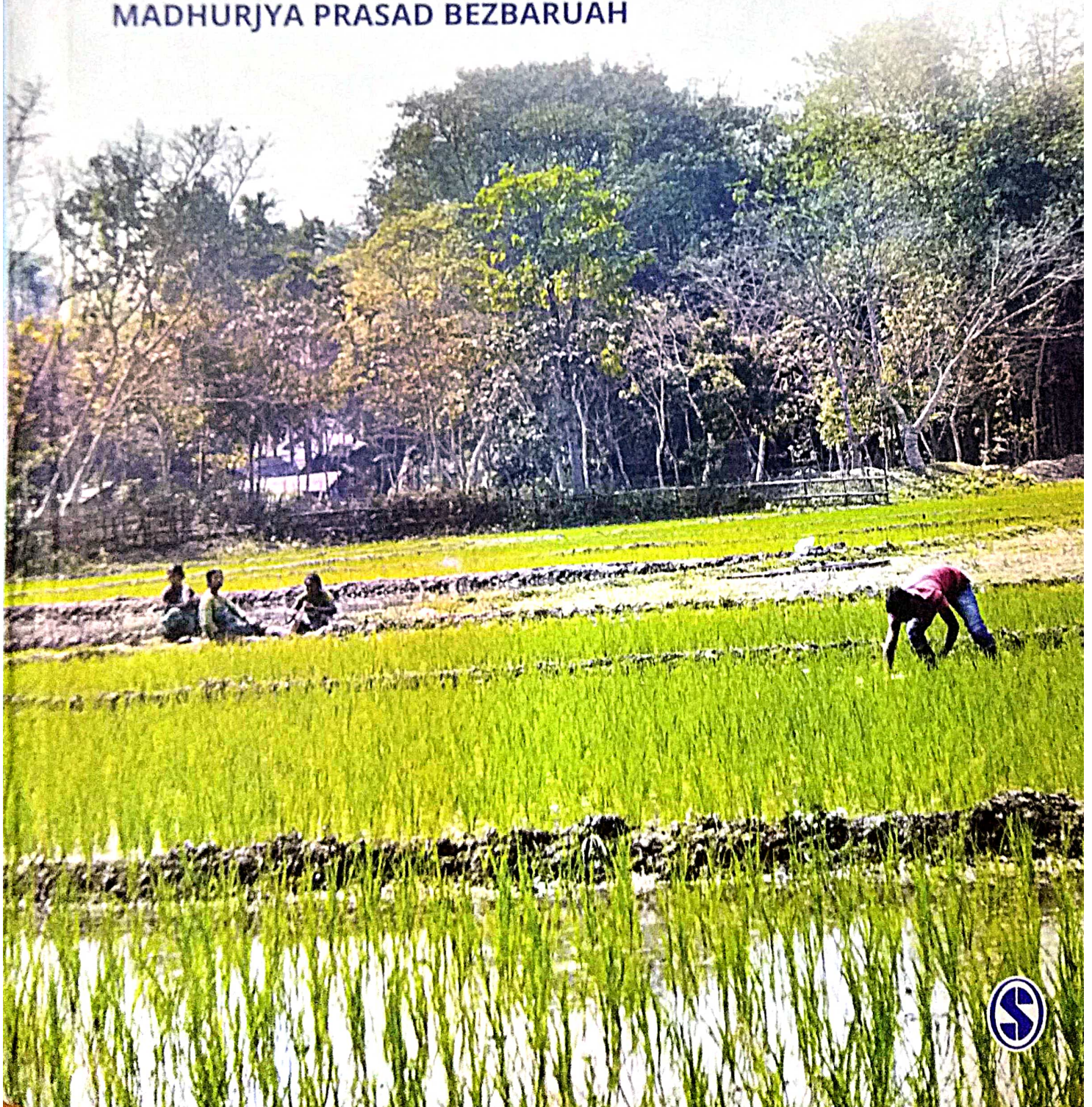
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# Chapter 1

## Introduction

**Binoy Goswami, Anup Kumar Das and  
Madhurjya Prasad Bezbaruah**

Agriculture in India, as in most developing countries, is organized with farm households as the basic production units. But farm households rarely possess different factors of production in the optimal proportions. While only a small proportion of rural households own large plots of farmland, landless, marginal and smallholders constitute the majority of the rural population. When it comes to labour, small and marginal farmers usually have more manpower in their possession relative to the land that they own. The pattern of transactions in the markets for leasing of land (land rental markets) and the rural labour markets has been traditionally playing the role of optimizing the land–labour ratios across larger and smaller farm households. As agriculture in the country has modernized with the adoption of newer technologies and progressive mechanization of farming operations, factor markets in agriculture have also expanded in numbers and transaction volumes.

Take the case of farm machineries and equipment, such as tractors, power tillers, irrigation pump sets and harvesters. As acquiring such machines requires lumpy investments, only farmers with access to the necessary financial resources, owned or borrowed, can afford to procure them. Small and marginal farmers rarely have access to enough

## Chapter 4

# Agricultural Labour Markets

## Structure and Functioning

Raju Mandal and Anup Kumar Das

### 4.1. INTRODUCTION

Unequal endowment of factors of production among the households is a common characteristic of an agrarian economy. More often, it is found that in relation to farmland, labour is abundantly available with smaller farmers, and it is scarce for larger farmers (Ray 2011, 409). As a result, cultivation is carried out with varying land-labour ratios, and usually, a small farm operates with excess labour, whereas labour power is deficient in large farms. Meanwhile, the average size of landholding is getting smaller due to an ever-increasing population pressure and division of land ownership with inheritance, which has resulted in an increase in the number of farmers with surplus labour. Under such circumstances, there is the emergence of the agricultural labour market and land-lease market to correct the unequal distribution of such factors of production. An agricultural labour market facilitates the transfer of the services of manpower from labour-surplus households to labour-deficient households. However, it is a stylized fact that as the economy matures, a segment of agricultural workers moves away to sectors with high productivity and better remuneration. India, an

## Chapter 6

# Rental Market of Farm Machineries and Equipment

Anup Kumar Das

### 6.1. INTRODUCTION

The scope of increasing agricultural production through the expansion of cultivable area is getting reduced due to increased population pressure on land, the supply of which is inelastic in nature. Consequently, intensive utilization of farmland becomes important to raise agricultural production. Farm mechanization that facilitates enhancement of agricultural production through intensive and productive utilization of farmland has therefore gained importance. The use of farm machineries such as tractors, power tillers and pump sets enhances cropping intensity (Agarwal 1984; Rao 1972; J. Singh 2006; Verma 2006) and productivity in agriculture significantly (Rao 1972; Roy and Blase 1978; Verma 2006). Farm mechanization helps in timely cultivation, maintaining the quality of operation, increasing the productivity of factors like land and labour, reducing the cost of cultivation and risks of weather and non-availability of labour, all of which raise agricultural output (G. Singh 2006, J. Singh 2006). However, farm mechanization is constrained by factors like small and fragmented landholdings and poor economic conditions of the farmers. For instance, the use of ploughing machinery in a farm requires the farmland to be of a viable minimum size.

---



# 3.

## **An Introduction to Cognitive Load Theory**

**Dr. Vinod Kumar Yadav\***

### **Introduction**

**C**ognitive aspect of learning is concerned with thinking processes and underlying mental procedures involved in the overall learning process. Cognitive factors impacting learning ranging from basic learning processes including memorizing facts and information, to advanced level processes including understanding, application, analysis and evaluation. A substantial cognitive aspect of learning that can impede or facilitate learning is prior knowledge and prior learning experience of learners. Learners come from diverse backgrounds, educational experiences, and prior knowledge resources and skills as well. The learning is determined by the prevailing

\*Assistant Professor, Department of Commerce, Rajiv Gandhi (Central) University, Arunachal Pradesh, India.

# **ARUNACHAL PRADESH**

**Re-inventing a Frontier Ethno-space**

Edited by  
**K. Jose SVD**  
**Rachel Kabi**



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Dedicated to

The Land and People of Arunachal Pradesh

Especially to those who cultivate a sense of social responsibility towards their less fortunate brothers and sisters. Very specially we fondly remember late Prof. Tamo Mibang, the former Vice Chancellor of Rajiv Gandhi University who instilled in us academic passion for original Anthropological Researches. May he Rest in Peace.

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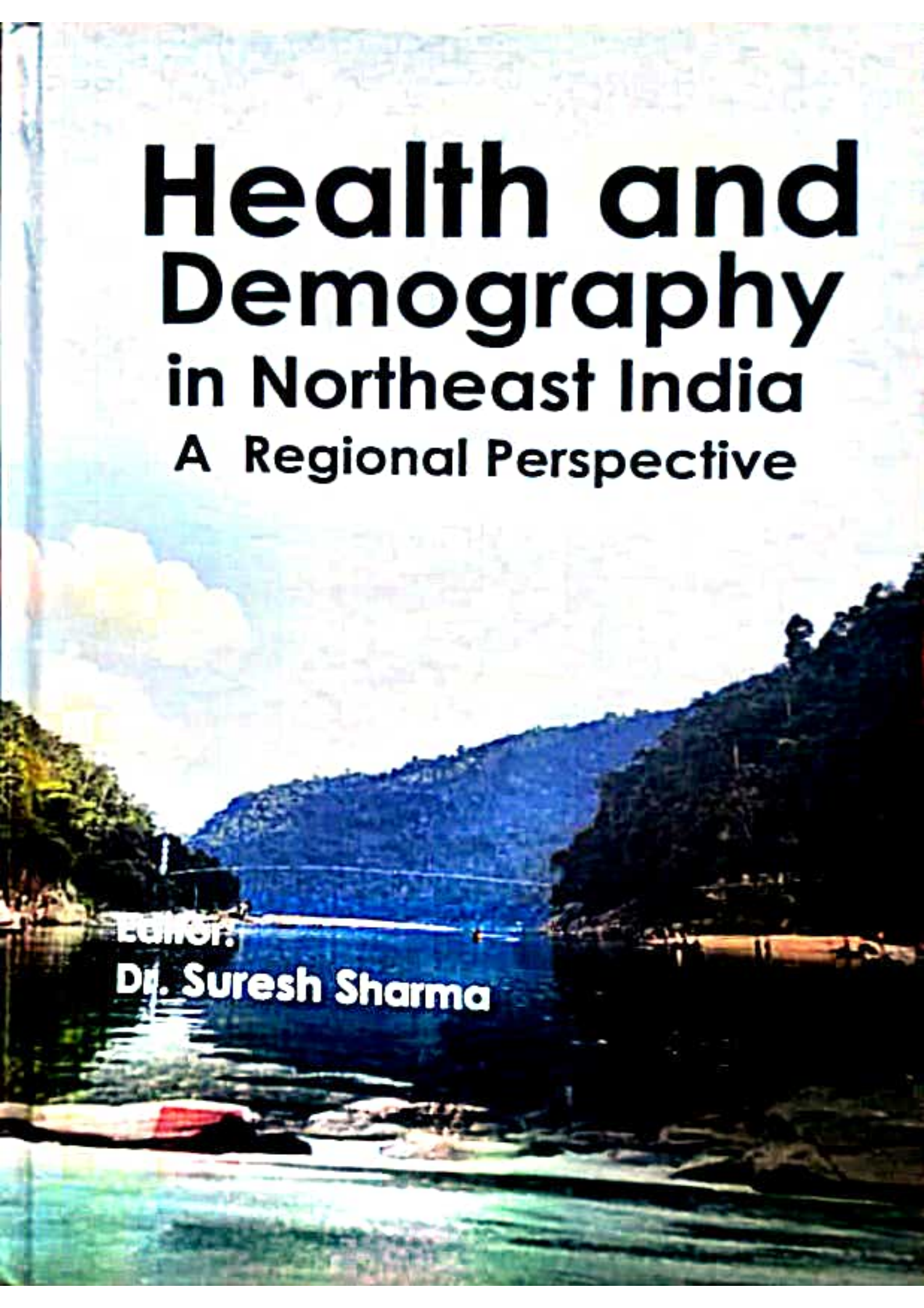
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**Shyamalee Gogoi  
Havobijam Vokendro S  
Dhritiman Sarma**

**Introduction**

After the discovery of the megalithic sites in Arunachal Pradesh in 2010, the department of Anthropology of Rajiv Gandhi University, Rono hills, Itanagar, Arunachal Pradesh started the academic investigation into it from 2015, as the department was started in 2012. At first, the team started the work on the megalithic sites of Western Arunachal in West Kameng district, and eventually it was found that a large number of megalithic sites are there. The only protected site in the area was Lungjukthung megalithic site. This is protected by the Directorate of Research in Arunachal Pradesh.

In Assam history, no written record is found about the tribes of Arunachal Pradesh in detailed manner, but from anthropological



# **Health and Demography in Northeast India**

**A Regional Perspective**

**Editor:**

**Dr. Suresh Sharma**

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## Assessing the Determinants of Infant Mortality among the Tea-Garden Workers of Upper Assam

Kanchan Devi<sup>1</sup>  
Vandana Upadhyay<sup>2</sup>  
Arnob Paul<sup>3</sup>

### Abstract

*Infant mortality rate serves as a crucial indicator reflecting both the health status of infants and the overall well-being of a society. Assam, a North-Eastern state in India, has historically struggled with a high number of maternal and infant deaths. Recent data from NFHS-5 shows a slight improvement in Assam's infant mortality rate, with a decline to 31.9 per thousand live births compared to the national average of 35.2. While this represents an improvement, the state's overall ranking in terms of infant mortality has only moderately improved, moving from the 34th position to the 25th position. Moreover, this improvement is not evenly distributed among the various communities within the state. Notably, human rights violations are particularly pronounced among tea garden workers in Assam, with Adivasi children and women bearing the brunt of these violations, resulting in high maternal and infant mortality rates.*

*This study aims to identify the factors contributing to infant mortality among tea garden workers by analyzing primary data collected from 300 women workers in Sonitpur and Tinsukta districts of Upper Assam.*

*The binary logistic regression method is employed for the analysis. The results indicate that out of the six potential factors considered – mother's educational qualifications, mother's age at marriage, daily working hours, daily wage for tea*

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*garden labor, total number of births, and the source of drinking water—these factors, namely the total number of births, age at marriage, and the source of drinking water, emerge as significant determinants of infant mortality among tea garden laborers in Assam.*

**Keywords:** Infant Mortality, Tea Garden Worker, Women, Assam, Human Rights, Healthcare, Maternal and Infant Mortality.

### **Introduction**

The tea industry is one of the largest private sectors in India that employs around 1.2 million permanent workers and thousands of seasonal employees throughout the country (Mishra, 2012). Out of every 7 organised workers in the country, 1 belongs to the tea industry (Sen, 2015). More than 50 per cent of tea garden workers are females, who mostly belong to lower caste and the Adivasi community. They are fourth generation immigrants brought 150 years ago from the states of Bengal, Bihar, Odisha and Madhya Pradesh<sup>4</sup>. Generational servitude spanning decades have compelled them to being dependent on the tea industry as their only form of livelihood. It is characterised by low wages and has associated barriers, which has pushed them towards the state of exclusion and marginalization.

Assam, the largest tea producing state in India, produces more than half of the total production of tea throughout the country and contributes about 1.6% of the world production of tea. Most of the workers in the tea gardens of the state belong to marginalized sections of Central India. They were brought to Assam in the 1900s by the Britishers. The workers continue to earn wages below the state's minimum wage and about 60 to 70 per cent of them are hired with few or no benefits<sup>5</sup>. Although tea garden workers are found throughout Assam, they are primarily concentrated in the districts of Darrang, Sonitpur, Nagaon, Jorhat, Golaghat, Dibrugarh Cachet, Hailakandi, Karimganj and Tinsukia. The workers live in the villages inside tea estates and are characterised by mass illiteracy, poverty, and alcoholism with poor standard of living<sup>6</sup>. Though the permanent workers in the tea gardens are provided with the facilities to access education and health related services, but the casual workers, which constitute 50 per cent of the total labour force, are left out from such arrangements which leaves them deprived from basic necessities like right to education and health.

The healthcare system in the state is gradually improving but the situation is still pathetic in the tea gardens of Assam. Topno, S (2020) in the article 'The Situation of the Assam Tea Garden Hospitals and Delivery of Reproductive and Child Health Service', a survey which was carried out in Dhekiajuli Block, of

<sup>4</sup> <http://labourbureau.nic.in/NECOWW-Plantation-200809.pdf>

<sup>5</sup> Nazdeek Report, [india.adobe.com/view/aa000ca-8407-4ea0-982e-ca8b3555168a](https://india.adobe.com/view/aa000ca-8407-4ea0-982e-ca8b3555168a).

<sup>6</sup> Status Report on Children and Women in the Tea Gardens of Assam Tea Corporation Limited (ATCL) Submitted by Department of Sociology, Tezpur University, March, 2014.

Sonitpur, Assam tried to understand the conditions of healthcare systems and its responsiveness in Tea Gardens of the selected block. He found that in the tea garden area, the availability of hospitals was little and they were of poor quality in terms of service and resources. The study suggested effective implementation of the policies and programs for monitoring and evaluation of the healthcare services of the tea garden areas in Assam. The Report of Government of Assam (2018) revealed that the health care centers of the tea gardens do not have enough drugs and medical equipments, which increases in the burden of infant and maternal mortality both in a direct or an indirect way<sup>7</sup>. Around 35 per cent hospitals in the tea garden area are operating without a single doctor. The report also claimed that the hospitals of the tea garden area lack skilled human resources in healthcare settings.

It cannot be denied that, different policies and programs introduced for improving the health sector have achieved several turning points, but the results are not satisfactory for some areas which may be seen in the current Infant Mortality Rate (IMR), MMR (Maternal Mortality Rate) and the prevalence of malnutrition in some rural areas. Such a high rate of IMR, MMR and malnutrition in rural areas occurs due to several reasons, viz. dearth of skilled human resources, lack of infrastructure, lack of quality health care services, poor implementation of healthcare services, problem of accessibility of resources and accountability of health services provider. Another reason for poor healthcare outcomes is that tea garden management provides basic facilities only to 60 per cent of the total workers, so a large number of households are left without basic facilities that add to high disease burden and mortality rate<sup>8</sup>.

Many studies on the maternal health and nutritional status at various national and international levels reveal that the nutritional status of the workers in the tea gardens of Assam is poor and anemia, hypertension, malnutrition and diarrhea are some common diseases that contribute to the high infant and maternal death<sup>9</sup>.

There is a sizable demand & supply gap of the healthcare facilities which results in delay in receiving care and treatment. Besides this, lack of awareness over rights and entitlement, lack of effective services, poor quality of treatment, consumption of alcohol jeopardizes the effectiveness of healthcare services in the state.

<sup>7</sup> Government of Assam. Health and Family Welfare, National Health Mission. (2018). *PPP with Tea Garden Hospitals*. Retrieved from <https://nhim.assa.gov.in/schemes/PPP-with-tea-garden-hospitals>.

<sup>8</sup> Study on Contributing Factors of IMR and MMR in Tea Gardens of Assam-2015, Phase-II; Report of 190 tea gardens by Regional Resource Centre for Northeastern States (a branch of NHRSC), Ministry of Health and Family Welfare, Government of India.

<sup>9</sup> Francesca Fergulio End MMNOW No time to Lose: Fighting Maternal and Infant through Community Reporting. Available at <https://www.academia.edu/22797335/EndMMNOW-No-Time-to-Lose-Fighting-Maternal-and-Infant-through-Community-Reporting>.

In Sonitpur district only 21 per cent health facilities have 24-hour delivery service, 39 per cent have labour rooms and 1.7 per cent have the inpatient service system<sup>10</sup>. Rehman (2017) acknowledged the massive challenges and pressure of frontline workers in providing healthcare services to the tea garden workers. Only 37 per cent of married women in Assam use proper family planning compared to the national average of 47 per cent. In Assam, nearly half of the pregnant women in the reproductive age-group are anemic. Reports state that around 90 per cent women being hired in tea gardens are anemic<sup>11</sup>. Anemic mothers are likely to develop infections after the child birth with their babies tending to be smaller in size (Disha Shetty, 2019). Phukan and Mahanta (1998) studied some of the tea gardens of the Dibrugarh district of Upper Assam with the total of 2432 live births and 46 still births. They found that neonatal deaths mostly occurred in infants with no immunization, who were delivered by untrained person and given newborn care at home. The prominent causes for infant deaths were immaturity, fever/sepsis, breathing disorders, neonatal diarrhea etc. Failure to access non-medical services like transportation facility, mass-media, sanitation, clean drinking water, proper security and so on are some important causes of high maternal and infant deaths among the tea gardens. Apart from the problem of undue payments, poor hygiene and overcrowding at hospitals, discriminatory treatment, lack of awareness of the rights, contributes significantly for both infant and maternal mortality rates among the Adivasi community working in the tea gardens<sup>12</sup>. Hazarika et.al, (2017), stated that time has come to find the factors associated with high IMR, MMR and prevalence of anemia among the women of the tea gardens in order to provide appropriate healthcare services in the tea gardens of Assam.

Though the tea industry of Assam is labour oriented, but facilities for the labourers are minimal. Their conditions both social and economic were neglected since the British period and are further deteriorated due to exploitation and negligence. Nevertheless, the reproductive and child health programs have not benefitted these workers which have resulted in poor health status of women and children in the tea gardens which hasn't improved much since (Narain and Kumar, 2016). Though the state has implemented various schemes and programs under (Public-Private-Partnership) and Mobile Medical Unit, under the National Health Mission, but the condition is still not satisfactory. A number of studies conducted in different levels ascertained that tea gardens have been provided a wide variety of services, but haphazard, improper implementation and poor monitoring of the services and schemes, makes those efforts

<sup>10</sup> Rapid Appraisal of National Rural Health Mission Implementation, university of Guwahati, Department of Statistics, Population Research Centre, 2009.

<sup>11</sup> Interview Constructed by Project team with Sonitpur district Health Officials, date Dec 19, 2015.

<sup>12</sup> Francesca Fergulio End MMNOW No time to Lose: Fighting Maternal and Infant through Community Reporting. Available at <https://www.academia.edu/22797335/EndMMNOW-No-Time-to-Lose-Fighting-Maternal-and-Infant-Mortality-through-Community-Reporting>.

unsuccessful. Thus, monitoring and evaluation is essential to enhance the health care system in the tea gardens of Assam.

This paper seeks to determine the factors contributing to Infant Mortality among the Tea Garden Workers in Assam.

### Methodology

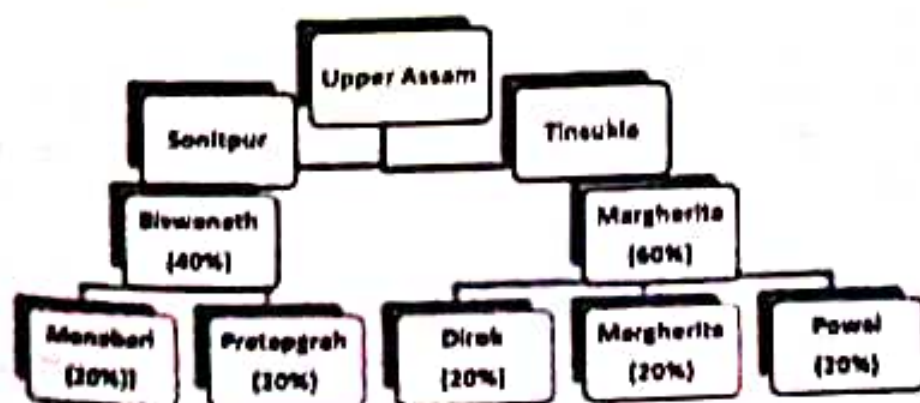
#### Data Source

The study is based on both qualitative and quantitative analysis. This involves, use of observation of household schedules, semi-structured interviews and making the use of both primary and secondary data sources.

The primary sources include household surveys, which focus on parameters of socio-economic conditions and information on child and maternal health. Secondary sources include information collected from various reports of the government, and non-governmental organizations, 2011, census of India, journals and articles.

#### Sampling Procedure

A multistage sampling procedure has been adopted to carry out this descriptive research. In the first stage, Sonitpur and Tinsukia districts were selected purposively as they are districts, having the largest tea estates in Assam. In the Second stage, one sub-division from each district has been selected purposively based on the concentration of tea estates. Thus, the Biswanath sub-division from Sonitpur and Margherita sub-division from Tinsukia have been selected for stage II. At stage III, five tea garden areas have been selected randomly from the study area. Thus, Monabari and Pratapgarh tea estates from Biswanath Subdivision and Dirok, Margherita and Powai tea estates from Margherita sub-division have been selected. Finally, at stage IV, 60 women workers have been randomly selected on a proportionate basis from each tea estate. Thus, a total of 300 workers have been selected randomly from the five tea garden areas from the Sonitpur and Tinsukia district of the upper Assam.



**Fig 1: Sampling Framework**

## Analytical Framework & Statistical tools

### Description of the Variables:

In Table 1, we have given the list of variables which are incorporated in the Model 1. Out of the independent variables the *marriage age* of the respondent, *education* of the respondent, *daily wage* of the respondent and *work hours* of the respondent are continuous variables, whereas, the *source of drinking water* of the respondent is the categorical variable. The dependent variable is the categorical variable which shows whether the mother experienced infant mortality or not; if so then the IR=1 else, it is 0.

Table 1: List of Variables

Variables		Notation	Description and Category		Value Assigned
Independent Variables	Marriage Age	MA	Continuous	In years	—
	Education	EDU		In years	—
	Wage	W		In Rupees	—
	Work Hours	WH		In Hours	—
	Total Birth	TB		In Numbers	—
	Source of Drinking Water	DWS	Discrete	Shared Tubewell	0
		Tubewell		1	
		Well		2	
		Shared Well		3	
		Tap		4	
		Tap Shared		5	
Dependent Variables	Occurrence of Infant Death	ID	No	0	
			Yes	1	

Note: Shared Tube well is the reference variable.

### Logistic Regression:

In this study, the binary logistic regression model was employed. The dependent variable Infant Mortality (IM) is a qualitative variable which can only take the value of either 0 or 1. The value of IM is taken as 0 when the infant death is 0 in a family and the value of IM is taken as 1, if the infant death is more than 0 in a family. Thus, the following model is estimated:

$$P_i = \frac{1}{1 + e^{-z_i}} \dots \dots (1)$$

Where,

$$z_i = \alpha_0 + \alpha_1 MA_i + \alpha_2 W_i + \alpha_3 WH_i + \alpha_4 EDU_i + \sum_{k=1}^9 \alpha_k D_k + \alpha_{10} TB_i + U_i$$

Where,

$Z_i$  = Infant Mortality

$\alpha_0$  = Intercept (Constant)

$MA_i$  = Marriage age of the respondent  $i$ .

$W_i$  = Daily wage of the respondent  $i$ .

$WH_i$  = Daily work hour of the respondent  $i$ .

$EDU_i$  = Years of education of the respondent  $i$

$D_i$  = Source of Drinking water (the shared tube well is the reference variable).

$D_1$  = if the source of drinking water is well then it is 1, else 0

$D_2$  = if the source of drinking water is Shared-tap then it is 1, else 0.

$D_3$  = if the source of drinking water is tap then it is 1, else 0.

$D_4$  = if the source of drinking water is tube well then it is 1, else 0.

$D_5$  = if the source of drinking water is Shared well then it is 1, else 0.

$TB_i$  = Total live births.

## Result & Discussions

### A. Socio-Economic Status of the Sample Worker

Table 1, captures the socio-economic profile of a sample worker. Out of 300 female tea workers 3.9 per cent belonged to the age group (<15) years, 16 per cent belonged to the age group 15-20 years, 20.9 per cent belonged to the age group 21-25 years, 21.2 per cent belonged to the age group 26-30 years of age and 15.5 per cent belonged to the age group of greater than 30 years.

It also shows that 14.5 per cent of the female workers were married before reaching the age of 15 years, 61.6 per cent of workers were married between the age of 15-20 years, 22.6 per cent married at the age of 21-25 years, 0.7 per cent at the age 26-30 years and 0.5 per cent were married after the age of 30 years old.

Regarding Educational Qualification, about 60 per cent of the sample workers had no education (illiterate), 19.3 per cent had educational qualifications up to middle school, 14.0 per cent had basic education and only 1.7 per cent studied up to secondary level.

Regarding status of additional employment, only 26.7 per cent of were found to have additional employment and the rest 73.3 per cent did not have additional employment.

Table 1: Socio-Economic Profile of Study Area

	Criteria	Number of Respondent	Percentage (%)
Age	<15	15	3.9
	15-20	62	16.0
	21-25	81	20.9
	26-30	82	21.2
	>30	60	15.5
Marriage Age	>15	43	14.5
	15-20	183	61.6
	21-25	67	22.6
	26-30	5	0.7
	<30	2	0.5
Educational Qualification	Illiterate	179	59.7
	Basic	42	14.0
	Primary	16	5.3
	Middle	58	19.3
	Secondary	05	1.7
Additional Employment	Yes	80	26.7
	No	220	73.3
Whether Availed Credit	Yes	39	13.0
	No	261	87.0
Status of Bathroom	Own	144	48.0
	Shared	65	21.7
	Open	91	30.3
Whether have Electricity connection	Yes	248	82.7
	No	52	17.3
Source of Drinking Water	Tap	40	13.4
	Well	96	32.0
	Tube well	164	54.6
Infant Mortality status	Occurred	35	11.6
	Not Occurred	265	88.3

Source: Field survey.

### B. Extent of Infant Mortality

The reports of the field survey show that, out of the total i.e., 300 sample female workers, 11.6 per cent workers have experienced infant deaths in the study area. More infant deaths were recorded in Tinsukia district (62.86 per cent) compared to the Sonitpur district (37.14 per cent). Among the tea estates, the highest infant death is occurred in the area nearby to Dirok tea estates (40 per cent) and the lowest in Margherita tea estate (8.57 per cent).

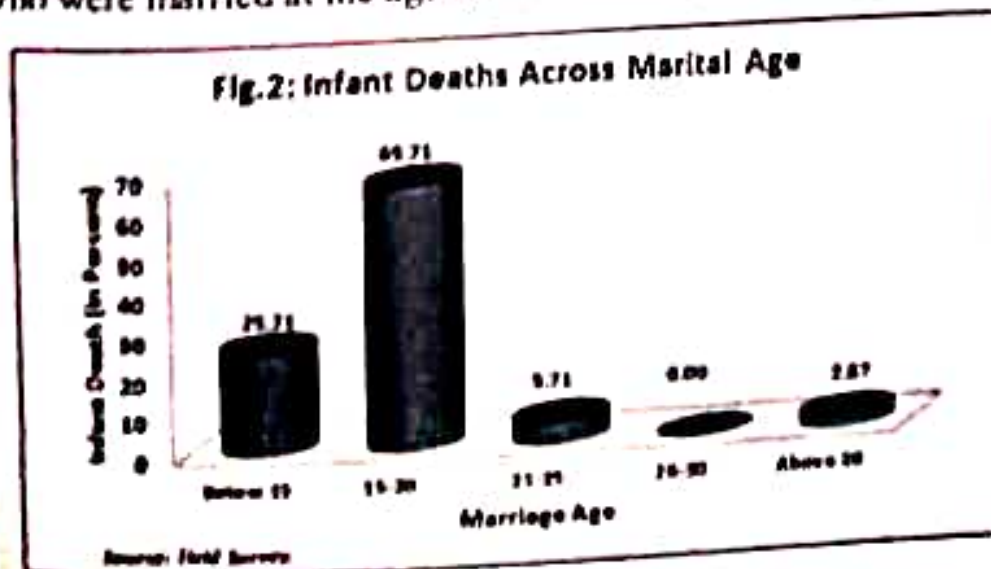
**Table 2:** Extent of Infant Mortality by Districts and Tea Estates

Districts	Tea Garden Area	Infant death as a percent of total infant deaths
Sonitpur	Monabari	25.71
	Pratapgarh	11.43
Tinsukia	Dirok	40.0
	Margherita	8.57
	Powai	14.29

Source: Field survey.

The extent of infant mortality varies at different levels of marital age. It is generally higher for the mother with an early marriage compared to those, who got married at a relatively later age (Hossain et.al. 2022). (Konwar D., et al., 2017).

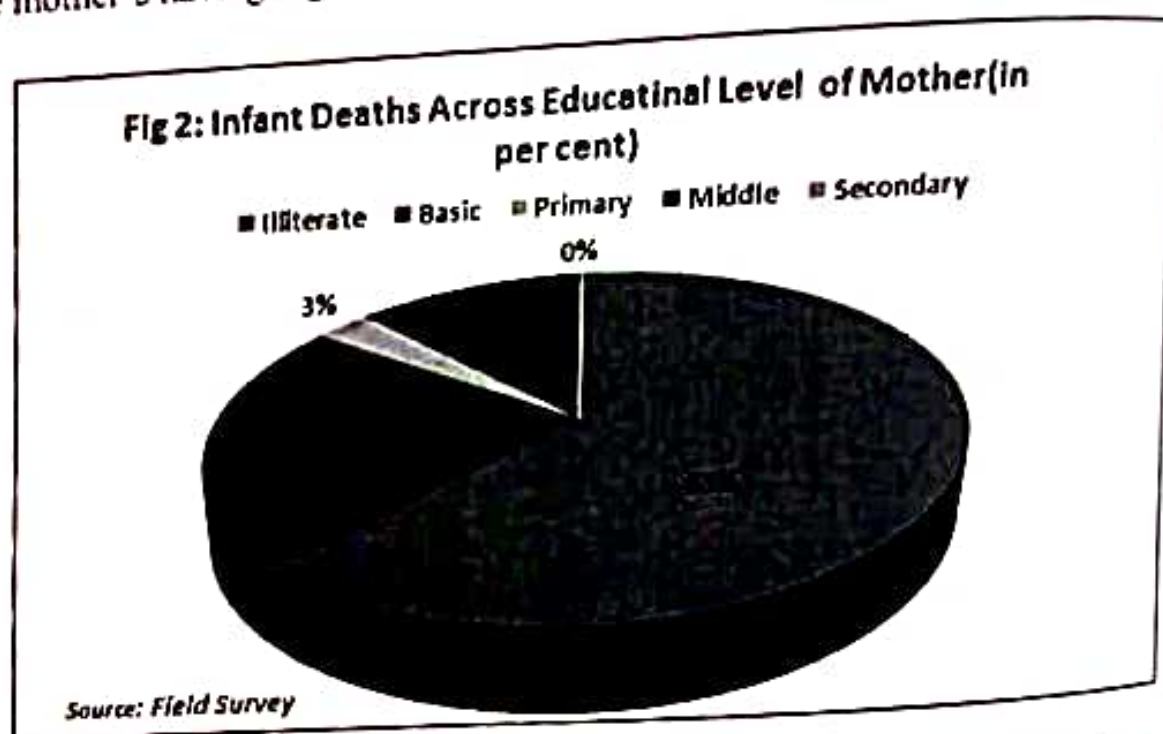
In the study, most of the infant mortality was seen in the women who got married at the age between 15 to 20 years, followed by the age group less than 15 years, and then 21-25 years (Fig.2). Least infant deaths were recorded for women who were married at the age between 26-30 years.



**Fig.2:** Infant Deaths Across Marital Age



Infant mortality also differed across the education level of the mother. Our study corroborated the findings by Keith et al. (2011) in which it was found that high infant mortality was found to be associated with the mother having a lower education and vice versa. In the study area, the highest infant mortality (63 per cent) was found to be of the illiterate mother's, followed by mother's having only basic education (23 per cent). The lowest infant mortality was observed for the mother's having higher education (Fig.3).



**Fig 3: Infant Deaths Across Educational Level of Mother (in per cent)**

### C. Determinants of Infant Mortality among Tea Garden Workers

In the Table 4 the result of the logit regression model is presented

**Table 4: Estimated coefficients of the model**

Variables	Coefficient
Intercept	-3.92**
MA	-0.74**
EDU	-0.03
W	0.003
WH	-0.03
D1	-0.05
D2	1.57
D3	1.32
D4	0.92

Variables	Coefficient
D5	1.00**
TB	0.86***
<b>Model Summary</b>	
Nagelkerke pseudo R <sup>2</sup>	0.28
Cox and Snell R <sup>2</sup>	.15
Dependent Variable: Infant Mortality	
NOTES: *** denotes statistically significant at 0.01 level. ** denotes statistically significant at 0.05 level	

These results show that the explanatory variable Marriage Age of the respondent (MA) and D5 (shared tube well) as a source of drinking water are significant at a 5 per cent level and total Birth (TB) is significant at a 1 per cent level. The negative and significant value of the MA indicates that as the marriage age of the respondent increases, the probability of occurrence of infant mortality is decreases. It is because lower marriage age induces teenage pregnancies. This is consistent with the findings of Hossain et.al. 2022, that babies born to very young mothers are more likely at a risk of infant mortality. The positive and significant value of TB signifies that as the number of births of a mother increase, the probability of infant mortality also increases. This is because as the number of total births increases, she (the mother) gets lesser and lesser time to take care of the infant, which increases the risk of infant mortality. Lastly, the significant and negative value of the D5 variable indicates that the respondent using the shared well as a source of drinking water is more likely to get a case of infant mortality compared to other categories. This is because; the quality of water in most of the tea gardens in Assam is not satisfactory at all. Most of the tea garden workers in Assam use tube wells as a source of drinking water which is used on a shared basis due to the scarcity of sufficient water facilities in the tea garden areas. (Sahoo, D., Konwar, K., and Sahoo, B.K., 2011). Tube wells of the tea garden areas are contaminated with cadmium, manganese, zinc and copper which increases the health risk in the tea gardens of Assam (Borah et.al. 2018) and (Dutta, J., Chetia, M., and Misra, 2011).

### Conclusion

The study found that out of 300 sample tea garden workers 11.6 per cent have reported the occurrence of infant mortality. Here, we have employed a binary logistic model to find out the determinants of infant mortality among the tea garden workers.

The result shows that the marriage age of the respondent, total number of births by the respondent and shared tube-well as a source of drinking water

significant determinants of infant mortality in the tea gardens of Assam. To sum up, the following findings and suggestions are given:

1. In our study, more than 60 per cent of infant deaths were found in the Tinsukia district. It shows that infant death registration was more prevalent in the Tinsukia district than Sonitpur district. It is suggested to maintain stringent records of the birth and death registration system properly in the tea garden areas of the Sonitpur district.
2. The survey report also shows that more than 90 per cent of infant deaths were recorded among mothers, whose marriage age was 20 or below 20 years. This is primarily due to a lack of awareness and education among the tea garden workers. So, it is suggested to implement strict laws to prevent early marriages in the tea garden areas of Assam.
3. More than 60 per cent of infant mortality occurred in the mothers, who are illiterate, and no infant mortality was found for the mothers with higher education levels. Hence, it is suggested to increase the literacy rate in tea gardens to reduce infant mortality.
4. It is found that the marriage age of the respondent, total births that occurred for the respondent and the usage of shared-well as the source of drinking water are more likely to be associated with the occurrence of infant mortality among the tea garden workers in Assam. Thus, the study suggested effective implementation of some laws to reduce child marriage and spread awareness about the risks of teenage pregnancies in Assam. The importance of family planning for better health and wealth should also spread and taught in the tea gardens of Assam to reduce the health risk of the subsequent child by reducing family size. Further, the study also suggests the improvement of the ground water quality and making sufficient water facilities in the tea gardens in Assam.

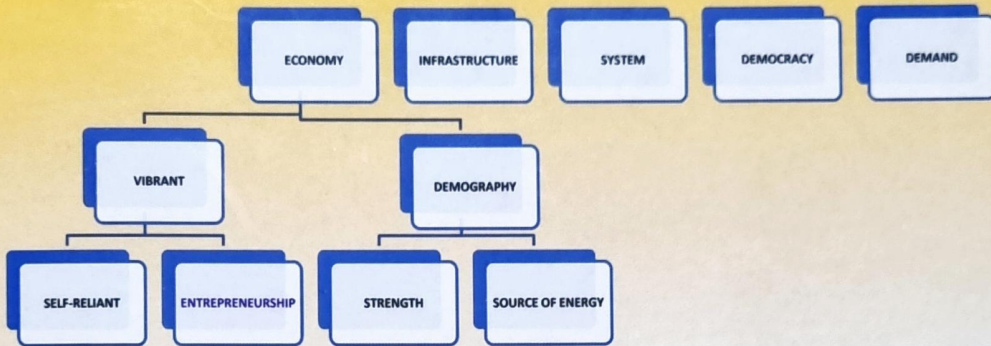
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**PROCEEDING OF THE NATIONAL SEMINAR  
ON  
AATMANIRBHAR BHARAT ABHIYAN AND NORTH EAST INDIA  
3<sup>rd</sup> and 4<sup>th</sup> March, 2023**

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Anil Tanti

Dr. Rama Chandra Parida

**Abstract**

Prime Minister Narendra Modi invented a slogan; "Sabka Saath, Sabka Vikas, Sabka Vishwas and Sabka Prayas" is important motto to make the nation Atmanirbhar Bharat. Atmanirbhar Bharat is regarded as the root to build a self-sufficient and strong India. So, both central government and state government of Assam have shown interest and given special priority to the women entrepreneurs also who are engaged in self help groups. The governments have incorporated policy measures to promote a culture of improvement of entrepreneurship in the country to alleviate increasing unemployment issues and it can be solved through entrepreneurship development. It is known that without women development and empowerment half of the population of India will remain backward and the dream of Atmanirbhar Bharat will not be possible for the nation. This paper has focussed on Atmanirbhar Bharat Abhiyaan for women empowerment through Self-help groups. The prime objectives of this paper to analyse the role of government towards self help groups for making women empowerment and the economic status of self help groups among tea tribes in Sivasagar district. The research study will discuss the initiatives have taken by the government for women self help groups under National Rural Livelihood Mission. Further, it will analyse the economic factors of the members of the self help groups.

**Key words:** Self-sufficient, policy, unemployment, empowerment, economic

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**Women Empowerment for Atmanirbhar Bharat: A Study of Self Help Groups among Tea Tribes of Sivasagar District in Assam**

**INTRODUCTION:**

The term Atmanirbhar Bharat is known in English phase as 'self-reliant' which was used by Prime Minister Narendra Modi in relation to promote economic development of the nation during Covid crisis in 2020. For hoping speed growth and recovery of Indian economy, he announced Rs. 20 lakh crore which is equivalent to about 10% of the country's GDP. Government has taken several initiatives to make popular the ANB. So, it may be thought that women also will be benefited through this scheme because 50% population of our country belongs to women. Nobody deny of their significant contribution towards the society. They play vital role at different period of time in different fields like family, save the dignity of women, freedom struggle, uplifting education, economic empowerment, art, and culture, sports, medicine, science, technology, research and development, politics, journalism and fighting against evils in the society etc. Therefore, we can't expect and ensure of sound economic development of the nation without paying proper attention and development of women. It has been observed that many women or groups of women are engaged in entrepreneurial activities through self help groups to get economic strength and stand. Situation also is demanding that all the occupations must be opened for women irrespective of time but with safeguard to be Atmanirbhar. They need special care, financial assistance, motivation and skills for making beautiful world through empowerment and development.

**OBJECTIVE OF STUDY:**

1. To study the economic status of self help groups among tea tribes in Sivasagar district.
2. To study the role of government towards self help groups for making women empowerment.

**RESEARCH METHODOLOGY:**

The study is based on both primary and secondary data. The primary data were collected from the respondents of self help groups through face to face schedule interview. The secondary data has taken from various research papers, journals; articles and studied in Google search drive. The study involves women entrepreneurs' related article- government websites for observing the present data of women entrepreneurship in the nation. The data are designed, tabulated and analysed to have useful information. The first objective is confined in three different blocks Nazira, Amguri and Demow in Sivassagar district and the second objective is based on secondary data which is discussed the different initiatives and measures have taken by government for women empowerment and development.

The first objective highlighted the demographic, occupation, land ownership, monthly income and monthly saving.

**Table -1 Distribution of Respondents of SHG by block wise according to Socio economic Profile (N=340)**

SL.NO	VERIABLE	NAZIRA		DEMOW		AMGURI		Total		
		Frequency	%	Frequency	%	Frequency	%	Frequency	%	
1	AGE	Below 20	1	.5	1	.8	0	.0	2	.6
		21 - 30	44	23.2	18	15.0	15	50.0	77	22.6
		31 - 40	50	26.3	38	31.7	4	13.3	92	27.1
		41 - 50	11	5.8	12	10.0	5	16.7	28	8.2
		51 - 60	84	44.2	49	40.8	6	20.0	139	40.9
		Above 60	0	.0	2	1.7	0	.0	2	.6
		Total	190	100.0	120	100.0	30	100.0	340	100.0
		Married	180	94.7	115	95.8	28	93.3	323	95.1
		Widow	2	1.1	3	2.5	0	.0	5	1.5
		Unmarried	8	4.2	2	1.7	2	6.7	12	3.5
2	MARITAL STATUS	Separated	0	.0	0	.0	0	.0	0	.0
		Divorced	0	.0	0	.0	0	.0	0	.0
		Total	190	100.0	120	100.0	30	100.0	340	100.0

SL.NO	VERIABLE	NAZIRA		DEMOW		AMGURI		Total		
		Frequency	%	Frequency	%	Frequency	%	Frequency	%	
3	FAMILY SIZE	Single member	0	.0	0	.0	0	.0	0	.0
		2 members	10	5.3	3	2.5	0	.0	13	3.8
		3 members	36	18.9	22	18.3	6	20.0	64	18.8
		4 members	70	36.8	38	31.7	6	20.0	114	33.5
		5 members	60	31.6	35	29.2	4	13.3	99	29.1
		Above 5 members	14	7.4	22	18.3	10	33.3	46	13.5
		Total	190	100.0	120	100.0	30	100.0	340	100.0
		Pucca	117	61.6	74	61.7	1	3.3	192	56.5
		Semi-pucca	42	22.1	24	20.0	29	96.7	95	27.9
		RCC	29	15.3	21	17.5	0	.0	50	14.7
4	TYPES	Total	2	1.1	1	.8	0	.0	3	.9
		Illiterate	190	100.0	120	100.0	30	100.0	340	100.0
		Below V	46	24.2	32	26.7	19	63.3	97	28.5
		V - VIII	37	19.5	17	14.2	1	3.3	55	16.2
		IX - X	35	18.4	17	14.2	1	3.3	53	15.6
		XI - XII	50	26.3	23	19.2	7	23.3	80	23.5
		Graduate	16	8.4	23	19.2	1	3.3	40	11.8
		PG	6	3.2	7	5.8	1	3.3	14	4.1
		Total	0	.0	1	.8	0	.0	1	.3
		Primary:	190	100.0	120	100.0	30	100.0	340	100.0
		Business	38	20.0	10	8.3	4	13.3	52	15.3
		Tea Garden Worker	71	37.4	48	40.0	16	53.3	135	39.7
		Day rated worker	35	18.4	35	29.2	7	23.3	77	22.6
		Agriculture	5	2.6	1	.8	0	.0	6	1.8
		Agricultural labour	0	.0	0	.0	0	.0	0	.0
Housewife	38	20.0	26	21.7	3	10.0	67	19.7		
Nurse	1	.5	0	.0	0	.0	1	.3		
Others (1 Jibika Sakhi, 1 Pashu Sakhi)	2	1.1	0	.0	0	.0	2	.6		
Total	190	100.0	120	100.0	30	100.0	340	100.0		
Secondary:	2	1.1	2	1.7	0	.0	4	1.2		
Business	33	17.4	14	11.7	2	6.7	49	14.4		
Tea garden worker - Temporary	42	22.1	18	15.0	12	40.0	72	21.2		
Day rated worker	69	36.3	60	50.0	10	33.3	139	40.4		
Agriculture	0	.0	0	.0	0	.0	0	.0		
Agricultural labour	30	15.8	22	18.3	4	13.3	56	16.5		
Housewife	0	.0	0	.0	0	.0	0	.0		
Nurse	0	.0	0	.0	0	.0	0	.0		
Others (1 Jibika Sakhi, 1 Pashu Sakhi)	14	7.4	4	3.3	2	6.7	20	5.9		
Total	190	100.0	120	100.0	30	100.0	340	100.0		
Own land	23	12.1	27	22.5	1	3.3	51	15.0		
Agricultural land	1	.5	0	.0	0	.0	1	.3		
Industrial land	87	45.8	35	29.2	10	33.3	132	38.8		
Ceiling surplus land	2	1.1	3	2.5	1	3.3	6	1.8		
Govt land	1	.5	5	4.2	0	.0	6	1.8		
Land less	76	40.0	50	41.7	18	60.0	144	42.4		
Total	190	100.0	120	100.0	30	100.0	340	100.0		

**Source: Primary Data**

the awareness and requirements. It is apparent from Table 1 that the majority of respondents and prospects. It is apparent from the age group 51-60 years followed by age group between 40-9% were between the age group 27-31%. It indicates that the old age group is 31-40 years which is constituted of financial benefit so that they can engaged in self help groups for hoping of expenditure of the family. On the other hand, support their family and meet the expenditure of the family. The other hand, young group are engaged in self help group to employ themselves because of their unemployment.

**Marital status:** From the table- 1, it is found that the majority 95% of the respondents of the self help groups is married while 3.5% respondents are unmarried and widow just 1.5%. It is good sign that there is no separated and divorce are found among the women of tea tribes. Such type of ill practices is not found among them. It indicates that majority of the married respondents are middle aged.

**Family size:** The table - 1 showed the size of family members of 340 respondents of self help groups which are analysed on the basis of number of family members. The above table indicates that there is no single member family. The family belonged of four members 33.5% while the two member's family is placed 5%. Further it is found that five members' family 29.1% whereas above five members just only 13.5%.

**Types of houses:** The table -1 revealed that the majority of respondents 56.5% lived in Kacha houses which is made of thatch and bamboos while the rest of the respondents 27.9% lived in Pucca houses, 14.7% in Semi-Pucca houses and only .9% in R.C.C type of houses. The evidence of Kacha houses showed the respondents' poor financial background.

**Education:** It was detected from the table - 1 that 71.5% respondents were illiterate while 28.5% were literate. The education level of the respondents showed that 16.2% below class five, 15.6% between five to eight standards elementary stage, 35.3% between class nine to twelve standards, 41% graduate and just only .3% in post graduate level have received the education. It revealed that 94.6% respondents' educations were below secondary and only 4.4% had received the higher education of graduate and post graduate.

the education and eagerness to come forward to see the beautiful world. **Occupation:** The occupation of the respondents has divided into two parts as primary and secondary of the self help groups who are engaged in multi tasks which stated above table - 2. 15.3% respondents are involved in petty shops termed as business, 39.7% respondents are working in tea garden as tea garden labour, 22.6% are day rated workers and 1.8% are busy in agriculture, 19.7% are housewives. But there were not found agriculture labour, only .3% was respondents explained secondary occupation as 2% in small business, 33% temporary tea garden labour, 42% day rated worker, 69% petty agriculture, 0% agriculture labour, 30% housewife, 14% no secondary occupation, there was not found Jeebika sakhi or Pasu sakhi and nurses, 33% **Land Ownership:** From table - 1, it was shown that 15% women of SHG respondents had land ownership, 3% agriculture land, 38.8% industrial land, 1.8% ceiling surplus land, 1.8% government land and 42.4% were have no land who were landless respondents. The respondents who were lived in the industrial land they were not the actual land owner. The owner of this land was the tea company. The total landless among the respondents 81.2% where was included industrial land. The respondents deprived from bank loan to grow their businesses due to lack of land holding certificate.

**Table no. 2 Distribution of Monthly Income:**

Monthly Income	Naitra		Demow		Amguri		Total	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Less than 5000	177	93.2	117	97.5	30	100.0	324	95.3
5000 - 10000	9	4.7	2	1.7	0	0	11	3.2
10000 - 20000	4	2.1	1	.8	0	0	5	1.5
Above 20000	0	.0	0	0	0	0	0	.0
Total	190	100.0	120	100.0	30	100.0	340	100.0

The table no. -2 narrates the monthly income of the respondents from self help group activities which was shown that 95.3% respondents' income is less than

Rs. 5000, 3.2% respondents' income between Rs. 10000 to Rs. 20000 and there was not found respondents' income among the respondents above Rs. 20000. Majority of the income group below Rs. 5000 which is insignificant. respondents' income of tea tribes is insignificant. entrepreneurs among women of tea tribes is insignificant.

**Table no. 3 - Distribution of Monthly Saving:**

Monthly Saving	Narain		Demow		Amgurt		Total	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
No savings	5	2.6	12	10.0	0	.0	17	5.0
<500	164	86.3	104	86.7	30	100.0	298	87.8
500 - 1000	6	3.2	3	2.5	0	.0	9	2.6
1000 - 1500	15	7.9	0	.0	0	.0	15	4.4
Above 1500	0	0	1	.8	0	.0	1	.3
Total	190	100.0	120	100.0	30	100.0	340	100.0

The table no.-3 represented that saving position of the respondents of the self help groups where found that 5.0% have no saving, 87.6% have less than Rs.500, 2.6% between Rs.500 to Rs.1000, 4.4% between Rs. 1000 to Rs.1500 and .3% respondents have only above Rs. 1500. It is observed that the saving condition of the respondents is very low and poor and their income is not enough for saving.

With the objective of women economic development and empowerment through entrepreneurship government has taken several initiatives for capacity building and training arrangements. Further, government has acted significant contribution by providing various services towards women as given below

- ❖ Prime Minister Shri Narendra Modi interacted with members and community resource persons of women Self Help Groups (SHG) through Atmanirbhar Narishakti se Samvad to promote entrepreneurial activities of the women under the Deendayal Antyodaya Yojana-National Rural Livelihoods Mission (DAY-NRLM).
- ❖ The Prime Minister also released funds Rs. 1625 crore for capitalization support to over 4 lakh Self Help Groups

addition, Rs. 25 crore were provided to SHGs as seed money for 7500 SHG members under the Prime Minister Formalisation of Micro Food Processing Enterprises (PMFME) under the Scheme of Ministry of Food Processing Industries and Rs. 4.13 crore as funds to 75 Farmer Producer Organizations (FPOs). Government has opened more than 42 crore Jan Dhan accounts of which close to 55% of the accounts are of women. That will be helpful for women self help groups to get easy loans from banks.

- ❖ Central government provided unsecured loan of about Rs.4 lakh crore to self-help groups. There was a time when bank loans close to 9% per annum but now it has come down to 2-3 % to encourage the women of the Self Help Group.
- ❖ The central government made the limit for loans available without guarantee to the self help groups to Rs 20 lakh.
- ❖ Deendayal Antyodaya Yojana - National Rural Livelihoods Mission (DAY-NRLM) has its footprints in 6861 blocks of 723 districts across all States and UTs (except Delhi and Chandigarh) under its implementation strategy. It has mobilised a total of 8.71 Crore women from poor and vulnerable communities into 81 lakhs SHGs

**Capacity Building:** Continuous and intensive capacity building and training of SHG members is an important feature of DAY-NRLM. As part of capacity building, pre-NRLM institutions of the poor are also identified and strengthened. Apart from SHGs, the Mission also provides for capacity building and training of federations of SHGs at all levels. Integral to capacity building is identification and training of CRPs, Activists, Animators, Book-keepers, Para-professionals who would in turn, take up sustained capacity building of SHGs and the federations and provide other types of community-based support. A significant feature of the Mission is that the entire professional support cost incurred at the block and sub block level for social mobilization and institution capacity building is treated as eligible programme expenditure.

Services Rendered by Assam government... taken various initiatives to provide, training, financial facilities, entrepreneurship development programs and schemes to SHGs/VOs/CLFs, members and leaders of entrepreneurship which are mentioned below:

**1. Trainings:** Trainings to SHGs/VOs/CLFs, members and leaders of SHGs/VOs/CLFs, Community Cadres under Social Mobilisation, SHGs/VOs/CLFs, Community Building,:

Institution Building & Capacity Building:  
The target group are the members of SHGs/VOs/CLFs

- a. Criteria for labelling SHGs as "NRLM Compliant
- b. SHGs should have membership from at least 70% BPL families
- c. SHGs have members from households identified as poor
- d. through the P.L.P process conducted by NGOs/ Line departments subjected to the P.L.P list being vetted by the Gram Sabha and approved by the Gram Panchayat

- e. SHGs practicing 'Panchasutra' (Regular meetings; Regular savings; regular inter-lending; Timely repayment; and Up-to-date books of accounts )

**2. Grant of Revolving Fund (RF) to SHGs:**

a. Grading is done after the SHG becomes 2 months old and have a SB A/c.

b. RF to eligible SHGs of Rs.10, 000-15,000 as coprus, to meet the members' credit needs directly and as catalytic capital for leveraging repeat bank finance.

c. RF is given to SHGs that have been practicing 'Panchasutra'

**3. Community Investment Fund (CIF) support to SHGs/VOs:** CIF as Seed Capital to SHG Federations; to meet the credit needs of the members through the SHGs/VOs as per Micro Credit Plan (MCP) prepared by the SHGs, and also to meet the working capital needs of the collective activities at various levels.

**4. Village Organization (VO) Start Up cost:** The start-up costs provided to the eligible VOs for initial operational cost required for setting up VO office. An amount of Rs.25000 only per VO is given as Start Up cost.

**5. Credit Linkage Facilitation:** As and when the SHG becomes 6 months old, ASRLMS facilitates eligible SHGs for credit linkage in multiple doses. Services of community cadre like Bank Mitra/Sakhi are leveraged. Further, community-based recovery mechanisms (sub-committees on bank linkage and recovery of loans) are established for ensuring timely recovery.

**6. RSETI Facilitation:** Rural Self Employment Training Institutes (RSETI) are managed by Banks with active co-operation from the Government of India and State Government. Livelihood Mission (ASRLM) coordinates with Ministry of Rural Development (MoRD) for fund settlement of RSETIs. ASRLMS facilitates enrolment of NRLM Compliant SHGs in various skill based training programmes conducted by RSETIs.

**Conclusion:**

From the above discussion it is known that both state government of Assam and central government have taken remedial measures through introducing several plan, policies and schemes for women entrepreneurship development. To promote women empowerment in entrepreneurship government provides training to enhance entrepreneurial skill and efficiency grants, made bank linkage and awareness programme among women entrepreneurs. The government of Assam has formed and established various agencies and institutions to assist women entrepreneurs and self help groups With the help of these facilities women entrepreneurs can solve their problem of financing and management of their business enterprises.

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## ECO-TOURISM AND SIVASAGAR: PROSPECTS AND PROBLEMS

Dr. Meghali Bora

Mrs. Nomami Dutta

### Abstract

The idea of tourism holds enormous potential for sustainable development. The tourism industry is one of the fastest growing industries around the globe. Many new concepts have come up to this industry like eco-tourism, adventure tourism, religious tourism, medical tourism, and cultural tourism. Eco tourism also called as nature tourism is the most significant segment of tourism as it reconciles the idea of conservation with ecological development by improving the well-being of the local people.

The district of Sivasagar, a prominent heritage site of Assam, has huge potential for eco-tourism development due to its rich biodiversity, unusual cultural and ethnic diversity and untapped natural beauty. With government's 'Amanirbhar Bharat' eco-tourism gained importance as a pillar of growth in NE Region including Sivasagar district.

The current paper provides a description of eco-tourism. The main goal is to highlight the eco-tourism opportunities and difficulties in the district of Sivasagar.

**Keywords:** Atma Nirbhar Bharat, Eco Tourism, Sivasagar, Sustainable Development

# Witchcraft Practices in the Plantations of Upper Assam: A Case of the Santhals

OLYMPIA KURMI AND  
SARAH HILALY

## INTRODUCTION

The indigenous societies in India can be categorized on the basis of their habitat, their belief systems and the level of their encounters with organized religion. There are very few societies where indigenous practices are not mediated by the organized religion. In the north-east, three of the hill states have Christianity as the core of the belief system with layers of indigenous traditions subsumed within it, while one state has an indigenous belief system competing with Christianity. The indigenous communities of western and central India have been incorporated within the fold of Hinduism. While some of their deities have been subsumed within the Hindu pantheon, a substantial layer of indigenous beliefs remain at its core. This dimension is apparent in the religious practices of the santhals and important indigenous communities of those who inhabit the colonial regions of Chota Nagpur, particularly the space of the Santhal Parganas. The Santhals are one of the groups of Austro-Asiatics inhabiting the central and eastern part of India in the State of Jharkhand. Other cognate tribes belonging to this group are the Mundas, Hos, Kharias, Savaras (inhabit Orissa and Andhra Pradesh) and also the hunter-gatherers Birhors. Their origin and migration stories allude to their journey from Yunnan through the north-east of

India to their present location. The entire group were united as Kherwars, before they separated into individual tribes.<sup>1</sup> In terms of livelihood, the Birhors were hunter gatherers, while the other Austro-Asiatic tribes were all agriculturists incorporating a supplementary activity of gathering wild food. As regards specific forms of agricultural evolution, the Mundas farm terraced fields, carrying out wet-rice cultivation, while the Santhals practised the slash and burn or swidden agriculture of neolithic lineage. They are well-known for their expertise in clearing forest and turning it into arable land.<sup>2</sup>

The Santhals have been incorporated into the dominant Hindu society and the norms of social stratification. Their production system has also shifted away from community ownership of land and forest, yet some vestiges of it still remain. Their belief system rests on the belief that all diseases to both men and animals are attributed to either the wrath of evil spirits to be appeased or the spell of some witch or sorcerer, who should be destroyed or driven out of the land. They have a different set of rituals for the village collectively and for the family. In this space, only men can relate to the family spirits through prayer and partake of the sacrificed animal. Women are completely excluded from participating both in family and village rituals. They are not permitted access to the family spirits, nor are woman permitted to enter the inner shrine. They can neither sacrifice nor witness the process. The family spirits (*abge bonga* and *orak bonga*) of the clan and the family are passed on from father to son. The ritual specialists too are men.<sup>3</sup> Such a marginal position of woman is contingent to their not being ritually assigned full membership of the clan. Entry into the sacred groves are prohibited as also in the main dance of the agricultural festival.<sup>4</sup>

Within the Santhali cosmology, centrality is accorded to their belief in *dayans/dans/churails* (witches) or *bongas* (spirits) 'There is no genuine Santal', wrote Bodding, 'who does not believe in witches' (1986: 38).<sup>5</sup> This is posited within the belief that human beings can be intimate with and control evil spirits. Both men and woman can within this system bring harm and even kill their kin, as well as their fellow villagers. As women are ritually inferior in the society, any visible sign of them being in close contact with the *bongas*



would be treated as a witch and persecuted. Ritual specialists belonging to certain Hindu castes would generally play the role of an exorciser, which is a pointer to the hybrid cultural evolution, which renders women marginalized and the sole gender identified as keeper of evil. It is to be noted at this point of the discourse that neither the Santhal, nor the Bhil have words for 'witch' in their own languages.<sup>6</sup>

The Santhal myth of the origin of witchcraft ascribes it to the struggle between the genders, and in Santhal society as a whole. According to a version in circulation, is that the women came to know that the men had approached Maran Buru to teach them something. The women got the men drunk, dressed up in their attire and tricked Maran Buru into teaching them. Maran Buru then taught them the incantations and gave them the power of eating men. The next day when the men came, Maran Buru realized that he had been tricked by the women. He then made the men 'expert in the art of witch-finding'.<sup>7</sup> So this myth introduces the idea of trickery, which gives the woman power that draws one into the idea of illegitimate knowledge which they actually have no access to. The entitlement of men to such knowledge renders their authority supreme. Hunting witches, therefore, is a process of re-establishing social order with men at the centre of it. Women are denied access to priesthood, as it is presumed that they would turn to witches and misuse power.<sup>8</sup> The threat of being declared a witch and persecuted is thought to be a deterrent to non-conformist or deviance from established norms. It is during occasions of social crises in terms of epidemics or social tensions, due to conflicts that woman in the villages are targeted, persecuted inhumanly and even killed. Particularly, the life interest of widows in their husbands land is one of the key causes of persecution. This is because many Santhal woman can gather and sell forest produce and have exclusive rights over their income. This narrative has provided a background of the Santhal social milieu in their native habitat and their cultural evolution.

This article deals with the Santhals who have been uprooted from their traditional habitat, displaced and traumatized under conditions of colonial rule. The universe of study would be the Santhals

who live within and outside the plantations of Assam, where they were brought in as indentured labour along with other groups from eastern and central India. In addition, it was the Santhal experiment of 1880, which encouraged their movement into the forest villages of Goalpara for extraction of timber. Living in a milieu uprooted from their habitat, they continue to follow many aspects of their traditional culture.

#### THE HABITAT AND PEOPLE

The State of Assam lies between 22° 19' north to 28° 16' north latitudes and 89° 42' east and 97° 12' east longitudes. Falling under three natural divisions, it comprises of the two river valleys of the Brahmaputra and the Barak. The intervening range of the North Cachar and Karbi Hills separate the two valleys. On its north it is girdled by the Himalayan state of Arunachal Pradesh, home to a multitude of tribes. On its east lies, Nagaland, Manipur with Mizoram and Tripura to its south. Its demography is characterized by tribes living, both in the hills and plains and castes speaking both in Bengali and Assamese languages.

In the medieval period, the states of the Ahoms and Dimasas existed as distinct spaces within the geography of Assam. The current territoriality of Assam is the result of colonial intervention. With the advent of the British in 1826, in the aftermath of the First Anglo-Burmese War, the state under the Ahoms passed to British occupation. After a lapse of two years in 1828, the administrative division of Lower Assam (Kamrup Darrang and Goalpara districts) was annexed to the colonial state. Upper Assam (Sibsagar and Lakhimpur districts) was restored to the Ahom ruler Purander Singha. In 1838, Upper Assam was resumed and annexed to British territory on grounds of mis-governance. The latent cause was, however, the fateful discovery of tea and its successful manufacture in 1837.

Consequent to the manufacture of tea in 1836, the Government of Bengal approved the scheme and gave Assam, the first set of wasteland rules. The wasteland rules were revised in 1854. These rules permitted only Europeans to avail such concessions instituted Assam's plantation regime. This industry was labour intensive and

hence there had to be a constant supply of labour. The myth of the Chinese as the 'ideal tea-grower', led the British to induce their migration into the plantations till 1843. Then, the tea plantations came to be served by local inhabitants mainly Kacharis and Nagas. Resistance from these populations to intensive work and the expansion of the plantation industry resulted in a demand for labour.

From 1859 onwards, labourers from central and eastern Indian highlands and forests were imported for the tea plantations in large numbers. These indentured labour were brought in and regulated through the labour acts. The first Labour Act was passed in 1863, seeking to regulate the transport of labourers emigrating to Assam Valley, as well as their recruitment through *arkattis* (licensed recruiters). An Amendment Act of 1870 in the form of the *sardari* system of recruitment was also recognized. According to the Bengal Administrative Report for 1867-8, 22,800 were imported labourers and only 11,633 were local labourers. By 1880s, immigration of plantation labourers took place on an extensive scale.

The designation 'Upper Assam' was an administrative division in colonial Assam comprising of the undivided Lakhimpur and Sibsagar districts in the upper reaches of the Brahmaputra Valley. The other divisions are: Lower Assam, North Assam and Hills and Barak Valley. The division is under the jurisdiction of a Commissioner, stationed at Jorhat. In the aftermath of India's Independence, districts falling under Upper Assam are Dhemaji, Dibrugarh, Lakhimpur, Golaghat, Jorhat, Sibsagar and Tinsukia. An extended list of the region also includes the districts of Sonitpur, Karbi Anglong & Nagaon. The Upper Assam region is the most productive region in the state, which is rich in natural resources like coal, oil and natural gas as well as tea plantations.

The tea labour communities, constitute the oldest amongst Assam's immigrant groups. They were recruited by the British tea planters from present-day Jharkhand, Chhattisgarh, Bihar, Andhra Pradesh, Orissa, Uttar Pradesh and West Bengal, between 1861 until the early twentieth century, to work as indentured labourers in tea plantations in Assam, spread over the districts of western Assam, Morigaon, Nagaon, Sonitpur and Darrang in middle Assam, Golaghat, Jorhat, Sibsagar, Dibrugarh and Tinsukhia in eastern or upper

Assam, North Cachar and Karbi Anglong districts in southern Assam and the Barak Valley. Belonging to the indigenous groups such as Santhals, Mundas, Oraons, Kharias, Gonds, Khonds, Kisang and Nagesias, they settled down in Assam at the end of the contract period. During the colonial period, some left the tea plantations to settle in the surrounding agricultural lands before the expiry of the contract. The latter came to be known as time-expired or ex-tea coolies' who lived in villages neighbouring the tea estate, providing casual labour depending on seasonal demand. The present-day population of the tea labour community in the state is estimated to be 20 per cent of the population of the state, which according to a conservative estimate comes to six million. Despite their numerical strength and long history in Assam stretching more than a century, they remain 'outsiders' without the tribal status, as has been accorded to them in their place of origin, and are deprived of benefits availed by the other backward castes. Among the plantation workers, Santhals would constitute about three lakh out of the total tea tribes.

#### PRACTICE OF WITCHCRAFT AMONG SANTHALS

The belief system of the Santhals in their new space of habitation since the nineteenth century follows the same trajectory as amongst their kin in the Chota Nagpur region. The Santhals are one of the aboriginal tribes of India and were brought by the British in the latter half of the nineteenth century along with other tribes to the tea plantations of Assam to work as indentured labourers. They have retained their unique identity, traditional practices, rites and rituals in Assam. They practise their own religion and system of worship known as *sarna*. It is a form of nature worship wherein the Supreme deity is Marang Buru (God of Mountains) and Thakurjibi, who is believed to be the creator of the universe. The creator, however, does not feature in the numerous festivals, rites and rituals of the Santhals except his name being invoked on certain occasions. Uprooted from the original homeland, the Santhals in Assam, have over the course of time, become more Hinduized than their Jharkhandi and Oriya counterparts. They have adopted numerous Hindu

practices while striving to maintain their own. A substantial section of the population have also adopted Christianity in certain parts of the state.

The key role in the religious rituals is played by their priests. The priest who is highly revered and performs the life cycle rituals is the *naikekhili*, who comes from the Murmu/Hembrom clan of the Santhals. He is the main priest and performs the rituals at his own private place of worship. In his absence, the *puja* can be performed by *naike* (also priest), who can substitute the main priest only if the *naikekhili* is not available. However, to be chosen as a *naike*, it is believed that he should be possessed by the *gosain* (Marang Buru). To ascertain, whether he is really possessed by the deity or not, he has to undergo certain tests. He is generally beaten with a *charchari* (a form of whip made from thatch), and if he is possessed by the deity, the whip either breaks or bends. This system of selection of *naikes* is dying out and generally people are selected as *naikes*, if they belong to the appropriate clan and are knowledgeable in these matters of the spirit. Within the traditional belief system there is no scope of worship of idols. In festivals such as *Baha* that signify the onset of spring. The *naikekhili* has to perform the *puja* under a grove of *sal* trees with the presence of the *majhi* (village head), *jog majhi* (*majhi*'s assistant), and *godet* (helper). Only after the *naikekhili* performs this *puja* in the common place of worship, others in the village are allowed to perform the same at their homes. In this *puja*, the Marang Buru is invoked with an offering of wine and a sacrifice of either a white cock or white goat is made. In Upper Assam, steps were taken to abolish animal sacrifices and currently fruits and flowers are offered to the deity instead. The *naikekhilis* and *naikes* do not participate in magical practices. Their services are required at the time of festivals, and other life cycle rituals.

Like their counterparts in Jharkhand, the Santhals, among the tea tribes of Assam have a rich history of magical practices. Their belief in the magical world remains strong even today and irregularities in health, wealth and prosperity are believed to be the handiwork of someone, who has intentionally harmed them through the use of black magic. A clear distinction is made between white magic

and black magic. While white magic is done to remove the ill-effects of black magic, to perform exorcism, to cure the sick, to resolve problems in domestic life or work, black magic is done to harm someone with the intent to cause illness, loss of property and also to kill. However, it is interesting to note that the person who is knowledgeable in white magic might also be skilled in black magic. Among the Santhals, the medicine man or the practitioner of witchcraft is called *ojha*, who is conversant with both the arts. The knowledge of magic or witchcraft is attained through rigorous training and practice and passed on by an *ojha* to a person of his choice. This choice is made by carefully selecting a disciple, who is seen to be worthy of receiving such secret and powerful knowledge. Knowledge might not be passed on even to kin, if that person is deemed to be unworthy or seen as incapable of mastering the art. It is also worthwhile to mention that this knowledge is highly protected, not disclosed even to family members and passed on by the *ojha* only when he is old or infirm.

Magical powers are also attained by certain people who can be termed as witches or magical practitioners. There are also instances of couples being witches and practising such magical rituals. They would go into the most secluded part of forests to participate in the highly secret rites and rituals that give them their power. Such power can be attained by offering sacrifices and invoking the main deities or spirits like Rangkeni, Baghut, Churkin (malevolent spirit/witch), etc. While each of these deities is not necessarily evil, the power attained through deviantly manipulating them can be used for harming others. Some of the Santhals have gone on to compare Marang Buru with the Hindu God Shiva and Rangkeni with the Hindu Goddess Kali and much like a Tantric gains his power, the *ojha* or witch can gain power. While spirits and deities are benevolent and their blessing is sought for the happiness, prosperity and health by the Santhals, they can be invoked to attain special powers which can be used either for good or evil. Santhals have numerous deities and spirits whose powers can be used alternatively for good and evil. Spirits are called *bongas*. *Apge bonga* is a house spirit and protects the house of a Santhal. Certain rituals are performed to appease the house spirit for protection and peace at home.

Another spirit called *baghut* (tiger spirit) is a very violent one and its power can be used to harm someone. The most important deity, however, in the Santhal magical world is Rangkeni (compared to Goddess Kali), whose power is the strongest among all spirits and deities. Black magic practitioners generally invoke this Goddess to obtain power, to curse or harm someone. It is believed that the harm done through this magic is most effective and mostly irreversible. This Goddess is easily appeased and the power granted by the Goddess is very potent. Another lesser spirit which grants power is Churkin, which literally translates into a witch. Churkins are less powerful compared to other spirits/deities. Marang Buru, the supreme deity of the Santhals is a benevolent god and does not bestow evil powers. However, his powers/blessings can be used by an *ojha* to alleviate the sufferings of an individual affected by black magic. Lay people cannot perform secret magical rites, since it requires greater practice, skill and expertise in magic. However, if a common person is selected by a *guru*, that person can learn it. A person is selected by the existing practitioner, who has to pass on the knowledge before he/she dies. Otherwise, his whole family will be cursed and eliminated by the deity/spirit from which he draws his powers. The selected one can be any random person, who might be a son or daughter or relatives or any random person having the requisite qualities.

These magical practices of the Santhal tribe are quite ancient and have been preserved even now. However, it is interesting to note that the Santhals in Kokrajhar and surrounding areas have been more stringent in retaining their age-old customs, rituals and beliefs than their counterparts located in upper Assam. The Santhals of Upper Assam have either become more Hinduized or Christianized and have also become more intermingled with other tribes and castes in the area. As such, theirs is a more relaxed outlook and in fact, the younger generations do not follow the Sarna religion rigidly, only elements of it in life-cycle rituals and do not blindly believe the magical and healing abilities of *ojhas*, witches and shaman, etc. *Ojhas* are respected members of the society and their help is required in alleviating the ill effects of black magic, ill health, etc. However, it is worthwhile to mention that these *ojhas* can

dabble in black magic themselves and their services are sought to harm someone as well. A Santhal can seek help from *ojhas* belonging to other tribes too.

Whenever some harm befalls an individual or his family, it is generally believed that it is the handiwork of a black magic practitioner/witch. Even some educated Santhals persist in believing the powers of black magic. Though the belief in black magic is quite common, people do not have a clear understanding of who has actually done it. Conjectures are made regarding the identity of the black magic practitioner and people blame anyone who seems suspicious. However, the *ojha* is a well-known figure in the community as he provides his healing and has problem solving abilities to help others. In certain cases, he helps to identify who is a witch or black magic practitioner by citing some of their specific traits or characteristics.

There are no specific characteristics or symptoms by which the practitioners of witchcraft can be identified. People generally assume that a person may be a practitioner because of his or her looks such as being ugly, hunchbacked, emanating foul smell, etc., or someone who has threatened them in some way or someone who stays in isolation and is anti-social in behaviour. The physical characteristics of a person who practises witchcraft varies according to people's perception. A person with a violent temper and prone to threatening people, or one who is easily offended and does not engage in social interactions is suspected of participating in these practices. The Santhals believe that the practitioners might be envious of their health, wealth, beauty, etc., and have targeted them out of spite and jealousy. They may even blame members of their family for the cause of their misery. Identification can also be made with the help of an *ojha*, who would give certain specific details about the perpetrator. It is generally clues regarding their appearance, their traits or the location where the witch/practitioner lives. Priests cannot help to identify those who practice such craft.

It is seen that the belief in black magic and the harm caused by it is more at an individual level than village level in the Santhal populated areas in Upper Assam. Harm can range from ill-health,

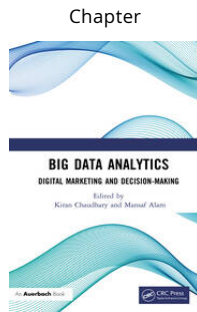


loss of property, hindrances in someone's career, obstacles in someone's marriage, death, etc. At village level, harm can be in the form of an epidemic like cholera, diarrhoea, blood dysentery, etc. Women are generally deemed to be associated with the practice, though both genders engage in these practices. It is a mere supposition that the power comes more easily to women than man. But, men are more powerful if they attain magical power. Hence, male practitioners are more feared.

There are ways to protect oneself from the harms of black magic. Devotion and regular worship of the supreme deity helps in warding off such evil attacks. If that doesn't help, the services of *ojhas* are sought whose mastery over such art helps in dispelling their ill effects. People are sometimes falsely accused of practising witchcraft. Such accusations are based on conjectures and speculations. The reasons for such false accusations can be a continuing dispute, grudge or petty jealousy. Women are generally accused of practising black magic, but persecution resulting in death is very rare in Upper Assam. Persecution or punishment of people or witch hunt is not common amongst Santhals in Upper Assam. This might be attributed to the fact that proper identification of the offending party is very hard. If someone is suspected of engaging in these arts and causing harm, the help of *ojhas* is sought to punish the culprit.

Persecution/witch hunt is very rare, though there have been few incidents, which generally went unreported. However, if such a hunt is organized, the victims generally tend to be women, who are either widows or those deemed to be fallen women. The most extreme form of punishment—which is also very rare—would be beating up the offending party by the members of the family of the aggrieved party or a group or a village mob. Other forms of recriminations include counter retaliatory measures through the *ojha*. In the rarest of cases where persecution results in death or driving the accused person away from the village, it might be related to custody of land or other property.

Witchcraft is a dying tradition amongst the Santhals of Upper Assam. Growing education and awareness amongst them has contributed immensely towards eradicating these practices. Also, it is



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तथा तुकी, सुनोरिन आदि पाठकों में अर्पित।

इलाहाबाद विश्वविद्यालय, मिजोरम विश्वविद्यालय एवं इंदिरा गाँधी राष्ट्रीय  
जनजातीय विश्वविद्यालय, अमरकान्ठक (मध्य प्रदेश) के एम.ए. तथा पी.ए. पाठ्यक्रम  
में कविताएँ शामिल।

काशी हिन्दू विश्वविद्यालय, सिक्किम विश्वविद्यालय के एम. ए. पाठ्यक्रम तथा सिद्धार्थ  
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गवर्नमेंट स्कुली पाठ्यक्रम में कहानियाँ शामिल।

सम्मान :

- o अखिल भारतीय हिंदी सेवी संस्थान द्वारा राष्ट्रीय वार्षिक सम्मान
- o पूर्वोत्तर हिंदी अकादमी द्वारा सारस्वती मित्र सम्मान
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समकाल की आवाज़

Innovations in Agricultural  
& Biological Engineering

# Advances in Food Process Engineering

Novel Processing, Preservation,  
and Decontamination of Foods



*Editors*

Megh R. Goyal | N. Veena | Ritesh B. Watharkar



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## CHAPTER 10

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# COLD PLASMA PROCESSING METHODS: IMPACT OF DECONTAMINATION ON FOOD QUALITY

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### ABSTRACT

Cold plasma (CP) has emerged as a novel processing technology for the preservation of food and food products. Food spoilage and foodborne illness have been a great concern for both industry and consumers. CP has proved to be a promising and a feasible non-thermal intervention for food processing. This is due to its decontamination efficacy against food borne pathogenic and spoilage microorganisms, minimal impact on food constituents without generating any toxic by-products, cost efficiency and sustainability. CP has also been shown to degrade microbial toxins and pesticides. These multidimensional effects have been ascribed to the generation of various reactive gas species and ultraviolet (UV) mediated chemical and microbial mechanisms. CP's application has been widely looked into various areas of food industry viz. fruits, vegetables, cereals, meat, poultry, and packaging with promising results. There are multiple approaches for plasma generations with the fundamental approach being excitation of individual gas or gas mixes to the plasma state which can be tuned for different applications. CP's characteristic effects have assisted in making food and food products safer for consumers and have opened avenues for further development.

## 10.1 INTRODUCTION

The World Health Organization (WHO) has suggested that the key to a healthy life relies upon access to a sufficient amount of nutritionally rich and safe foods. Globally, foodborne illnesses has been associated with a total of 31 contaminating agents comprising of bacteria, virus, parasites, toxins, and chemicals; and one in every 10 person falls sick on consuming such contaminated foods [65]. The World Bank has estimated an occurrence of combined losses of \$110 billion in production and medical treatment due to foodborne illness each year [21]. Thus, food safety is seemingly important.

In general terms, there are three specific goals for any food processing company; firstly, to reduce microbial risks, next product quality maintenance and thirdly shelf-life enhancement. The food sector employs diverse technologies, the selection of which is based on properties of specific food commodities or agriculture crops to be converted into finished products. The most widely trusted technology is thermal-based processing, which greatly mitigates microbial risks and confer considerable shelf-life to products. But the catch is, a high heat treatment greatly reduces quality (sensory and nutritional) characteristics. However, in the past two decades, the food industry is trending towards minimally processed foods, i.e., foods that are processed in a way to retain fresh-like characteristics. This is commonly achieved by employment of mild thermal treatments or utilizing non-thermal interventions. Unlike thermal treatment, non-thermal technologies involve the processing of foods at ambient or at milder temperature conditions. Some of these technologies include the use of ultrasound (US), high pressure processing, pulsed electric field, pulsed UV-technology, irradiation, ozone processing, etc., to name a few. Such processes preserve much of the natural like characteristics, provides microbial safety while maintaining acceptable shelf-life. These technologies have been widely studied and have demonstrated favorable applications. However, there are certain limitations concerning to achieving sterility as well as employment of complex machinery and maintenance costs.

The way in which a food is processed is of importance nowadays due to rising environmental safety, sustainability concerns alongside consumer safety. The food sector is an energy intensive sector and regulatory review in various countries has led the sector to look into sustainable processing technologies with long term safety of the ecosystem. As a consequence, the food sector is under constant pressure to adapt and innovate accordingly. Big manufacturing companies nowadays utilize the environment friendly

tag as it creates a positive brand image, thereby greater sales. Over the last few years, cold plasma (CP) processing has emerged as a new non-thermal technology with multifaceted application in maintaining safety and quality food and food products along with environment safety.

The current chapter discusses the knowhow of CP technology, mechanisms, efficacy in decontaminating microorganisms, and mitigation of contaminants to achieve food safety along with sustainability.

## 10.2 PLASMA SCIENCE: PHYSICS AND CHEMISTRY

The concept of plasma was first described by Irving Langmuir and his co-workers in the 1920s. However, the existence of plasma physics has been traced back to the 1600s during the time plasmas were known as *gas discharges* [48]. In general terms plasma is often stated as the fourth state of matter. We all have an understanding of the three states of matter: solid, liquid, and gas, each following a hierarchical increase in energy levels, followed by a change of state into the next on achieving a particular energy level. The increase in energy level cause loosening of interaction among molecules till the molecules become completely apart causing a change of state.

Plasma is repeatedly stated as the ionized form of a given gaseous state. When sufficient energy is applied to a gas system, the intermolecular and intra-atomic structures break completely, leading to the release of electrons and generation of ions, and thus plasma is generated. Consequently, any energy source which can achieve such an effect can be readily utilized as a source for plasma generation. Typically, plasma comprises of a co-existing mixture of excited atomic, molecular, ionic and radical species, reactive species, charged ions, electrons, molecules in neutral or excited states along with the release of quanta of electromagnetic radiation [42]. Common examples of plasma as one may observe in daily life include natural lightning or man-made plasma including neon lighting, plasma TV, LEDs (light-emitting diode) and arc generated during welding applications. Now, as we have established about what is plasma, let's understand the physics and chemistry involved.

### 10.2.1 PLASMA PHYSICS

Plasma can also be referred to as a quasi-neutral gas of charged particles which shows *collective* behavior [4, 16]. Although the particles in plasma

are charged, but overall, the charge densities cancel out at equilibrium, thus the quasi-neutral nature. There is a collective interaction between multiple charge particles occurring over long lengths and time scales. Putting this into perspective, let's consider two charge particles which are very close to each other. These two particles would interact with each other individually through their Coulomb electric field. However, when these particles move apart from each other beyond a mean particle separation distance ( $n^{-1/3}$ , where  $n$  is the charged particle density), these charged particles further interact simultaneously with other adjacent charged particles. Thus, indicating collective interaction.

Distinctively, plasma can be classified into thermal and non-thermal plasma (NTP). Ionization is the first step for plasma generation. The mechanism of ionizing very much relies upon the efficient collisions between electrons and other neutral species. For collisions, some of the electrons have to achieve high kinetic energies to exceed the ionization potential of the gas. This can be achieved by heating the gas at sufficiently high temperatures (in the order of  $2 \times 10^4$  K), such generated plasma is considered as "thermal plasma."

In thermal plasma, the constituent neutral species ( $T_n$ ), ions ( $T_i$ ), and electrons ( $T_e$ ), are in thermodynamic temperature equilibrium ( $T_i \approx T_e \approx T_n \leq 2 \times 10^4$  K) thus the overall plasma temperature is very high. NTP can have varying degree of non-equilibrium among the species, based on which they can be subdivided into quasi-equilibrium plasma (temperature range: 100–150°C) and non-equilibrium plasma (<60°C). In quasi-equilibrium plasma a local thermodynamic equilibrium exists between the constituent species. On the other hand, in non-equilibrium plasma, the collisions between the hot electrons and other particles are not frequent enough. Consequently, thermalization between the electrons and neutral species does not occur efficiently and overall, the system remains near room temperature. In simple terms, the electron remains at a much higher temperature than the constituent ions or neutral species ( $T_i \approx T_n \ll T_e$ ,  $T_e \leq 10^4$  K) [41]. Ascribable to such characteristics, non-equilibrium plasma is typically referred to as CP or NTP in general. Physicists often relate CP operations to occur at temperatures above hundreds or thousands of degrees above ambient temperature. As a result, the term "cold plasma" has now been assigned to generation of plasma at room temperature and at one atmosphere pressure unlike other NTPs. Such CPs can be typically generated using electrical discharges in gases. As such plasma generation occurs without extreme conditions, the importance of its application in the food industry becomes pertinent.

### 10.2.2 PLASMA CHEMISTRY

The plasma generation is driven by collision interaction between energized electrons with other atoms and molecules of a gas subjected to a sufficient high electric field (HEF). These collisions are important for the plasma chemistry. When an electron collides with other atoms or molecules, a wide range of effects are observed viz. ionization, dissociation, association, and excitation. For understanding, let's consider a situation where an electron  $e$ , which can collide with a molecule  $AB$  or an atom  $M$  in a gas. The following primary processes are found to take into effect:

- **Impact Ionization:**  $e + M \rightarrow M^+ + 2e$
- **Dissociative Ionization:**  $e + AB \rightarrow A^+ + B + 2e$
- **Dissociative Electron Attachment:**  $e + AB \rightarrow A^- + B$
- **Electron Attachment:**  $e + M \rightarrow M^-$
- **Electron Impact Molecular Disassociation:**  $e + AB \rightarrow A + B$  (either A or B could be excited electronically).
- **Electron Impact Excitation:**  $e + M \rightarrow M^* + e$  (excitation to higher atomic, molecular or vibration levels).

These are primarily the possible ways in which an electron can collide/interact with other molecules or atoms. Again, another interesting effect is penning ionization which has been observed with plasma discharges involving helium, neon, and krypton [31]. Penning ionization [ $A + B^* \rightarrow A^+ + B + e$ ] requires the interaction of a metastable species ( $B^*$ ) with a target neutral molecule ( $A$ ), having ionization energy lower than the internal energy of the metastable species. Photon and ultraviolet (UV) emission are also other additional processes during plasma generation. These processes occur when excited species release energy and come to the respective ground states. However, it has been suggested that the photon flux during atmospheric CP generation is not sufficient to achieve photocatalysis [23]. Additionally, the impact of UV on DNA damage and surface sterilization is well proven; this marks some decontamination ability of plasma. The probability of the above interaction to materialize is said to be dependent upon the electrons mean energy.

Electron mean energy is dependent upon the gas composition, temperature, and pressure in the discharge and it has been observed that input energy also plays a role. Thus, one can vary these functions to achieve specific process outcomes for any application in particular. The mean electron energy in NTP typically ranges between 2 eV and 5 eV. The plasma chemistry is basically driven by such generated species having lower activation energies consequently, upsurging reaction rates [41]. This leads to secondary effects;

secondary collision involving large or heavy molecules generated on electron collisions. Common secondarily generated molecules include ozone, hydrogen peroxide ( $H_2O_2$ ), nitric oxide, nitrites, etc. As it is possible to achieve such processes without involving extreme temperatures, CP technique provides a distinctive environment to initiate and assist chemical reactions. Thus, forecasting itself as an interesting technique to be applied to food and agriculture.

### **10.3 METHODS OF COLD PLASMA (CP) GENERATION**

Basic plasma system relies upon a feed gas which can be contained or be free-flowing. Frequently used feed gases are oxygen ( $O_2$ ), nitrogen ( $N_2$ ), air, helium (He), neon (Ne), argon (Ar) or their mixtures. Some common methods in practice to induce ionization include corona discharges, dielectric barrier discharges (DBDs), microwave discharges (MD) and plasma jets. Selection of these methods is based on the final application. However, these configurations simply follow one principle that the feed gas needs to be ionized into plasma at one atmosphere pressure or in certain cases below atmospheric pressure.

#### **10.3.1 CORONA DISCHARGES**

Corona discharges are stream of charged particles viz. ions and electrons accelerated by an electric field in a confined space. The reason of such streams is due to the asymmetrical nature of the electrodes, where one electrode may be a tip or pit point or a thin wire and the other a plate type. Close to such tips, electric fields of high intensities are formed, and the active corona is generated. Such plasma is not self-sustainable as most of the discharge volume is below the HEF. The plasma effects are mostly due to secondary processes such as photoionization or transport of charged carrier from the HEF region to rest of the confined space. Such discharges are commonly applied for treating fruits and vegetables with ozone in industrial setup [41].

#### **10.3.2 DIELECTRIC BARRIER DISCHARGE (DBD)**

DBD method involves excitation of feed gas into plasma by applying an oscillating current between two electrodes separated by a durable dielectric material which may be a glass or plastic. This dielectric medium avoids

charge transport and uniform non-equilibrium plasma is generated between the areas of the electrode unlike corona discharges. Thereby, one can change the electrode area and shape for higher volume applications which in turn is limited by the voltage supply. Thus, a DBD proves to be a flexible and a scalable plasma generation method. DBD has seen its application in improving air quality, ozone generation, water treatment along with microbial inactivation in juices [37, 38, 59].

### **10.3.3 MICROWAVE DISCHARGE (MD)**

Microwave discharges (MDs) are generated by the use of electromagnetic waves rather than electric current to ionize gases in a chamber. Microwave plasmas are mostly utilized for low pressure applications mostly for biomaterials [55]. The electromagnetic frequency typically exceeds hundreds of MHz, which is produced using a cyclotron. The major merit of MD method is its ability to create intense discharges in chemically active gases. Microwaves have been utilized more actively in plasma jet methods for medical application [20] but quite limited in the food sector.

### **10.3.4 PLASMA JET**

Plasma jet is not much of a source for plasma generation; rather it's merely a modification of the above mentioned configurations. Unlike the other system this is an open type system, i.e., the feed gas is not confined in a closed chamber. As per the name, the feed gas is blown at a high rate through two co-axial electrodes for ionization. The outer electrode is grounded and the other electrode is connected to the systems like microwave resonator or radio frequency [20, 41]. The propagating ionized gas blows out as waves and forms a stream of reactive gas species. The plasma interaction produces long-lived reactive species which in turn is exposed to the objects to be treated. This approach is important as it acts as a remote means of plasma generation and is favorable for use on living tissues; important for biomedical applications. However, its application in the food sector is limited or not cost-effective. In general, for food application, we come across three distinctive methods of exposing plasma to foods:

- Firstly, the food sample can be placed directly within the plasma field; for example, when a food is kept directly under the electrodes as in case of in a DBD method or in the chamber of MD type discharges;

- Secondly, the placement is at point close to the plasma generation, e.g., jet plasma; and
- Thirdly, a remote treatment, where a food is placed at a significant distance from the short-lived reactive species, here plasma effects are ascribed to secondary processes. Based on the methods, interesting results are obtained pertaining to microbial decontamination.

## 10.4 BIODECONTAMINATION USING CP

Biodecontamination refers to removal or inactivation or causing fatality of biological entities. Emphasizing on the food sector, the common biological entities that need to be dealt with are bacteria, fungi, and viruses. CP has received much importance as a non-thermal processing technology for decontamination owing to multifaceted properties. A lot of work has been carried out for understanding the decontamination process due to CP. As thermal effects are not a mode of action, one can broadly classify the mechanism under two heads. First, interaction due to reactive gas species and charged particles; and second UV inflicted cellular and genetic damage.

### 10.4.1 REACTIVE GAS SPECIES

The reactive gas species are considered to be the major entities that cause lethal or sub-lethal damage to microbes. The composition of reactive gas species mix is dependent on the type of gas or gas mixture used, plasma generation method and configurations, treatment time and also on applied energy causing ionization. Common feed gases include natural or synthetic dry or humid air, O<sub>2</sub>, N<sub>2</sub>, He, and others or their mixtures thereof. Some of the reactive gas species of interest, which have shown decontamination effects are compiled as follows:

1. **Reactive Oxygen Species (ROS):** Atomic oxygen (O), singlet oxygen (<sup>1</sup>O<sub>2</sub>), excited state of oxygen (O<sub>2</sub><sup>\*</sup>) superoxide anion (O<sub>2</sub><sup>-</sup>) [primary collisions] and ozone (O<sub>3</sub>) [Secondary effects].
2. **Reactive Nitrogen Species (RNS):** Atomic nitrogen (N), nitrogen positive ion (N<sub>2</sub><sup>+</sup>) and excited state of nitrogen (N<sub>2</sub><sup>\*</sup>) [primary collisions], nitric oxide free radical (NO•), nitric oxide (NO) [secondary effects].
3. When humidity is involved, species like H<sub>2</sub>O<sup>+</sup>, OH<sup>-</sup> anion, OH• radical [primary collisions] and H<sub>2</sub>O<sub>2</sub> is also generated due to



secondary effects. Water vapor along with nitrogen gas generates other secondary components viz. nitrite ( $\text{NO}_2$ ), nitrous acid ( $\text{HNO}_2$ ),  $\text{N}_2\text{O}_4$ , and  $\text{N}_2\text{O}_5$ .

It has been widely reviewed that reactive species interact with microbial cell components leading to inactivation. On plasma treatment, microbial cells are bombarded by activated radicals and energetic ion causing surface lesion, a phenomenon described as “etching.” Although microbes have their inherent repair mechanism such intense bombardment cannot be counteracted, thus the cells are stressed or injured sub-lethally.

Electropermeabilization, i.e., accumulation of electric charges on cell surface, induces cell rupture causing lethal injury during plasma treatment, a mechanism similar to pulse electric field mode of microbial inactivation [63]. It has also been put forward that ROS tend to cause degradation or damage of by breaking bonds of membrane lipid bilayer and proteins. ROS induces lipid peroxidation, as ROS being more reactive than molecular oxygen. Once the bi-layer is disrupted, the cells fail to transport molecules into and out of the cell for normal maintenance [10]. RNS with oxygen have shown to cause interruption of the antioxidant defense mechanism by targeting RpoE (DNA-dependent RNA polymerase), OxyR (oxygen regulated gene), DnaK (chaperone protein DnaK gene), and GroES (heat-shock gene) expression [10, 57] leading to cell stress or inactivation.

Another point of action is DNA damage due to reactive gas species interaction. The most important radical inflicting DNA damage are the  $\text{OH}\cdot$  radicals that accounts for 90% DNA damage on plasma treatment [63].  $\text{OH}\cdot$  radicals also initiate DNA oxidation reactions by reacting with nearby organic compounds leading to DNA damage along with disintegration of cellular membranes and other cell components; consequently, cell death [9]. Additionally, when liquid media are treated with plasma an acidification process is observed owing to diffusion and dissolution of gas species in the medium; scientists suggest it plays a role in decontamination [38]. Ozone and peroxide molecules, the outcomes in plasma processes are well known for their potent antimicrobial nature.

#### **10.4.2 UV PHOTONS**

The impact of UV-mediated decontamination effects in plasma processing is quite incongruous among scientists. UV is proven and widely known

to have DNA damaging effects. For CP treatment the effects of UV have been suggested to occur synergistically with the varied reactive gas species [7, 38]. Researchers working on microwave plasma and radio frequency plasma have pointed towards UV-mediated effects alone [41]. Mosian et al. [44] showed UV to be the vital reason for microbial inactivation in low pressure plasma applications. In contrast for plasma jet application crucial role of UV could not be assigned to microbial inactivation [66]. Overall, one can conclude that UV may not play a major role but cause microbial inactivation synergistically with other mechanisms.

Scientists have carried out a majority of experiments where bacteria, fungi, and viruses have been subjected to CP treatment with positive effects. CP has successfully demonstrated inactivation of pathogenic bacteria like *Salmonella* spp., *Escherichia* spp., *Listeria* spp., *Bacillus* spp., *Pseudomonas* spp., *Staphylococcus aureus*, *Campylobacter jejuni*, etc., in various food matrix with great efficacy [37, 38, 45, 63]. The fungi are competent invaders of a wide range of foods and have the ability to cause rots and produce mycotoxins, which is a serious concern.

Fungi of concern especially *Aspergillus* spp., *Penicillium* spp., *Cladosporium cladosporioides*, *Zygosaccharomyces rouxii*, *Alternaria alternata*, *Candida albicans*, etc., have been reviewed to be inactivated using varied CP treatments [15, 43, 55]. These microbes are of concern as they are responsible for spoilage of food products, more importantly cause food poisoning and other life risking conditions. More recently, the application of CP processing has been extended to study virus inactivation on food surfaces. Human norovirus (HuNoV), a potent etiological agent transmitted through consumption of raw foods or foods processed on un-sanitized surfaces. Although much of the work has been carried out on viral surrogates with CP, but it still opens up the possibility towards viral safety in foods [28, 40].

## 10.5 SCOPE OF COLD PLASMA (CP) IN FOOD SECTOR

CP technology drives its benefits from its ability to achieve food safety at room temperature, without negatively affecting the nutritional and quality attributes. This has been effectively used by food scientists, engineers, and technologists to provide consumer safety. Some of the application aspects in the various food sectors are compiled in this section.

Non Commercial Use

### 10.5.1 FRUITS AND VEGETABLES

Most fruits and vegetables are well known for their major health benefiting constituents and have been recommended to be consumed in adequate amounts and are mostly consumed raw [53, 54]. Thus, safety is of utmost importance when consuming raw foods. CP has been applied as an in-package treatment method to a wide range of fruit and vegetables including the fresh-cut produce category. A pilot-scale study utilizing an ionized H<sub>2</sub>O<sub>2</sub> aerosol plasma and demonstrated a reduction of *S. typhimurium* and *L. innocua* on inoculated in apples and tomatoes below detection limits (<0.7 log CFU/pc) [61]. The same group also reported similar reduction results for grapes, tomatoes, apples, cantaloupe, and Romanian lettuce [62].

In another pilot plant study with DBD method involving humid air was efficiently used to reduce *E. coli* and *L. monocytogenes* in strawberries and spinach by 2–2.2 logs and 1.3–1.7 logs, respectively [70]. In one study, a CP treatment (60 kV for 5 min) inhibited the inherent aerobic bacterial counts and enhanced the cutting induced phenolic accumulation in freshly cut dragon fruit [32]. In sliced carrots, about 2 log reductions of total mesophiles, yeast, and molds were observed whilst maintaining the textural properties with good carotenoid retention [39]. CP has been widely studied for treatment of other fruits and vegetables like cabbage, cherry tomatoes, cucumber, baby kale, radicchio leaves, and peas, to name a few [41]. The CP treatment has also been reviewed for its ability to inactivate of norovirus in foods such as blueberries, Tulane virus in Romanian lettuce opening upon further possibilities [13, 28, 40] in viral food safety.

### 10.5.2 JUICE PROCESSING

Decontamination of fruits and vegetables is a mostly surface process. Decontamination in liquids bit of a challenge. CP mediated decontamination in liquids is mostly due to reactive gas species generation and further dissolution and diffusion processes in the media. CP has proved to be effective in achieving an FDA recommended 5-log standard microbial reduction process [12] in juices pertaining to *S. typhimurium*, *E. coli*, and *L. monocytogenes*. However, the level of microbial reduction is dependent upon the juice matrix under treatment. Direct exposure of orange juice to a DBD type treatment (90 kV–2 min) with M65 gas (O<sub>2</sub>: 65%, CO<sub>2</sub>: 30%, N<sub>2</sub>: 5%) achieved approx.

5 log reduction of *S. typhimurium* and also resulted in around 80% reduction in pectin methylesterase activity [67].

A similar process was followed by researchers to inactivate over 5 log cycle reductions in microbes in tender coconut water with added citric acid; when inoculated with *S. typhimurium*, *E. coli*, and *L. monocytogenes* individually without majorly affecting its physicochemical properties [37, 38]. Yeasts like *Zygosaccharomyces rouxii* have been shown to be reduced by around 6 logs in apple juice using a plasma spray reactor (21.3 kV for 30 min) using normal air as the feed gas [64]. Significant reductions of *E. coli* has also been observed in tomato juices (~1.43 log CFU/mL), sour cherry (~3.34 log CFU/mL), and apple juice (~4.02 log CFU/mL) using plasma jet method (650 W, 30–120 s) [8, 33]. In juices, lowering of contents like polyphenol, anthocyanins, flavonoids, and ascorbic acid have been reported [19, 38, 52]. However, these reductions are lower as compared to conventional thermal treatments. In some cases, the quality of juices improved on plasma treatment, as in the case of beetroot juice, an increase in phenolics was observed and for pomegranate juice, anthocyanin content increased by 21–35% [11, 26]. Attempts are being made to optimize the plasma processes in a way to ensure safety along with nutritive stability.

### 10.5.3 DAIRY AND DAIRY PRODUCTS

Thermal treatment in the dairy industry is mainly targeted to deliver safety to consumers. However, it leads to undesirable changes in protein, cause non-enzymatic browning, vitamin losses and flavor changes. CP technology has been studied to show promising results in this sector as well. Kim et al. [24] suggested a 10 min plasma treatment (250 W, 15 kHz) for milk using ambient air and DBD method for plasma generation to effectively reduce bacterial counts for *S. typhimurium*, *L. monocytogenes*, and *E. coli* by 2.4 log CFU/mL. Yong et al. [68] applied a similar plasma treatment for the same microbes on cheese slices. They reported 2.8 log, 2.6 log and 3.1 log CFU/g reductions for *E. coli*, *L. monocytogenes*, and *S. typhimurium*, respectively.

Reviewed literature suggests that in dairy products substantial microbial inactivation could be achieved but there are limitations to be addressed. Common being lipid oxidation causing sensory and color changes [5]. Consequently, changing plasma parameters pertaining to identifying specific feed gas or gas composition could help solve the issue. Further research addressing the comparative changes of milk and milk products between CP and thermal treatments is needed.

#### 10.5.4 ANIMAL PRODUCTS: MEAT, POULTRY, FRESH FISH, AND SEA FOOD

We have discussed earlier about the generation of reactive nitrogen species (RNS) during plasma generation and secondary processes leading to formation of nitrite. Moreover, CP treatment has been shown to effectively inactivate *Clostridium botulinum* and its spores [35]. Nitrite is the most common additive for curing in the meat industry and *C. botulinum* a potent hazard, consequently supporting CP treatment as a viable technology for meat processing. Having said that, in-package CP treatment is the common go to for treating meat products. This is beneficial as it not only prevents further contamination of the treated products; also, the long lived reactive gas species, importantly  $O_3$  and  $H_2O_2$  continue to inactivate microbes even after the plasma treatment is stopped.

It has been suggested that common effective feed gas for plasma generation include a mixture of nitrogen/oxygen, helium/oxygen, or ambient air to confer efficient decontamination in meat products. Further, the microbicidal effects on *E.coli*, *L. monocytogenes* and *S. typhimurium* are dependent upon power input; an increase in power increases efficacy for inactivation and distance between electrodes [42]. Plasma treatment has successfully been applied to meat products like ham, bacon, pork loin, pork but, beef jerky, etc., to inactivate both gram-negative and gram-positive bacteria with treatment time varying from 90 s–10 min and affective microbial reduction ranging from 0.35 log CFU/g–3.03 log CFU/g [29, 69]. Recent review on the safety of chicken meat products viz. chicken breast and thighs (skin or skinless), slices, and filets; CP treatments have significantly eliminated pathogens such as *Campylobacter jejuni* among others along with inherent mesophiles and psychrophiles [14].

Raw or cooked eggs or egg components (yolk and egg white) have also been studied extensively in the past decade for safety using CP. Available literature suggests greater than 5 log reduction in *Salmonella* spp. and *L. monocytogenes* using feed gases  $He+O_2$ ,  $N_2+O_2$  and  $O_2+CO_2+N_2$  for direct and indirect mode of plasma processing [14]. It is important to note, the addition of moisture in a gas mixture or increasing  $O_2$  concentration confers enhanced inactivation in in-package CP treatments. More recently, global demand for fish and seafood consumption is on the rise as exotic meal consumption is becoming a part of food habit. So, concern regarding their safety is on the rise.

Fish and the seafood industry are also finding CP processing as a promising non-thermal intervention. Fillets of Atlantic herring and mackerel, semi-dried

pacific saury, dried filefish, and squids have been subjected to CP treatment with ambient air as the feed gas. The plasma processes significantly reduced *Photobacterium phosphoreum*, *P. citrinum*, *Pseudomonas* spp., *Staphylococcus* spp., *C. cladosporioides* and other marine bacteria, psychrotrophic, coliforms, lactic acid bacteria (LAB), yeast, and molds [27].

In shrimps, initial load of both *Staphylococcus* spp. and *Salmonella* spp. along with other background microflora were significantly reduced on N<sub>2</sub>/O<sub>2</sub> plasma treatment and extend the shelf-life by 14 days [60]. In slices of Asian sea bass, *S. aureus*, *E. coli*, *P. aeruginosa*, *Vibrio parahaemolyticus*, *S. aureus*, and *L. monocytogenes* were reduced significantly using Ar/O<sub>2</sub> plasma treatment [46]. Although CP has shown promising in the meat industry for food safety but quality changes, lipid degradation, protein denaturation and changes in color are a limitation. Further optimization of the technology is still necessary.

#### 10.5.5 CEREALS, LEGUMES, OILSEEDS, AND NUTS

Cereals, legumes, oilseeds, and nuts are low moisture foods. The safety of these products is predominantly limited by the presence of mycotoxin producing filamentous fungi. Mycotoxins have been associated with serious health issues with infants listed at a higher risk than adults. Mycotoxin mitigation through CP is achieved either by inactivating the producing microbe or by degrading mycotoxin. Both this course of action is mediated through plasma chemistry (reactive gas species and UV-light).

Los et al. [36] demonstrated inactivation of *B. atrophaeus* and *P. verrucosum* in barley and wheat grains. The authors reported a 2.4 and 2.1 log CFU/g in barley and for wheat 1.5 and 2.5 log CFU/g for *B. atrophaeus* and *P. verrucosum*, respectively. Successfully decontamination of the chickpea seeds, beans, soybean, oats, barley, rye, corn, and lentils contaminated with *A. parasiticus* and *Penicillium* sp. to < 1% of initial load depending on plasma treatment times (30 s–30 min) has been reported [56]. In maize grains, fluidized air plasma effectively reduced *A. flavus* and *A. parasiticus* by approx. 5 log CFU/g [7]. An ambient air corona discharge plasma jet exposure (operating at 20 kV, 58 kHz with air, 3 min) on rapeseed surface caused 1.8 and 2.0 log CFU/g decrease in yeast and mold counts, respectively [51].

*Aspergillus* spp. is the most common fungi which contaminate nuts. In Hazelnuts, fluidized air plasma inactivated *A. flavus* and *A. parasiticus* by 4.5 log and 4.19 log CFU/g, respectively [6, 7]. Complete inactivation of

*A. brasiliensis* was noted with a low pressure DBD plasma treatment with Ar/O<sub>2</sub> (10:1 v/v) on pistachios in 15 s [49]. In date palm, Ar gas jet plasma treatment completely inhibited *A. niger* spores [47]. A similar, Ar-plasma jet exposure caused complete destruction of *A. flavus* in fresh and dried walnuts within 11 and 15 min, respectively [1]. Literature review suggests that CP efficiently degrades several mycotoxins, viz. aflatoxins, trichothecenes, vomitoxin, zearalenone, sterigmatocystin, and fumonisins, and also inactivates mycotoxin producing fungi [15, 58]. Although in the initial stages of application, CP has shown promise to develop mycotoxin safe foods, such as: *B. atrophaeus*, and *P. verrucosum*.

### 10.5.6 HERBS AND SPICES

Safety of herbs and spices is quite a challenge among food technologists. This is due to susceptibility towards fungal contamination, bacterial attack and volatile losses on conventional heat treatment. In the above sections we have very well learnt that CP effectively kills fungi including bacteria and that too at room temperature. Thus, shifting towards CP intervention for herbs and spices seems logical. A high density microwave-combine plasma treatment with helium as the ionizable gas was effective in reducing *B. cereus* spores by 2.7 log spores/cm<sup>2</sup> in vacuum dried red pepper flakes [25]. In another work natural microbiota was significantly reduced in paprika powder and pepper seeds by 3 log CFU/g and in oregano by 1.6 log CFU/g using a remote plasma treatment [17].

In infected dried peppermint powder, substantial *E. coli* O157:H7 reduction was observed on low pressure radio frequency O<sub>2</sub>-plasma treatment [22]. Similarly, low pressure radio frequency oxygen plasma was applied to saffron that significantly eradicated *Aspergillus* spp., *Rhizopus* spp., and *Penicillium* spp. in 15 min [18]. A treatment involving pulsed light with CP, non-thermally inactivated spores of *A. flavus* (~1.3 log spores/g), *B. pumilus* (~2.3 log spores/g), and *E. coli* O157:H7 (>3.8 log CFU/g) in red pepper flakes [30]. Available research shows promising aspects of CP in the safety of herbs and spices.

## 10.6 COLD PLASMA (CP) AND SUSTAINABILITY

The world population is set to reach 10 billion by 2050, i.e., approx. 3 billion more are to be provided with food. Which the current climate change and

decline in available agricultural land, the food-Agri sector needs to opt for sustainable food production and processing strategies. A reduction in incidence of foodborne illnesses, product recalls and food safety will increase sustainability significantly. As discussed earlier, traditional technologies effectively reduce microbes and make food safe but also affect quality and are also energy-intensive. Food producers and processors also use chemical methods to overcome microbial contamination. However, it is not very safe in terms of immune reactivity, chances of retaining chemical residue and also effluent laden with chemical needs to be treated, which otherwise is a hazard. Thereby, alternatives of chemicals are a much focused area nowadays.

CP has found its applications at various stages so food production and processing, including enhancement of seed germination, water decontamination, decontamination of food, equipment, and packaging materials [2, 3, 34, 50]. CP operations achieve these effects by consuming less energy, operating at ambient conditions and generation of short-lived primary and secondary reactive species, thus leaving behind no major chemical residues; an added advantage. This makes CP treatment green and sustainable application for food, agricultural, and industrial sectors.

## 10.7 SUMMARY

CP is gaining attention owing to its multifaceted effects on different sectors of the food industry. Although this technique is in its nascent stages, it has proved its efficacy in delivering safe food by eradicating pathogenic microbes: bacteria, fungi (yeast and molds), and degrading mycotoxins. In all generated plasma, a variety of chemical and physical interaction takes place, which still needs to be understood well enough for specific application. The intricate plasma chemistry; reactive gas species, secondary species, and UV light generation effectively interacts with biological materials and confer much of its benefits. Not to forget its ability to bring changes at ambient conditions. However, the technology has certain limitations pertaining to the quality of products. Attributes like flexibility, scalability, and sustainability, the technique has opened unlimited opportunities in the food sector. Consequently, much know-how still remains to be generated. Further, with the emergence of viral pandemics, such as SARS-COV-2 and its ability to survive on varied surfaces; challenges on viral decontamination of food surfaces needs to be taken up.



## KEYWORDS

- **biodecontamination**
- **cold plasma**
- **food safety**
- **microwave discharge**
- **non-thermal technology**
- **reactive gas species**
- **ultraviolet**

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## COMMERCE EDUCATION IN INDIA: Retrospective & Prospective

Dr. Vinod Kumar Yadav

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*“Education does not mean teaching people what they do not know. It means teaching them to behave as they do not behave.”*

—Abraham Lincoln

### Introduction

Commerce is a special and wider discipline of education that is directly associated with industry, trade and commerce, which attempts to address the employment generation and employability enhancement issues. It should not be taken merely as branch of education, rather as a discipline of education dealing with entrepreneurship, vocation, occupation, business related issues. Commerce education is essential to have an insight about industry, trade and commerce (Gupta, 2019). Thus, it promotes self-employment that converts job seeking population into the job providing population. Commerce education is the foundation stone of the employment generation and entrepreneurial development in the country (Gupta, 2019). Commerce means trade i.e. purchase and sale of goods, and aids to trade i.e. banking, transportation, communication, advertising, insurance, packaging, direct services [CA, CS, ICWA, Accountant, Clerk], etc. Industry refers to the place where raw materials are processed and converted into the finished goods that are traded later. Industry is a manufacturing concern, and Trade is an exchanging concern where traders sell goods for a certain amount of money to earn profit. There is a great role of commerce education in the development of Trade, commerce and industry that generate employment opportunities and entrepreneurship.

Commerce is a branch of education and research that accommodates the diverse facets of business (Mankar, 2016). Commerce education is a vital and

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## A COMPARATIVE STUDY OF DIFFERENT PACES OF SURYA NAMASKAR ON STRENGTH AND FLEXIBILITY ON ADULT WOMEN

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**Abstract:** The objective of the study was to find out the comparative study of different paces of Surya namaskar on strength and flexibility of adult women. **Methodology:** 20 subjects (10= 30 sec treatment group and 10= 60 sec treatment group) were selected for the purpose of the study. The age ranges of the selected subjects were 35 to 40 years of age. The selected physical (spine flexibility, spine strength and hamstring flexibility) variables were tested before and after six week of Surya namaskar in different paces. The data were analyzed by applying the Analysis of Covariance (ANCOVA) at 0.05 level of significance. **Result:** There were significance differences found between the experimental and control group after 6 weeks training on different paces of Surya namaskar. **Conclusion:** On the basis of the findings, it is concluded that the practice of 30 and 60 seconds of Surya namaskar for 6 weeks was sufficient enough to bring out the significance improvement on back strength and left spine flexibility and insignificance difference were found on hamstring flexibility and right spine flexibility. The recommendation of the further study is to increase the physical and physiological variable and increase in the sample size.

**KEYWORDS:** Yoga, Suryanamaskar, Paces, Hamstring, Spine, Flexibility, Strength, Adult Women

### Introduction

Yoga is essentially a spiritual discipline-based science, which focuses on bringing harmony between mind and body. It is an art and science of healthy living. The word 'yoga' is derived from Sanskrit root 'Yuj', meaning 'to join' or 'to unite.' Yoga exercises require setting the body into a certain correct position (asana) and then staying in that position for a period from several seconds to several minutes. When performing these exercises, one may use a variety of assistive tools like mats, belts, and blankets, which may be very helpful to the exercising person, especially in the cases of those with a level of general fitness. Suryanamaskar is a component of yoga. Surya Namaskar is a very strong technique that has an impact on the entire body. It is generally consisting of twelve different postures performed rhythmically and simultaneously with controlled breathing. In some yoga scriptures we find the mention of sixteen postures also for performing one complete round of Surya Namaskar. The Surya namaskar is design with the twelve postures namely Prayer pose (Pranamasana) it relaxes the whole body and enhances body posture, raised arm pose (hasta

utthanasana) Here abdomen stretches and lungs expands, hand to foot pose (padahastanasana) Stretches on the back pelvic region, equestrian pose (ashwa sanchalanasna) here, it stretches from the thigh through the lower back, stick pose (adho mukha dandasana) Strengthens the spine, abdomen, legs, hips, improve digestion, reduce belly fat, improves function of liver and kidneys, and thyroid gland health, salute with light points (Ashtanga namaskar) this pose strengthens the leg and arm muscles, develops the chest and exercises the region of the spine between the shoulder blades, cobra pose (bhujangasana) it relaxes the spine. People suffering from peptic ulcer, Hermia, intestinal tuberculosis or hyperthyroidism should practice this asana. mountain pose (parvatasana) here, it strengthens spine, hips and legs. equestrian pose (ashwa sanchalanasana) this pose stretches the lower back, hip, and hamstring. head to foot pose (padahastanasana) it Straighten the both legs, raised arm pose (hasta uthanasana), prayer pose (pranamasana) relaxes whole body. It is executed in a dynamic, breath-synchronized manner and has three main component: form, energy, rhythm. Surya namaskar has been shown in the latest studies to benefit health in a variety of aspects, such as regulating blood glucose levels and maintaining the cardiovascular as regulating blood glucose levels and maintaining the cardiovascular system healthy along with positive psychological health benefits. Surya namaskar elicited high to moderate muscle activation of main postural trunk muscles and lower extremities during alternating flexion-extension movements, resulting in an overall energy expenditure of 13.19 kcal with an average of approx. 3.79 kcal/min. Surya namaskar is a faster and more convenient way to improve strength, body composition, and endurance. Suurya namaskar has been shown in the latest studies to benefits health in a variety of aspects, such as regulating blood glucose levels and maintaining the cardiovascular system healthy (Kumar et al., 2021 & Hipparagi et al., 2019). The astanga yoga group had decreased diastolic blood pressure and perceived stress, and increased upper body and trunk dynamic muscular strength and endurance, flexibility, and health perception. Improvements for the hatha yoga group were significant only for trunk dynamic muscular strength and endurance, and flexibility. The findings suggest that the fitness benefits of yoga practice differ by style (Cowen et al., 2005). Yonglitthipagon et al., (2017) state that there were significantly reduce in menstrual pain and improved in physical fitness and QOL

after doing yoga exercises at home. With all the above statement and conclusion of their finding the researcher wants to know whether the 30 sec more effective or 60 sec of sūryanaskar is more effective in this present study

**Methodology:** For this study 20 adult women was selected age ranging from 30 to 35 years old were selected and they were equally divided into two groups 10 each as 30 second treatment group and 60 second treatment group. The period of treatment was six weeks in a schedule of weekly 5 days of treatment was given to both the 30 second and 60 second treatment groups and the pre-test and post-test was collected on following variables: strength and flexibility. Analysis of covariance (ANCOVA) was used to analyse the data. To test the significance 0.05 level of confidence was fixed.

**Results:** table no.1 descriptive statistic of Hamstring Flexibility, Spine Strength, Right Spine Flexibility, Right Spine Flexibility

Variables	Group	Mean	SD
Hamstring flexibility	30 sec	30.6	6.75
	60 sec	41.8	2.29
Spine strength	30 sec	82.2	34.21
	60 sec	110.05	32.17
Left spine flexibility	30 sec	40.6	7.74
	60 sec	46.2	4.34
Right spine flexibility	30 sec	38.6	7.64
	60 sec	45.2	4.51

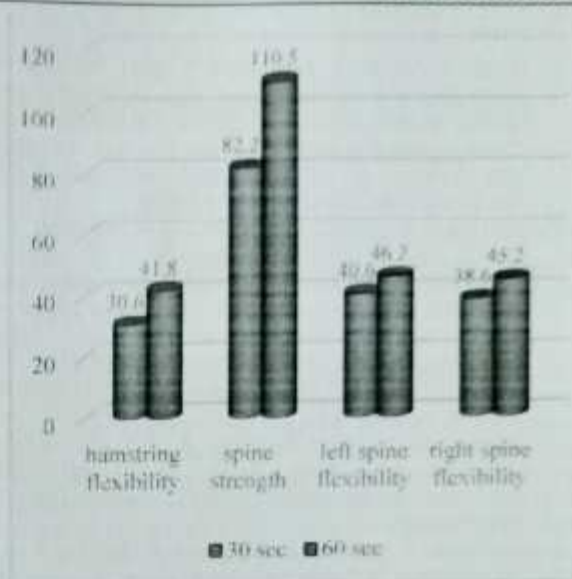
Table no. 2 ANCOVA table for the post treatment data of Hamstring Flexibility, Spine Strength, Spine Flexibility

Variables		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Hamstring flexibility	Contrast	0.721	1	0.721	0.21	0.653	0.012
	Error	58.397	17	3.435			
Spine strength	Contrast	32.086	1	32.086	1.438	0.247	0.078
	Error	379.361	17	22.315			
Left spine flexibility	Contrast	75.7	1	75.7	5.809	0.028	0.255
	Error	221.553	17	13.033			
Right spine flexibility	Contrast	67.2	1	67.2	4.405	0.051	0.206
	Error	255.355	17	15.256			

Table no. 3 pairwise comparison of 30 sec and 60 sec treatment group on Hamstring Flexibility, Spine Strength, Left Spine Flexibility, Right Spine Flexibility

Variables	Group	Mean Difference	Std. Error	Sig.	Lower Bound	Upper Bound
Hamstring flexibility	30 sec	0.63	1.375	0.653	-2.271	3.53
	60 sec	-0.63	1.375	0.653	-3.53	2.271
Spine strength	30 sec	-2.731	2.277	0.247	-7.536	2.074
	60 sec	2.731	2.277	0.247	-2.074	7.536
Left spine flexibility	30 sec	-3.945	1.637	0.028	-7.399	-4.92
	60 sec	3.945	1.637	0.028	0.492	7.399
Right spine flexibility	30 sec	-3.82	1.82	0.051	-7.66	0.02
	60 sec	3.82	1.82	0.051	-0.02	7.66

Fig: mean comparison on Hamstring Flexibility, Left Spine Flexibility, Right Spine Flexibility



**Findings:** Bintari et al., (2021) in their study said that both hatha yoga and surya namaskar increases the flexibility and balance of women. Jakhotia et al., (2015) circuit training and Surya namaskar having more effective in improving cardiorespiratory fitness muscle endurance and body flexibility. Juliash et al., (2019) suryanamaskar yoga training three times a week for six weeks can improve flexibility and strength of back muscle, as well as lung vital capacity Synthiya et al., (2018) state that there was improvement found on Body Mass Index (BMI), Flexibility, Muscular Strength and Endurance, Cardio Respiratory Endurance, Stress and Anxiety of experimental group due to the effects of Suryanamaskar practice with rhythmic training when compared to the control group. The result of the study also shows that the 30 seconds group does not show much improvement as compared to the 60 seconds on selected variables. So, suryanamaskar should be perform with 60 sec of duration for more effective to the practicers.

## CONCLUSIONS

From the analysis of the data, the following conclusions were drawn.

1. On the basis of the findings we concluded that the practice of Surya namaskar for 6 weeks is sufficient enough to bring out the significance improvement on back strength.
2. On the basis of the findings we concluded that the practice of Surya namaskar for 6 weeks is not sufficient enough to bring out the significance improvement on hamstring flexibility.
3. On the basis of the findings we concluded that the practice of Surya namaskar for 6 weeks is sufficient enough to bring out the significance improvement on left spine flexibility.
4. On the basis of the findings we concluded that the practice of Surya namaskar for 6 weeks is not sufficient enough to bring out the significance improvement on right spine flexibility.

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# Microbial Decontamination of Food

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# Chapter 14

## Decontamination of Fruit Beverages



**Nikhil Kumar Mahnot, Sayantan Chakraborty, Bhaskar Jyoti Das,  
Pallab Kumar Borah, and Sangeeta Saikia**

**Abstract** The beverage industry is one of the largest food processing sectors and the elevated growth of this industry is driven by consumer awareness toward eating nutritional and healthy diets. Consuming fresh beverages is universally recommended, however, fresh fruits and vegetable juices or their blends are prone to contamination by pathogenic- and spoilage-causing microbes. Consumption of such unsound beverages has led to multiple instances of food-borne disease outbreaks in the past. To ensure the delivery of microbiologically safe juices, alongside ensuring nutritional intactness and freshness, the beverage industry employs a gamut of technologies to decontaminate juices following national or international norms and practices, eg., conventional technologies like pasteurization and sterilization (thermal technologies). However, these treatment measures are known to drastically diminish nutrients and the flavor profile of juices. Additionally, consumer awareness toward minimally-treated products has led the industry to seek alternative technologies to improve preservation practices for adequate microbial safety, while maintaining freshness and flavor. The current chapter deals with the state-of-the-art practices in decontamination of beverage products, including high-pressure,

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pulsed-electric, pulsed-light, ultrasound and cold-plasma, and offers new sets of opportunities for both academia and industry.

**Keywords** Fruit juice · Beverage · Thermal technologies · High pressure · Minimally processed

## 14.1 Introduction

The beverage industry holds a big share of the food processing sector. This includes both alcoholic and nonalcoholic beverages and is considered to be quite mature. The nonalcoholic segment majorly includes the processed fruit and vegetable juices or their blends thereof, whereas alcoholic beverages comprise beer, wine, whiskey, etc. Tea and coffee are also included in the beverage sector (Uzuner and Cekmecelioglu 2019). Consuming beverages has been a habit for a long time; people find them soothing and palatable. Alcoholic beverages are consumed as a legal stimulant; nonalcoholic drinks are favored due to their sweet and unique flavors, refreshing characteristics, and nutritive value (natural sugars, fiber, vitamins, minerals, and bioactive constituents) to stimulate general health and well-being. In recent times, an increased understanding among consumers about the relationship between health and food intake has led to increased demand for beverages (more specifically nonalcoholic) that are either fresh or minimally processed, thus consisting of higher nutrients and unaltered natural flavor. This has further led to increased demand in both fresh and cold-pressed juice segments.

Beverage constituents, viz., sugars, vitamins, minerals, etc., are sufficient to support the growth of various microbes and at times provide a safe haven. However, certain products inherently have a low pH, are highly acidic, and have high sugar content, making them less susceptible to microbial growth. Nevertheless, there are numerous spoilage and pathogenic microbes that are well adapted for proliferation in such acidic formulations and can lead to spoilage (Shankar et al. 2021). Beverages are highly prone to contamination by microbes which either are naturally present or are incorporated during extraction, faults in processing, and improper packaging and storage. Microbial contaminations pose serious risks to consumers and also majorly disrupt the beverage characteristics making them unfit and unsafe for consumption purposes. Microbial spoilage of beverages is either bacterial or fungal or mixed as per the suitability of the beverage to support the growth. Varied strains of microbes that commonly contaminate beverages are *Saccharomyces* sp., *Candida* sp., *Zygosaccharomyces* sp., *Lactobacillus* sp., *Bacillus* sp., *Staphylococcus* sp., *Escherichia* sp., *Salmonella* sp., and *Listeria* sp. While some cause only spoilage, others cause food-borne diseases (Salomão 2018). Owing to the wide range of consumption of beverages by all age groups, it is of paramount importance to provide safety to consumers. Importantly, beverages are required to be manufactured under strict sanitary conditions as per governmental regulations worldwide.

The objective of the current chapter is to shed light on the validated and promising decontamination strategies that can be employed by the beverage sector.

The current chapter attempts to emphasize the application of novel/non-thermal technologies for ensuring beverages' safety and retaining fresh-like characteristics.

## 14.2 Safety Consideration for the Beverage Industry

Unheated fruit juices are susceptible to rapid microbial, enzymatic, chemical, and physical deterioration. Previously, it was thought that contamination of beverages (especially juices) with disease-causing microbes was improbable owing to low pH (<4.5). Low pH was considered to hinder their growth. However, several pathogenic food-borne disease outbreaks have been linked to the consumption of contaminated juices (Salomão 2018). For instance, consumption of unpasteurized orange juice caused disease outbreaks in Australia (1999) as well as in Florida, USA (1995). In Uganda (2015), a large persistent outbreak of typhoid fever was linked to the consumption of street-vended beverages contaminated with *Salmonella typhi* (Kabwama et al. 2017). Similarly, Washington, D.C., USA, witnessed outbreaks linked to *E. coli* O157:H7 and *L. monocytogenes* in people who consumed unpasteurized apple juice (Malik et al. 2020). Studies have reported the presence of pathogenic microorganisms in juices sold by many street cart vendors in India (Aneja et al. 2014; Titarmare et al. 2009; Tambeker et al. 2009). A *Vibrio cholerae* outbreak was reported in Pune, India, due to consumption of contaminated street-vended sugarcane juice (Malik et al. 2020). In all the mentioned instances, microbial contamination was observed to be arising from unhygienic manufacturing practices. Overall sources for contamination can be summarized as presence of microbial load on the fruit surfaces, use of contaminated water harboring fecal coliforms and *Shigella* sp. for washing and dilution purposes, contaminated ice, poor personal hygiene of handlers, improper storage, and presence of insects (Rashed et al. 2013; Aneja et al. 2014; Snyder and Worobo 2018; Malik et al. 2020).

In response to several outbreaks worldwide, different government bodies have made regulations to ensure safety associated with the consumption of beverages. For example, in India, the Food Safety and Standards Authority of India (FSSAI) have recently revised their microbiological standards for beverages (including minimally processed, thermally/non-thermally processed) which suggest an absence of *Salmonella*, *E. coli* OH157:H7, *Listeria monocytogenes*, and *Vibrio cholerae* in 25 mL of samples (FSSAI 2018). The European Union (EU) also advocates the complete absence of *Salmonella* in unpasteurized beverages (fruits or vegetables), and processors need to follow strict microbial reduction regimes to eliminate *E. coli*, *Salmonella*, and *Listeria* sp. Further, the EU also stresses on implementation of microbiological criteria in Hazard Analysis and Critical Control Points (HACCP)-based procedures alongside other hygiene control measures (European Commission 2005). The Food and Drug Administration (FDA), USA, also requires food processors to follow a processing regime to achieve at least 5-log reduction of pertinent microbes, viz., *E. coli*, *Salmonella* sp., and *Listeria* sp., in any food or beverages while also employing HACCP supported by Good Manufacturing Processes (GMP)

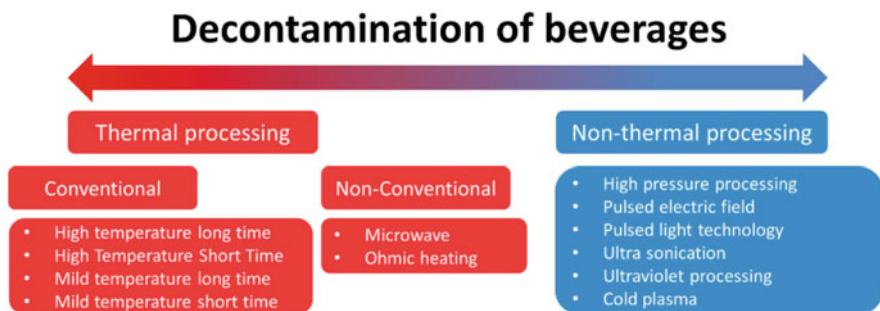
and Sanitation Standard Operating Procedures (SSOP) (FDA 2001a). The International Organization for Standardization (ISO) brought in ISO 22000 as a food safety management system. The system integrates risk analysis, hazard identification, monitoring system, and pan corrective measures to control food safety hazards. Likewise, GMP ensures that the product safety from microbial contaminations, involving plant sanitation, and management aspects of the processing units, maintenance of cleanliness of all the equipment, processing areas as well as personal hygiene of all the personnel working in the food industry (Aadil et al. 2019).

### 14.3 Technological Interventions for Decontamination of Beverages

Beverage decontamination in the industry is mostly dominated by thermal treatments. Thermal treatments ensure microbial safety and confer product stability leading to a sufficient shelf-life. However, novel technologies have created a niche for themselves as they have shown remarkable promise in ensuring safety while maintaining much of the natural and fresh-like characteristics of products. Both researchers and industrialists are looking forward to explore such techniques for industrial applications in the near future. Regardless of the decontamination technique used, it must ensure adequate microbial safety. The following sections discuss the different technological intervention in use and exploration for decontaminating beverages, as highlighted in Fig. 14.1.

#### 14.3.1 Thermal Processing

The thermal treatment of beverages to achieve a fivefold reduction in microbial population as well as inactivation of certain enzymes such as pectin methylesterase,



**Fig. 14.1** Summary of beverage decontamination interventions in use and current exploration. (Danyluk et al. 2012; Bevilacqua et al. 2018)

ubiquitous to citrus fruits, is currently based on recommended regimes of time and temperature formulated by the US Food and Drug Administration Hazard and Control Guide. Such thermal treatments range from mild treatment conditions to prolonged treatment, to deliver beverage products that are shelf-stable at either refrigerated conditions or without the need for refrigeration. Herein, the temperatures used for the process typically range from 60 to  $>100$  °C, where the lower limits apply to juices such as lime and the higher ranges apply to juices such as orange and grape. However, thermal treatment of beverages is associated with flavor, nutrient, and color degradation which are primarily driven by the breakdown of volatile sensory components accompanied with protein denaturation. Therefore, there is a pertinent need to improve existing thermal processing technologies which are based on the conventional steam and hot water-based plate-and-frame and shell-and-tube heat exchangers. Overall, the varied thermal treatments considered in the food industry or by researchers can be placed under two categories at large. Firstly, conventional thermal treatment methods can be further subdivided into treatments, viz., High Temperature Long Time (HTLT) [ $\geq 80$  °C— $>30$  s], High Temperature Short Time (HTST) [ $\geq 80$  °C— $<30$  s], Mild Temperature Long Time (MTLT) [ $<80$  °C— $>30$  s], and Mild Temperature Short Time (MTST) [ $<80$  °C— $\leq 30$  s]. Secondly, nonconventional thermal treatments involve the employment of microwave (200–1200 W/few seconds to several minutes) and ohmic heating techniques (Petruzzi et al. 2017). Among these, HTLT treatments are the go-to method for beverage processing and include processes like pasteurization and canning, or sterilization. Additionally, researchers have also utilized intrinsic hurdles such as changing pH, soluble solids, and adding natural/artificial antimicrobials along with mild heating conditions for safely processing beverages (Mahnot and Mahanta 2021).

Microwave heating has promising advantages over conventional treatments, viz., better process control, higher efficiency, reduced processing times, and floor space-saving. Literature reports have shown the elimination of microbes, inherent microbiota, as well as pathogens like *Listeria monocytogenes* in beverages. In recent studies, microwave heating resulted in non-detection of background microflora in sugarcane juice (Adulvitayakorn et al. 2020), and in orange-milk beverages, the bioactive properties were enhanced posttreatment (Martins et al. 2021). However, certain drawbacks like color and pH changes in juice products are significant. More importantly by optimizing microwave power and shorter treatment times, conferring safety against pathogenic microbes and stability during storage, as well as retention of nutritive constituents makes this technology more attractive.

Ohmic heating and nanofluid-based thermal processing are interesting emerging prospects in this regard (Salari and Jafari 2020). The former ohmic heating differs from conventional heating in its internal heat generation. Herein, the entire volume of food is heated, unlike conventional heating which relies on conduction and convective energy transfer. As such, ohmic heating can result in rapid and uniform heating (Wattanayon et al. 2021). Ohmic heating works via conduction of electric current, typically  $1 \text{ kV cm}^{-1}$  (Ariza-Gracia et al. 2020) through the beverage, resulting in rapid and volumetric heat dissemination depending on resistance,

voltage gradient in the field, and the electrical conductivity of the medium. The resulting uniform heating of the beverage is paramount in thermal damage and nutritional loss reduction (Mesías et al. 2016). It is of note that beverage conductivity in the range of  $10^2$  to  $10^5 \mu\text{S cm}^{-1}$  is the ideal framework for the application of this technology (Piette et al. 2006). Another method, viz., nanofluid heating, additionally holds immense promises for the thermal treatment of beverages. The method is based on the principle of higher thermal conductivity in nanofluids consisting of metals and their oxidized derivatives (dimension  $<100$  nm). For example, aluminum and copper have a thermal conductivity that is 600–700 times higher than water. Using such properties, it is possible to promote heat transfer alongside minimal pressure drop and fluid friction in a beverage (Farajollahi et al. 2010). Here, the volumetric nanomaterials' particle size is observed to be proportional to the heat transfer capacity (Munyalo and Zhang 2018; Zhang et al. 2021). Even low volume fractions, i.e., 1–5%, have been observed to increase the thermal conductivity of base fluids by  $>20\%$  (Xuan and Li 2000). Here, some important tips for consideration from the beverage industry are cosolvent type, nanomaterial size, nanomaterial concentration, and the thermal conductivity of the nanomaterials. Overall, such techniques have been carefully selected, employed, and continuously being optimized (considering the nature of matrices) to provide sufficient microbial safety and to better retain the nutritive and organoleptic value.

### **14.3.2 Non-thermal Processing**

Consumer needs are quite elusive. Current consumers are highly aware to consume healthy foods, with better retention of natural-like characteristics, and they prefer foods that are minimally exposed to harsh processing conditions. Non-thermal processing technologies tend to deliver on these demands. Thus, such technologies appeal to both consumers and industry. Table 14.1 enlists the efficacy of the major non-thermal interventions for decontamination of beverages. The different non-thermal technologies are quite concisely discussed in this section.

#### **14.3.2.1 High-Pressure Processing**

High-pressure processing (HPP) is one of the most studied and the most widely practiced technologies in the industry for non-thermal processing. Beverages are some of the most common foods to be treated using HPP. Conventional HPP treatments utilize pressures between 150 and 900 MPa for a short time frame (Bevilacqua et al. 2018). HPP involves pre-packed food that is placed in a pressure-transmitting medium (generally water) inside a chamber; the loaded chamber is pressurized at appropriate pressures and for a set period. The loaded chamber is depressurized and the treated product is ready to be delivered to consumers. Such treating conditions have proven to increase the shelf-life of juices and enhance safety



**Table 14.1** Summary of the effect of some non-thermal treatments on decontamination of beverages

S. No.	Technological intervention	Beverage	Processing conditions	Target microorganism	Outcome	References
1.	High-pressure processing	Orange juice	~400 MPa, ~200 s	<i>E. coli</i> O157:H7	>5-log reduction	Petrus et al. (2020)
				<i>S. enterica</i>		
				<i>L. monocytogenes</i>		
		Soy smoothie	450–650 MPa, 3 min	Mesophilic bacteria	3-log reduction	Daher et al. (2017)
2.	Pulsed electric field	Cactus juice	200 MPa, 10 min	Yeast-, mold-, and acid-tolerant microorganism	3-log reduction	Daher et al. (2017)
				Yeast, mold, and aerobic bacteria	1.8-log reduction	
		Red fruit smoothie with orange, banana, and lime	350 MPa, 7 min	Enterobacteria	2.4-log reduction	Daher et al. (2017)
				Psychrotrophic bacteria	2.5-log reduction	
		Low alcohol red wine	40 kV cm <sup>-1</sup> , 270 μs	Yeast count	2-log reduction	Puligundla et al. 2018
		Strawberry juice	35 kV cm <sup>-1</sup> , 27 μs, 350 mL min <sup>-1</sup> , 2 μs pulse	Acid-tolerant <i>E. coli</i>	5-log reduction	Yildiz et al. (2019)
Yeast and mold	2-log reduction					
Total aerobic count	2-log reduction					
<i>Saccharomyces cerevisiae</i>	8-log reduction					
Orange juice	30 L h <sup>-1</sup> , 20 kV cm <sup>-1</sup> , 150 kJ L <sup>-1</sup>	<i>E. coli</i>	9-log reduction	Lee et al. (2020)		
		<i>E. coli</i> O157:H7	5-log reduction			
Apple cider	Repletion rate of 1000–1500 pps at 30–35 kV cm <sup>-1</sup>	<i>S. typhimurium</i>	5-log reduction	Mendes-Oliveira et al. (2020)		
3.	Pulsed light technology	Orange juice, Pineapple juice, Tender coconut water	4-log, 4.5-log, and 5.33-log reduction	Preetha et al. (2021)		
		Pineapple juice	5-log reduction	Vollmer et al. (2020)		
Verjuice	6.12 J cm <sup>-2</sup> , 47 °C, 8.5 min	Aerobic mesophilic bacteria, yeast, and mold	5-log reduction	Kaya et al. (2020)		
		<i>Saccharomyces cerevisiae</i>				

(continued)

Table 14.1 (continued)

S. No.	Technological intervention	Beverage	Processing conditions	Target microorganism	Outcome	References
4.	Ultrasonication	Rice beverage	130 W, 10 min	<i>Salmonella enteritidis</i>	8.7-log reduction	Campaniello et al. (2018)
		Apple juice	40 kHz, 700 W, 5 min	<i>Salmonella typhimurium</i>	5.88-log reduction	Park and Ha (2019)
		Tomato juice	40 W cm <sup>-2</sup> for 5 min, 28 W cm <sup>-2</sup> for 10 min	Aerobic microbe, lactic acid bacteria, coliform bacteria, and yeast	> 10-log reduction	Starek et al. (2021)
		Kiwi juice	180 W, 40 kHz, 10–30 min, ~20 °C	Yeast and mold	0.9–1.5-log reduction	Tomadoni et al. (2017)
5.	Ultraviolet processing	Apple juice	1668 mJ cm <sup>-2</sup>	<i>Lactobacillus plantarum</i>	4.07-log reduction	Barut Gök (2021)
		Coconut water	40 mJ cm <sup>-2</sup>	<i>Saccharomyces cerevisiae</i>	1.97-log reduction	
		Orange juice	1420 mJ cm <sup>-2</sup>	<i>E. coli</i> , <i>Salmonella typhimurium</i> , <i>Listeria monocytogenes</i>	>5-log reduction	Bhullar et al. (2018)
6.	Cold plasma	Apple juice	1200 mJ cm <sup>-2</sup>	<i>Saccharomyces cerevisiae</i>	4.44-log reduction	Niu et al. (2021)
		Coconut tender water	Dielectric barrier type, 90 kV, 2 min, air	<i>Zygosaccharomyces rouxii</i>	5.46-log reduction	Xiang et al. (2020)
		Blueberry juice	Plasma jet, argon + O <sub>2</sub> , 11 kV, 6 min	<i>S. typhimurium</i>	>5-log reduction	Mahnot et al. (2019a, b)
		Tomato juice	Glowing arc discharge, N <sub>2</sub> gas, 40 W, 5 min	<i>Bacillus</i> sp.	7.2-log reduction	Hou et al. (2019)
		Apple juice	Plasma spray reactor, 21.3 kV, 30 min, air	Total aerobic mesophilic bacteria, yeast, and mold	3.45-, 3.55-, and 3.32-log reduction	Starek et al. (2019)
				<i>Zygosaccharomyces rouxii</i>	6-log reduction	Wang et al. (2018)

(Bevilacqua et al. 2018; W/giorgis 2019). HPP is effective in decontaminating vegetative cells and pathogenic and spoilage microbes, viz., *Salmonella* serovars, strains of *E. coli* and *L. monocytogenes*, *Bacillus* sp., and *Lactobacillus* sp., along with yeasts and molds in juices such as apple, peach, mango, grapes, cucumber, tomato, whey-based beverages, etc. (Daher et al. 2017; Podolak et al. 2020). It is of note that although HPP processes are capable of inactivating microbes, the efficacy is dependent upon process parameters (pressurization vs. depressurization vs. time), the type of product, extrinsic and intrinsic factors, and the target microorganism. As varied microbes have varied tolerance limits, one might consider the following microbe pressure tolerance pattern before implementing HPP: prokaryotes &gt; eukaryotes, Gram+ &gt; Gram-, cocci &gt; bacilli, stationary phase cells &gt; vegetative cells, spores being the least sensitive, and yeast and mold being the most sensitive to pressure (Bevilacqua et al. 2018; Huang et al. 2020). Typical HPP inactivation mechanism involves conformational changes in the bacterial cell wall and overall morphology, inhibition of protein synthesis alongside key enzymes, and disruption of genetic and cellular functions (Podolak et al. 2020). Petrus et al. (2020) demonstrated an effective HPP process in orange juice (~400 MPa for ~200 s) that successfully reduced >5-log reduction in each of *E. coli* O157:H7, *S. enterica*, and *L. monocytogenes*. In carrot and beetroot juice, HPP treatment (300–400 MPa, 5–10 min) sufficiently inactivated *E. coli* and *Listeria* sp. strains for enhanced shelf-life of the juices during storage (Nasiłowska et al. 2018). A compiled report of multiple studies reported that HPP treatment of soy smoothie at 450–650 MPa for 3 min and cactus juice at 200 MPa for 10 min caused 3-log reduction in mesophilic bacteria in the former and yeast, mold, and acid-tolerant microorganisms in the latter, respectively (Daher et al. 2017). Further, in red fruit smoothie with orange, banana, and lime, a 350 MPa for 7 min HPP treatment led to 1.8-log reduction in yeast, mold, and aerobic bacteria, 2.4-log reduction of enterobacteria, and 2.5-log reduction of psychrotrophic bacteria. Overall, HPP has been implemented by more than 160 industries (Daher et al. 2017). Evidently, HPP results in enhanced shelf-life via microbial inactivation; however, it is important to optimize the process parameters to assure total microbial safety to such products in accordance with the requirements set out by regulatory bodies, alongside minimizing changes in product characteristics.

#### 14.3.2.2 Pulsed Electric Field

Currently, the food industry employs pulsed electric field (PEF) treatment for enhancing mass transport, for increasing the yield of bio-actives and juice production, and also for pasteurizing liquid foods non-thermally. Basically, in PEF-based juice processing, the target juice is forced through a strong electric field generated between a two-electrode system. The electrodes are fed with high voltage pulses in microsecond ( $\mu\text{s}$ ) periods (Timmermans et al. 2019). Above a critical field strength, typically between 5 and 50  $\text{kV cm}^{-1}$ , confers microbial deactivation (bacteria, fungi, and others). Mechanistically, such strong electric fields induce the formation of pores on microbial cell membranes or by enlargement of existing pores. Depending

upon the treating conditions, such pores may be reversible or irreversible, i.e., permanent, thus changing cell membrane permeability. The altered permeability allows the loss of cell contents to the surrounding media or there is an influx of the surrounding medium, leading to altered barrier functions, membrane potential, and electrical resistance of the cells. This results in cell inactivation. USDA National Advisory Committee on Microbiological Criteria for Foods (Ransom and NACMCF 2005) has allowed the use of PEF technology for pasteurization. Also, juice processors can utilize PEF for commercial pasteurization in compliance with FDA's 5-log reduction regulation (21 C.F.R. 120; FDA 2001b). PEF technology is effective for beverage processing, including fruit juices and alcoholic beverages via inactivation of microorganisms such as *E. coli*, *L. monocytogenes*, *Lactobacillus plantarum*, *Salmonella* sp., *S. cerevisiae*, etc. In low-alcohol red wine, ~2-log reductions in the viable yeast counts were achieved with a PEF treatment of electric field intensity at 40 kV cm<sup>-1</sup> and a cumulative treatment time of 270 μs (Puligundla et al. 2018). For strawberry juice, a PEF treatment at 35 kV cm<sup>-1</sup> for 27 μs treatment time and 350 mL min<sup>-1</sup> flow rate with 2 μs pulses resulted in ~5-log reduction of acid-tolerant *E. coli*. The same treatment also resulted in a reduction of background microbiota (total aerobic bacterial counts and yeast-mold) by 2-log (Yildiz et al. 2019). A pilot-scale PEF treatment of orange juice resulted in 8-log and 9-log reduction in *Saccharomyces cerevisiae* and *Escherichia coli*, respectively, by flowing orange juice at the rate of 30 L h<sup>-1</sup> at a field strength of 20 kV cm<sup>-1</sup> at a specific energy of 150 kJ L<sup>-1</sup> (Lee et al. 2020). A continuous flow bench-scale PEF-processing system for apple cider at a repletion rate of 1000–1500 pps at 35–30 kV cm<sup>-1</sup> accomplished 5-log reduction of pathogens *E. coli* O157:H7 and *S. typhimurium* (Mendes-Oliveira et al. 2020). In a recent development, a microchip-PEF treatment on blueberry juice flowing at the rate of 7 mL min<sup>-1</sup> at 350 V with a pulse width of 0.15 ms led to complete inactivation of total plate counts and yeast-mold counts while extending the shelf-life and retaining bioactive components with minimal changes in sensory characteristics. This microchip technique requires a lower operating voltage to achieve the same germicidal effect compared to conventional PEF (Zhu et al. 2019). Multiple factors that affect the microbial inactivation with PEF are process factors (electric field intensity, exposure time and temperature, pulse wave width and shapes, chamber configurations), microbial entity factors (type, concentration, and growth phase of microbes), and sample matrix factors (pH, ionic strength, conductivity, and antimicrobials). Overall, microbial inactivation increases with increasing electric field intensity, exposure time, and the matrix temperature (Timmermans et al. 2019). However, the desired temperature is <40 °C. Again, it is to be noted that Gram-positive bacteria and yeasts are more resistant to electric fields than Gram-negative bacteria. With PEF a linear inactivation is generally observed for microbes in the first moments of the treatment followed by a tailing (Sagarzazu et al. 2010; Walter et al. 2016). Tailing phenomena indicate an increased resistance of the microbial population inactivation. Recently, a team of researchers revealed that splitting PEF treatment with a period of delay in between led to tailing disappearance (Delso et al. 2020). The authors supported their results with *Salmonella typhimurium* in milk and orange juice. This opens further opportunities in strategically developing PEF-based decontamination in juices.

### 14.3.2.3 Pulsed Light Technology

Pulsed light technology (PLT) is an innovative method used for food decontamination. In PLT a food material is subjected to a short duration of high-intensity pulses of light emitted by an inert-gas flash lamp. Such short-duration high-intensity pulses are capable of inducing cell disruption and cell death. The short pulses cover the ultraviolet (100–400 nm), visible (400–700 nm), and infrared (700–1000 nm) light spectrum range. Currently, the widely accepted antimicrobial effect hypothesis involves photochemical, photothermal/photophysical, and indirect chemical mechanisms (Franco-Vega et al. 2021). The photochemical mechanism is majorly mediated by UV, which is well known to negatively disrupt genetic material leading to microbial inactivation. In the photothermal mechanism, the pulsed light energy gets absorbed by microbial cells, which generates a rapid and lethal increase in cell temperature leading to cellular rupture. Concerning indirect chemical mechanisms, PLT-induced germicidal chemicals such as hydroxyl radicals, ozone, or hydrogen peroxide are responsible for microbial reductions. There is quite limited work carried in beverages pertaining to pulsed light treatments. Mostly, it has been applied to fruit juices, while applications on vegetable juices are scarce. PLT application in different beverages is effective in achieving ~5-log reduction in pathogens such as *L. innocua*, *E. coli*, and *S. enteritidis* in juices such as melon juice at a pulse energy of 71.6 J cm<sup>-2</sup> for 60 s (Ferrario et al. 2013). Also, greater than 5-log reduction in spoilage microorganisms such as *S. cerevisiae* has been reported for melon juice, apple juice, blueberry wine, and white grape wine (Ferrario et al. 2013; Mandal et al. 2020). In a recent study, a maximum of *E. coli* inactivation of 4.0 log, 4.5 log, and 5.33 log was noted in orange, pineapple juice, and tender coconut water, respectively. These juices were subjected to pulsed light at a fluence rate ranging from 0.18 to 5.6 W cm<sup>-2</sup>, the dosage of 95.2 J cm<sup>-2</sup>, and treatment time varying between 0 and 15 s (Preetha et al. 2021). Also, a 5-log reduction in aerobic mesophiles and the yeast and mold counts was obtained on pulsed light treatments with 2.4 kV with either 94 or 187 pulses (757/1479 J cm<sup>-2</sup>) in pineapple juice (Vollmer et al. 2020). Although PLT seems promising, a lot of research needs to be carried out to further strengthen its application in the beverage industry. However, one can utilize pulsed light technology in combination with other available strategies to increase the efficiency of microbial inactivation of hardy microbes.

### 14.3.2.4 Ultrasonication Treatments

Ultrasound (US) technology has seen quite wide applications and has emerged as a non-thermal method for processing, extraction, and decontamination. Owing to its microbial deactivation ability, it has been promisingly used for juice preservation. The antimicrobial action mechanism of US is attributed to the cavitation phenomena that lead to physical, thermal, and chemical effects. The rapid cavitation leads to localized pressure changes and temperature hot spots that induce cell walls to break,

the cell membranes to disrupt on thinning, free radicals mediated DNA damage leading to cell inactivation, etc. (Paniwnyk 2017; Dolas et al. 2019). In beverage processing applications, the range of ultrasound used lies between 20 and 10 MHz. In a study with apple juice, ultrasound treatment (400 W and 24 kHz) induced sublethal injuries to spoiler yeasts *Candida parapsilosis* and *Rhodotorula glutinis* leading to enhanced storage of the juice (Bastianello et al. 2016). Similarly, in passion fruit juice, ultrasonication for 8 min (500 W and 20 kHz) proved to be optimum to enhance its shelf-life by inactivating aerobic mesophilic bacteria and yeast (Gómez-López et al. 2017). In fresh-pressed tomato juice, ultrasound application (20 kHz) with exposure to an ultrasonic field of 40 W cm<sup>-2</sup> for 10 min completely rendered tomato juice free from aerobic microorganisms, lactic acid bacteria, coliform bacteria, and yeast (Starek et al. 2021). Again sonication in red and yellow watermelon juice resulted in non-detection of total aerobic plate counts and *Enterobacteriaceae* counts. In Sirkenecubin syrup (mixture of vinegar and honey), ultrasonication (26 kHz) led to non-detection of counts of *Enterobacteriaceae*, total aerobic bacteria, and yeast and mold in 15 min (Yıkmiş 2020a). The same author reported a similar non-detection of microbes in red and yellow watermelon juice upon sonication for 8 min (Yıkmiş 2020b). Further, it is important to point out that ultrasound alone cannot be a technique that can suffice beverage decontamination especially considering the presence of spores that are difficult to deactivate (Lim et al. 2019). In common practice, ultrasound has been employed along with temperature (thermosonication), pressure (manosonication) or both (manothermosonication), and osmotic pressure (osmosonication) for spore and spore former decontamination.

#### 14.3.2.5 Ultraviolet Processing

In general, UV treatment is most commonly associated with water disinfection. Lately, UV processing has evolved as a promising application for assuring food safety. The US Food and Drug Administration (USFDA) has concluded and approved the usage of UV radiation for safe processing and handling of foods through their issued Code 21CFR179.41, and can be used as an alternative treatment to reduce pathogens and other microorganisms (Shah et al. 2016). The UV-mediated germicidal effect is achieved by the use of UV-C (200–280 nm) part of the UV radiation spectrum (100–400 nm). The UV-C is widely known for its germicidal properties and lethality against bacteria, fungi, viruses, and protozoa (Martínez de Alba et al. 2021; Mackenzie 2020; Yin et al. 2013). A UV-C radiation of 253.7 nm is the commonly used optimal wavelength having maximal germicidal action (Bhullar et al. 2018). Mechanistically speaking, UV-C can disrupt the genetic material (DNA/RNA) in microbial cells, thereby altering cell metabolism and reproduction, the result being cell death (Singh et al. 2021). Sufficient research has been carried out on the decontamination of beverages with UV treatment. UV-mediated decontamination of a wide range of beverages prepared from apples, grapes, pomelo, pineapple, watermelons, oranges, carrots, red pitaya, coconut water, tiger nut milk,

soymilk, iced tea, etc. has resulted in promising as well as successful results (Shah et al. 2016; Singh et al. 2021). These studies have covered different microbes such as *Escherichia coli*, *Salmonella* sp., *Listeria monocytogenes*, *Alicyclobacillus acidoterrestris*, *Lactobacillus* sp., *Cladosporium* sp., yeasts, and molds as well as background microflora. Various configurations of UV reactor/treatment systems have been studied; the process efficacy of such systems depends upon the transparency of a beverage, UV dose delivery, and its mixing efficiency. In one work, researchers developed a thin-film concentric ring type UV-C reactor and were able to reduce *Alicyclobacillus acidoterrestris* in inoculated cloudy apple juice by more than 5 logs on recirculation through the reactor at a UV dosage level of  $125 \text{ J mL}^{-1}$  (Sauceda-Gálvez et al. 2021). On the evaluation of a UV-C reactor based on Dean vortex technology for its efficacy against *Lactobacillus plantarum* and *Saccharomyces cerevisiae* populations in apple juice, this resulted in 4.07 log and 1.97 log populations, respectively, at a dosage level of  $1668 \text{ mJ cm}^{-2}$  (Barut Gök 2021). In another study using the same Dean vortex technology, it was observed that a UV-C dosage of  $8.38 \text{ mJ cm}^{-2}$  was able to reduce *Escherichia coli* O157: H7 by >5 logs. On the contrary, the same treatment could not fully decontaminate yeasts and molds in a pineapple-mango juice blend. However, the colony counts for yeast and molds were under the permissible limit ( $1.26 \text{ log CFU mL}^{-1}$ ) (Amanina et al. 2019). Bhullar et al. (2018) with a flow spiral reactor at dosage levels of  $30 \text{ mL cm}^{-2}$  were able to achieve >5-log reductions of *E. coli*, *Salmonella typhimurium*, and *Listeria monocytogenes* in coconut water without generating any cytotoxic components. In recent times, UV-C light-emitting diodes (LEDs) as an alternative UV source have been employed for juice decontamination specifically in orange and apple juice. Studies with UV-C LEDs have shown that at a  $1420 \text{ mJ cm}^{-2}$ , dosage 4.44-log reduction of *S. cerevisiae* population in orange juice could be achieved, while in apple juice, *Zygosaccharomyces rouxii* levels were significantly reduced by 5.46-log reductions at  $1200 \text{ mJ cm}^{-2}$  dosage (Niu et al. 2021; Xiang et al. 2020). In a pilot-plant study, 3.6 log-cycles, 3.7 log-cycles, and 1.3 log-cycles of inactivation were achieved in an orange-banana-mango-kiwi-strawberry blend for *L. plantarum*, *E. coli*, and *S. cerevisiae*, respectively (Fenoglio et al. 2020). Another pilot-scale study with a UV system with a turbulent flow resulted in a 4-log reduction in different microbes' population, viz., *E. coli* K12, *Staphylococcus aureus*, *Salmonella* sp., and *S. cerevisiae* except for *Cladosporium* sp. when inoculated to Rooibos iced tea beverage (Monyethabeng and Krügel 2016). In carrot juice, a UV-C treatment led to a significant improvement in shelf-life as it restricted the growth of mesophilic and psychrotrophic bacteria along with *Enterobacteriaceae*, yeast, and molds as compared to untreated juice (Riganakos et al. 2017). Most studies about UV-C treatment of beverages have suggested minimal or no impact on the physical, chemical, as well as sensory properties. Overall, one can easily deduce that UV-C treatments are quite effective in reducing microbial loads, thereby providing safety in beverages and increasing shelf-life. However, still more research needs to be carried out to better optimize UV-C treatment taking into consideration of the varied juice matrices.

### 14.3.2.6 Cold Plasma Processing

Cold plasma (CP) processing has created a niche as a novel, green, non-thermal processing technology for decontamination of food and food products. The plasma process is acclaimed to be a fast, simple, economical technique that leaves no chemical residues (Mahnot et al. 2020). CP technology employs gases that are energized, leading to the generation of reactive gas species, charger ions, and neutral gas species, which in turn confer microbial inactivation (Niemira 2012). Literature suggests that CP inactivation, in general, is majorly mediated by the reactive oxygen species (ROS) and reactive nitrogen species (RNS), along with minor contributions due to emitted ultraviolet radiations. However, in liquids these generated gas species also tend to diffuse into the liquid causing acidification, synergistically leading to microbial cell stress and eventual cell death. These species tend to damage lipid by layer and degrade DNA, lipids, and proteins leading to impaired complex cell responses and cell signaling. The cells are unable to repair such damage and eventually get killed or inactivated (Thirumdas et al. 2015). CP technology has been routinely utilized for surface decontamination; however, the technology faces a challenge when considering decontamination of liquids owing to the diffusion of gas species inside the liquid. Nonetheless, scientists have come up with unique strategies to treat liquid foods to eradicate both bacteria and fungi using variously configured plasma generating and treatment conditions. Mahnot and others (2019a, b) were able to inactivate >5 logs of *S. typhimurium* populations in tender coconut water using a dielectric barrier discharge (DBD) type plasma setup in 2 min at 90 kV using air as a working gas for plasma generation. The same group also were able to decontaminate *L. monocytogenes* and *E. coli* by 5 logs, through a similar setup using both air and modified air (O<sub>2</sub>, 65%; CO<sub>2</sub>, 30%; N<sub>2</sub>, 5%) as the working gas (Mahnot et al. 2019a, b). In apple juice and sour cherry nectar, an atmospheric jet plasma setup with air as a working gas was able to achieve 4 and 3.3-log reductions with a treatment time of 2 min (Dasan and Boyaci 2018). *Bacillus* sp. are hardy organisms; a plasma jet treatment (argon + 1% O<sub>2</sub>) on blueberry juice led to a 7.2-log reduction in *Bacillus* sp., in 6 min at 11 kV (Hou et al. 2019). A gliding arc discharge method for decontaminating tomato juice using N<sub>2</sub> gas resulted in 3.45-log, 3.55-log, and 3.32-log reductions in the total aerobic mesophilic bacteria colonies, yeast, and molds, respectively, just after a 5-min treatment at 40 W power level (Starek et al. 2019). The same lab also reported a 3.7-log reduction in *Candida albicans* in 1 min and a 3.5-log reduction in *Saccharomyces cerevisiae* in 5 min in tomato juice at the same treatment conditions (Starek et al. 2020). In apple juice, a plasma spray reactor (operating conditions: 21.3 kV, 30 min) using normal air as the feed gas enabled approx. 6-log reduction in *Zygosaccharomyces rouxii* (Wang et al. 2018). But with a DBD setup, 5-log reductions of *Z. rouxii* were achieved in 140 s at 90 W power with the feed gas as air (Xiang et al. 2018). In an interesting work indirectly related to the safe processing of wine, CP technique could completely inactivate *Brettanomyces bruxellensis*, while *Pediococcus pentosaceus* and *Acetobacter pasteurianus* inactivation were limited (Sainz-García et al. 2021). From the various studies, one can



deduce that CP process parameters such as power, voltage, treatment time, feed gas composition, and sample treatment volume are key parameters to be optimized to get maximal inactivation efficacy. Overall, CP technology has delivered promising results in decontaminating beverages, although there is a need for further process optimizations and pilot-scale studies to make it a commercially viable technique.

The other non-thermal processing techniques for beverages such as ozone treatment, use of antimicrobial metabolites, fermentation, and combinations of the technologies mentioned so forth, also commonly described as hurdle technologies, are being actively researched, and interested readers are directed toward other excellent reviews, books, and studies (Lacroix 2010; Badwaik et al. 2015; Singh and Shalini 2016; Brodowska et al. 2018).

## 14.4 Conclusion

Decontamination in the beverage processing sector is taken quite seriously. Optimized conventional, novel technologies or combinations of multiple technologies are being explored or even implemented to deliver on consumer demands. For processors, considerations such as beverage matrices, type of spoilage and pathogenic microbes, quality, and sensory value retention are quite important to process beverages with appropriate techniques and deliver as per consumer preferences. Although considerable research is available as discussed in the chapter, the shelf-life considerations of processed juices specifically by novel technologies are not quite extensive. Limited shelf-life and requirement of refrigerated storage remain as hurdles for processes from being implemented on industrial scale. Nonetheless, in-depth research on deciphering mechanisms to easily inactivate hardy microbes and extensive shelf-life studies would be quite important. The ongoing COVID-19 pandemic has hampered the beverage sector initially but the market is on track for a significant growth. Importantly, the pandemic has taught us the importance of building strong immunity and keeping oneself safe from deadly diseases. As a consequence, people seek products having immune-boosting characteristics. The beverage sector is gearing up for the same and looks forward to delivering newer functional beverages with the “immunity-boosting” tag at the same time maintaining strict microbial safety. The newer blends in the beverage sector will require unique interventions and optimizations in processing technology, to deliver on the changing consumer needs. Considering the emergence of viral pandemics, challenges on viral decontamination in beverages remain a rather unexplored area alongside other known pathogenic microbes. Thus, further research needs to be carried out to process and develop safe beverages that can be industrially viable.

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# Disease Detection in Tomato Leaves Using Raspberry Pi-Based Machine Learning Model



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and Ram Sewak Singh

## 1 Introduction

India has the second-highest population in the world, and of this, nearly 70% of people rely on agriculture for their living, either directly or indirectly. Because of our wide climatic variations, they grow various types of cash crops and food crops, such as wheat, rice, and mangos [1]. Farmers have to face many difficulties, but one major difficulty is identifying plant disease. Plant disease detection by seeing is a more time-consuming and inaccurate process that can only be performed in specific domains. Using an automated detection approach, on the other hand, requires less efforts, less time, and improves accuracy. Some colour spots, early and late scorch, and various fungal, viral, and bacterial diseases are common in plants. Artificial intelligence-based approaches may be used to identify and classify plant diseases automatically as method used in signal processing with AI [2–6]. Today, most plant disease detection is done mostly by just seeing the plants and guessing the disease. Then, they use different pesticides for that disease. Sometimes it works, but many times it can't guess. It leads to the wrong and unnecessary use of chemicals, and the original disease is still present there. It results in more losses for farmers. Their crop is damaged. They have financial losses from buying pesticides, and their crops are also poisoned by these chemicals. We have some methods to detect diseases, but they

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# **Dynamism of Democratic Development**

*Contemporary Concerns and Gandhian Roadmap*

**EDITORS**

**Ravi Ranjan Kumar • Monika Sharma • Shriprakash Pal**



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*Routledge Readings*

# **ROUTLEDGE READINGS ON SECURITY AND GOVERNANCE IN NORTHEASTERN INDIA**

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This book will serve as essential reading for students, scholars, policy-makers, practitioners of South Asian studies, Northeast India studies, history, development studies, labour studies, sociology, public administration, environmental studies, law and human rights, regional literature, cultural studies, geography and economics.

**Sumi Krishna** is an independent scholar and widely published author on gender, environment, development and livelihoods, is former President of the Indian Association for Women's Studies and is Series Editor of the Routledge 'Transition in Northeastern India' series.

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# Routledge Readings on Security and Governance in Northeastern India

Resource Conflicts, Militarisation  
and Development Challenges

Edited by Sumi Krishna



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K. B. VEIO POU

# Preface

Academic and general interest in northeastern India has increased greatly in recent years, with new directions in public policy and improved connectivity. Even as higher education in the northeastern States has expanded, the number of research students and teachers from the region at universities and institutions across India has also grown. Their interest in studying their home States has provided an impetus to reconsider many prevailing assumptions. The resulting cross-currents of thought have led to a remarkable output of high-quality studies. The two companion volumes, *Routledge Readings on Colonial to Contemporary Northeastern India: Customary Practices, Gender and Livelihoods* and *Routledge Readings on Security and Governance in Northeastern India: Resource Conflicts, Militarisation, and Development Challenges*, meet the felt need for compendiums of significant writings.

These *Readings* represent a fraction of Routledge's publications on northeastern India between 2010 and 2020. I have tried to choose original, informative and analytical contributions to scholarship, marked by academic rigour and readability, so as to reach students, researchers, policy-makers and interested non-specialists. Each volume stands on its own and includes 15 selected chapters, full reprints in the original formats, with Part Introductions that highlight the chapters. The Introduction to both books focuses on critical cross-cutting themes. Many chapters point to the rapid changes in the region; in a few cases, updates since the chapters were written are mentioned either in the Introduction or the Part Introductions that deal with specific sets of chapters in each book.

The authors include doyens in the field and younger scholars whose refreshing perspectives have altered the ways in which we understand northeastern India. Their diverse voices and grounded research deal with the region as a whole, the eight States – Arunachal, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura – and the north Bengal 'gateway' into the Brahmaputra valley. The complexity of issues is reflected in the wide range of disciplines that the chapters draw upon: literature, history, political science, social anthropology, sociology, economics, public policy, ecology, agriculture, life sciences, gender studies, urban studies, international studies, peace and conflict studies. The interdisciplinary

approach of the *Readings* provides insights into the historical and current trends shaping northeastern India and points to new directions and challenges for research and policy.

Most of the authors are from one of the eight States or are located there. A few have had long associations with the region through research and writing. Indeed, my own interest, sparked by contemporaries from the northeastern States at the University of Delhi in the late 1960s, grew into sustained professional engagement in subsequent decades. For many years, travel and communication in the interior areas of the hill States (for which 'Inner Line' permits are still required) was difficult; tourism was acceptable, research was looked askance at. It was possible to carry out field studies in the region only because of the overwhelming hospitality of a cross-section of people and the support of professionals in varied occupations.

I thank Routledge India for inviting me to edit the *Readings*, and Shoma Choudhury, Rimina Mohapatra and Shashank S. Sinha for over a decade of working productively together on the Routledge 'Transition in Northeastern India' Series, for which I have been series editor. I am particularly grateful to all those who offered pertinent suggestions and comments on the selection of chapters in the *Readings* and on the Introduction. Special thanks to the editors/authors of the volumes from which these chapters have been taken for their cooperation in this collective endeavour.

**Sumi Krishna**  
Bengaluru

# A Note on Style

I prefer to use the term 'northeastern India', eschewing the homogenising term 'North East', which was imposed on the region in a particular political context half a century ago. Some of the chapters in the *Readings*, however, use different terms: such as 'North East India', 'Northeast India', 'North-East India', and the 'North East'. This varied usage has been retained and itself reflects the problems in viewing a diverse region as a whole.

– Editor

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# Introduction

## Colonialism to Development in Northeastern India

*Sumi Krishna*

This book covers a range of interrelated concerns, examining India's vision for the region's economic growth as a 'power-house', a strategic conduit to southeast Asia and associated questions of security and governance. It discusses conflicts around common resources and the criticality of land; how modern laws themselves may undermine people's resource rights; and why resource conflicts intensify ethnic differences, erupting into violence. It analyses how state policies play out in varied contexts, from the negation of forest rights to the leveraging of ethnicity in negotiations around development, and how the significance of traditional community institutions in managing resources holds in rural and urban contexts.

Parts of northeastern India are among the most heavily militarised regions in the world. The military presence overshadows governance and development. So, even as the discourse on security has been broadened to encompass human wellbeing and health, transforming these normative ideas into practical programmes is difficult, particularly in areas that are close to the international borders. In the 21st century, literacy and education are keys to human development, but rural–urban and gender gaps persist. Both school and society shape social stereotypes and smaller tribal groups have to negotiate many-layered identities. This is also apparent in the rich seam of creative writing across the States, which reveals the power of an adopted language, English, in giving voice to the structural violence of daily life in the diverse and highly charged politicised environments of the region.

The chapters in this book, together with the companion volume *Routledge Readings on Colonial to Contemporary Northeastern India: Customary Practices, Gender and Livelihoods*, address a range of interrelated issues. This Introduction locates these chapters within a broader context of writings on the region and provides an overview of four critical themes that cut across both books: a) Framing northeastern India; b) Diversities and identity assertion; c) Patriarchy and the women's question; and d) Politics of resource control and development.

## Framing northeastern India

*‘Where is this North-east?’*

– Patricia Mukhim (2005)

If the familiar map of South Asia is turned upside down, the northeast of India appears in the southwest, like the spreading roots of a tree rather than a far out branch. This peripheral ‘branch’ of the Indian subcontinent has held a particular allure for colonial administrators and the Indian nation-state.<sup>1</sup> With scattered tribal<sup>2</sup> populations in the hills, and tribal and non-tribal settlements in the valleys, this resource-rich region served the British as a security buffer against inimical forces beyond its margins and a source of economic goods like tea, timber and petroleum – an approach inherited by Independent India. The Constituent Assembly debated governance options for the Scheduled and Tribal Areas<sup>3</sup> but as Savyasaachi (1998: 4) says, ‘the liberal tradition for governance did not have the ear for the voices of the tribal forest dwellers, nor did they see that both protection and reform were based on social relations of dominance and subjugation’.

The ‘agglomeration of a number of distinct politico-administrative units in which people and territory have been organised at different phases of history’ (Xaxa\* 2018: 19) are now eight ecologically and socio-politically different States formed at different times, under different constitutional arrangements: Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. The North Eastern Council (NEC) was set up in 1972, under the Union Ministry for Development of North-Eastern Region (DoNER), as Meghalaya and Mizoram were separated from Assam and the Union Territory of Manipur became a State. Some critics (Prabhakar 1973) saw the NEC as the centre’s attempt to retain control over the region. With the liberalisation of the Indian economy in the 1990s, the ‘Look East’ policy invested the northeastern region (henceforth NER) with a certain unity (Planning Commission 1997; Verghese\*\* 2008). Subsequently, the geographic ‘opportunity’ presented by the NER in a globalising world was seized upon in the *North Eastern Region Vision 2020* (DoNER 2008; Rajkumar\*\* 2016). This has been critiqued (D’Souza 2018: 450–451) for ‘getting the geography of NER to sidestep its own history’, misreading ‘a range of realities on the ground’. The compilation of the ‘Northeastern Region District SDG Index’ (NITI Aayog 2021) documents ‘intra-regional disparities’ (within each State and among them) on the UN’s sustainable development goals. It avoids the earlier terminology of isolation and backwardness but continues to emphasise the NER’s resource potential and the lack of industries, infrastructure and connectivity for national and strategic reasons.

Viewed from within, the NER is no undifferentiated whole. Indeed, *Shillong Times* editor Patricia Mukhim’s (2005) anguished question: ‘Where is this North-east?’ continues to reverberate in Chitra Ahanthem’s (2021) angry assertion that a ‘single uniform identity’ for all the writing

from the States in the region ‘is not remotely authentic’. As Sanjay Hazarika (2018: 342) observes,

For a start, where does the ‘Northeast’ figure in the public imagination? Of course, it is there in PhD theses, lectures, seminars and workshops, in books, essays and formal papers, press statements and articles. But where is it in the public imagination? For in the region we call the Northeast, few people think of it as a whole, as a package. It remains an artificial construct, which is emphasized in official approaches and ideas of the region and its connect to the neighbourhood. But in the eyes and imagination of ordinary people, say in Assam, there is an Assamese or Bodo or Bangla or Mishing imagination, or a Chakesang, Ao, Sumi [Sümi], Angami or Tangkhul imagination among the Nagas, or a Manipuri imagination for the Meiteis. These are just examples of how people think – to think for the region is something left to politicians, officials, intellectuals and media figures who when they return home return to their original identities.

Arambam Noni\* (2016: 25) argues that the NER is ‘such a difficult terrain of politics and governance’ because colonialism cast the region as a peculiar frontier; this framing lingers on, arresting the normal practices of politics, an ‘image trap’ from which it needs to be rescued.

### Diversities and identity assertion

*I am a curiosity, an ethnic specimen.*

*Politics, history, anthropology, your impressive learning,*

*All unable to answer the fundamental question –*

*‘What does an Indian look like?’*

*An Indian looks like me, an Indian is Me.*

– Cherrie L. Chhange (2011): ‘What does an Indian Look Like’

The extraordinary diversity of the NER is related to its singular geological and biogeographic history. This is where the pre-tertiary Tethys Sea first began to close as the Indian (Deccan) and Eurasian continental plates collided thrusting up mountains that are still rising and fragile. The Himalayan ranges lie on an east–west plane but have been wrenched into a north–south axis in Arunachal and curve around sharply in the extreme east of Assam (at the India-China-Myanmar tri-junction) into the Patkai hills along the India–Myanmar border. The young mountains are dissected by geologically older rivers creating a varied topography of hills, gorges, plateaus and riverine valleys, a complex hydrological system that drains into the Brahmaputra, the Barak and their tributaries. In the valleys, with abundant rainfall and flooding rivers, often no sharp line separates land and water. In eastern Assam the Pagla (mad) river meanders continuously; in the foothills of eastern Arunachal a masonry bridge stands in the midst of fields where



once a river ran (Krishna 2012a). Dilip da Cunha's (2019) thesis that rivers are culturally constructed as neatly drawn 'lines' on a map has particular resonance in the NER.

The geological uplift of the eastern Himalaya opened up pathways for floristic elements from all directions (present-day Tibet, India, China, Malaya and Myanmar). The confluence of flora in varied micro-climates makes the NER a rich repository of endemic and diverse tree, plant and food-crop species. The complex vegetation of the Darjeeling-Sikkim mountains defied British attempts at classification (Arnold 2005: 196):

At times the representative flora of the tropical, temperate, and alpine zones, instead of being geographically distant and distinct, could be seen simultaneously from a single vantage point or found entangled in jungles that were, botanically speaking, tropical and temperate at the same time.

Today, the NER is among India's (and the world's) centres of biodiversity designated as 'hotspots' that are threatened by human activities.

These heterogeneous landscapes within a small area (8 per cent of India) are intertwined with the NER's human diversity (4 per cent of India's population), peopled since pre-historic times by several waves of migrations. The women and men who inhabited, dwelt and worked on the hillsides, plateaus, valleys, forests and wetlands shaped these varied landscapes by their activities, investing local spaces with particular beliefs and patterns. This is akin to a 'taskscape made visible' (Ingold 1993: 152), 'an enduring record of – and testimony to – the lives and works of past generations who have dwelt within it, and in so doing have left there something of themselves' (ibid: 167). Taskscapes are also 'genderscapes' (Krishna 2009), reflecting the community's gender ideology and practices; as the Nagas say, 'forests for men, fields for women; wild animals for men, domestic animals for women'.

The Anthropological Survey of India (Singh 1992: 44) identified 382 distinct communities in the NER. *Vision 2020* mentions 200 ethnic groups (DoNER 2008: vii). In multilingual Nagaland, 23 'indigenous language groups' have been recognised, with the same language often varying from village-to-village and between women and men (Sreedhar 1974). An Angami story explains this: People were constructing a tower to heaven; as they built higher and higher, God (a woman) feared that she would not have sufficient gifts for them all if they reached her. So, she made their languages unintelligible to one another, spreading confusion and ensuring that the tower was not completed.<sup>4</sup> Till the late 19th century these several tribes had no common name. They adopted the term 'Naga' after it was used by the British, and Nagaland was formed in 1963 on ethnic, not linguistic grounds.

The colonial encounter and evangelical missions altered the people's fluid, multifarious relationships with their environments. Lianboi Vaiphei\*

(2016) says missionaries introduced the idea of identity linked to territory but the ethnic communities in the Manipur hills also incorporated their traditional beliefs into Christianity. Of the Naga, John Thomas\* (2016: 35–36, 2019: 315) observes that their universe was ‘centred on land’, on equal sharing and maintaining ‘reciprocity and respect’ and that their belief systems were rooted in specific hills, rocks and rivers, trees and animals, an everyday material world that varied from one village to the next, not defined, standardised, proclaimed, a localised ‘spatiality’ that was negated by evangelical (and ‘temporal’) Christianity. Nevertheless, it was their understanding of Christianity that enabled them to cope with assaults on their dignity and rights.

In pre-colonial Assam, Ritupan Goswami (2012) notes that settlements followed three natural agro-ecological zones: temporary cultivation on seasonally flooded riverine islands and *chars* (sandbanks); transplanted rice in fertile densely populated lands further inland; and the foothills around the valley inhabited by hill tribes. British colonial policy viewed the Brahmaputra’s flood plains as potential revenue, waiting to be permanently occupied, cultivated and taxed. Peasants from East Bengal were encouraged to migrate and settle, but recurrent floods destroyed fields and homes, impoverished the people, and made a life-giving river a problem requiring ‘flood-control’. Although the policy was soon abandoned, the settlement pattern had changed.

Today, such riverine tracts are sites of conflict as the Assam government is evicting poor settlers (former jute cultivators who now grow vegetables for urban consumers) with the stated aim of allotting the land to other cultivators for agriculture and livestock, such as the Gir cow being introduced from Gujarat (S. Baruah 2021).

Colonial interests also ruptured the linkages between the hills and valleys (or aggravated differences that already existed). Sanghamitra Misra\* (2011) shows how a previously mobile community in Goalpara (western Assam) was rendered sedentary within a bounded space by the demarcation of the ecological landscape into jute and paddy fields, forests, riverine areas, commons and wastelands. Similarly, the colonial administration disrupted the mobility between the Garo, Khasi and Jaintia hills (Meghalaya) and the plains – a process that has continued in post-colonial times, eroding traditional forms of cooperative resource usage and management (Karlsson 2011). Joy L. K. Pachuau (2014: 101) says the struggle between the colonial powers and the indigenous Mizo ‘can be seen as an identity founded on territory and territoriality and an identity founded on movement, which made the forcible “rooting” of a people to a fixed space even more significant’. In Assam, where a tribal-non-tribal continuum existed, Uddipana Goswami\* (2014) highlights the pre-colonial inter-ethnic fluidity among the Axamiyā, Bodo, and Koch-Rajbangsi and their later diversification. Pradip Phanjoubam\*\* (2015) sees the undermining of linkages between the hills and plains in Manipur (and elsewhere in the NER) as the reason for ethnic conflicts.

Identity assertion has become intertwined with gaining fixed territorial boundaries as communities have coalesced, reclaiming their heritage, demanding material benefits and political spaces. This is a fraught process because even small areas in the NER are rarely homogeneous. A sense of identity and belonging is enriching but when differences become grounds for inequality, this leads to both marginalisation and resistance. As Amartya Sen (2006: 2) has said, ‘Within-group solidarity can help to feed between group discord’, often leading to violence.

In India, today, how does someone from a northeastern State see themselves and how do others see them? Mizo poet Cherrie L. Chhangte (2011) says defiantly: ‘An Indian looks like me, an Indian is Me’, while G. Kanato Chophy (2021) analyses:

I belong to an emerging class of educated Nagas who consider themselves ‘constitutional Indians’; many of the young in my community, and perhaps the north-east more broadly, are culturally conservative, proud of their region’s distinctive history, tradition, language, and ethnic identity, but at the same time seeing and desiring common ground with fellow citizens in other regions of the country that have their own – sometimes almost incomprehensibly different – language, history, and culture. For a Naga, this common ground is the idea of a modern and secular India – as the truly Ambedkar-inspired Constitution defines it – not the largely elite and Brahmanical notion of a timeless Indian civilisation and tradition dating back thousands of years.

People’s identities do not lie on a single axis; a sense of self and wellbeing depends on plural affiliations that cut across gender, ethnicity, language, culture, location, status, education, occupation, etc. Among many challenges that these diverse differences pose, perhaps the most contentious in contemporary northeastern India is that of gender.

### **Patriarchy and the women’s question**

*A woman’s work is never finished, but when the jhum kheti [shifting cultivation field] rests, we rest.*

– Nyayo Bam (2004)

The notion that gender disparity is not an issue in the NER, first propagated by Western anthropologists, persists among policy makers, academics and the public. The Anthropological Survey of India’s volume on Mizoram (Singh 1995: xiv) proclaims: ‘Mizo women do not suffer from any discrimination’. Patriarchy, the systemic male domination of institutions and privileging of male values, operates differently under varied social and material conditions, among tribal and non-tribal communities in the NER but some form of discrimination and disparity is common to all. Re-examining historical Ahom texts (of Assam), Manorama Sharma (2004: 72) notes that

the women ‘held their position in society through their participation in productive labour, although there is no doubt that they were made the disadvantaged section in the society because of the existing patriarchal norms and values’. Women’s behaviour, roles, responsibilities, status and rights continue to be circumscribed by customary norms (see Fernandes and Barбора 2002; Krishna 2015; Sharma Ed. 2017). Lovitoli Jimo’s\* (2017) reassessment of the marriage practices of the Sümi (also spelt Sumi or Suemi, formerly Sema) Naga reveals the embedded gender bias in the oral tradition and colonial writings.

Mobility and the ‘freedom’ to work outside the home do contribute to improved gender equity. By certain demographic and economic indicators (sex ratio, female literacy, workforce participation, etc.), women in the NER on average rank higher than the all-India average. Their visibility and easy interactions in markets seem to reinforce this. The reality, however, is complex and varied. Of particular concern is the declining child sex ratio in Manipur, Meghalaya, Mizoram, Assam and Tripura, although still higher than the national average (Niti Aayog 2021). Data reviewed by Vandana Upadhyay\*\* (2015) reveal gender gaps in literacy, school enrolment and dropout rates; Lakshmi Bhatia’s\*\*\* (2010) research in southern Mizoram shows how gender stereotypes may be reinforced by schooling and society. Bornali Borah’s\* (2018) study of trends in women’s employment in Meghalaya and Assam indicates that higher workforce participation does not translate into women’s greater wellbeing because this is driven by distress, and women are clustered in low-paid work or self-employment.

Throughout the region women are responsible for food-provisioning, perceived as an extension of domestic tasks: growing rice and vegetables; tending livestock (R. Dzuvichu 2013b) and poultry; and post-harvest food-processing and preparation but have no role in decision-making. The small Apatani plateau, near Ziro in Arunachal Pradesh is renowned for its irrigated rice and fish cultivation at the high altitude of 1500–2000 m. The Apatani landscape has been shaped over generations by a gender ideology that determines the division of roles and responsibilities. Men manage the forests and channel the mountain streams into the paddy fields below. Women manage the fields. Apatani women have a deep grasp of farming knowledge, identifying varieties of paddy suited to different soils and selecting pure seed. A gendered reading, a ‘genderscape’ of the Apatani taskscape reveals that the picturesque and seeming ecological balance masks the patriarchal subordination of women who are valued only for their capacity to labour and have almost no rights (Krishna 2012c).

More broadly, the NER’s rich agro-biodiversity and rice-farming systems carry an embedded, unrecognised ‘gendered price’ (Krishna 2005, 2012b). Vincent Darlong, D. K. Hore and S. Deb Barma\* (2012) have highlighted the risk to Tripura’s repository of rice germplasm, which was traditionally conserved by women. Darlong (2021) observes that by 2019 *jhum* (shifting cultivation) as the ‘predominant livelihood’ of a section of tribal communities had been decreasing due to sedentary farming of mixed agro-horticulture

species including fruits and cash crops; in some cases, this followed the allotment of forest land under the Forest Rights Act, 2006. ‘Overall, there had been reduction in the production of upland rice among tribal communities’. When *jhum* farming plummets, women’s farming knowledge and food security for the poor are affected. Elsewhere, as young educated women move away from farming, the responsibility and burden of cultivation is increasingly borne by older women (Krishna 1998a, 1998b). A middle-aged woman farmer’s drudgery is continuous; as Nyayo Bam (2004) in West Siang (Arunachal) says, it is only ‘when the *jhum* kheti rests’ that women rest.

Women do not participate in customary decision-making bodies and there is strong male resistance to include women in modern governance systems in rural and urban areas. Sikkim (formerly an independent protectorate) joined the Indian Union in 1975. It implemented the Constitution (73rd Amendment) Act, 1992, on panchayats with reservation for women. It also recognised the customary *dzumsa* (gathering of elders) of the Bhutia Lachungpa and Lachenpa tribes of north Sikkim. The people prefer this traditional system of governance and conflict resolution, yet as Ganga Maya Tamang\* (2018) found, the *dzumsa* excludes women and they accept this. In Nagaland, however, the Naga Mothers Association fought for reservation for women in urban bodies under the Constitution (74th Amendment) Act, 1992 and won a favourable Supreme Court verdict. This could not be implemented because popular male opinion views women’s representation as being against Nagaland’s special rights under Article 371A.<sup>5</sup>

Arunachal has had a dual system of the traditional *kebang* (village council) and panchayats. Both exclude women. Some tribes disallow women totally, others let women enter as observers; the Gallong of Siang allowed women to wear the red coats that identify council members but only to serve tea at the meetings, not to speak (J. Ete 1997). The Arunachal Women’s Association has been fighting with little success for gender equal customary laws; Jarjum Ete (1996: 43) says:

There are vast gray areas which constitute the essence of life and of struggle for the women of the North East – with the innate need to uphold the heritage and rich cultural values of their tribes while simultaneously struggling against new forms of oppression within their communities in the name of tradition.

A study of 14 tribal groups across the NER, summarised by Melvil Pereira and R. P. Athparia\* (2018), found that people generally prefer traditional conflict resolution systems to the modern courts, but among tribes with high female literacy like the Ao (Naga) and Mizo, women want reform. Mizoram’s customary laws were ‘codified’, documented in writing, a century ago by the colonial administration. This has largely been accepted by male Mizo chiefs and the State government. The all-Mizoram women’s group Mizo Hmeichhe Insuihkhawm Pawl (MHIP) has tried to change

gender-biased customs, asserting women's rights to their earnings, property, inheritance, etc. (Lanipuii 1997). But men in authority reject changes outright as being contrary to Mizo culture. Sawmveli\* (2018) says: 'We should be asking whose interests are being served by these traditions and customs'. Tribal women's groups in the NER tread a difficult path – they want to reform the customary laws, but they do not want to replace it by Indian law (Krishna 2004; Haksar 2018; Ghosh 2007).

A very few communities like the Khasi, Jaintia and Garo of Meghalaya are matrilineal, tracing descent through the female line, and matrilocal with the husband moving into the wife's home. The division of labour is gendered, except when extreme poverty forces men to share in economic activities obscuring gender inequality (Nongbri 2003). Despite women being custodians of the family/clan land, ownership vests with brothers. Women have no role in jural and political decision-making. Indeed, the matrilineal system is constantly being contested by men, most recently through the legislation proposed by the Khasi *dorbar shnong* (Agarwala 2021). As Bitopi Dutta's (2022) study of the gender impact of displacement in Meghalaya's coal mining areas reveals, intensification of mining has led to migration and affected gender relations, increasing domestic violence and pushing women into the sex-trade. Studies across the NER by Walter Fernandes (2012) and his associates show how women are impacted by the loss of community lands.

Exceptionally in the NER, the patrilineal Meitei of the Manipur plateau do not socialise girls and women into subordination, although elite men do enjoy certain privileges denied to women. The women's sphere of work increased in the 19th century when the Anglo-Burma wars caused a severe decline in the male population. Meitei women control the rice and commodity markets and are known for their independence and collective solidarity, but have little role in formal political systems (Krishna 1996: 120–121). Despite the spread of Vaishnavite Hinduism, promoted by the ruling elite (the adoption of caste Hindu names, rituals, values and practices like vegetarianism), Brahminical influences proved unable to subvert women's economic power and male–female cooperation in the religious sphere, says Manjusri Chaki-Sircar (1984).

A 'common narrative' (Krishna 2004: 390) runs through the region: Inequitable gender relations and resource control, embedded in tribal customary practices, in some cases supported by special Constitutional arrangements; the question is why matriliney (Khasi and Garo), literacy (Mizo and Ao) and economic power (Meitei) do not seem to have any impact on women's political empowerment. As elsewhere in India, women have been in the forefront of protest movements but their political representation in decision-making bodies from the local to the national level is minimal (T. Misra and U. Misra 1995).<sup>6</sup> Furthermore, when tribal people move from agriculture to new occupations, women lose their traditional skills and productive roles, and new forms of male dominance emerge. To what extent is this process linked to the rise of a new 'middle' class and resource politics in a globalised world?

## Politics of resource control and development

*For sale*

*this battered, autistic land with its lucre-laden earth,  
our precious minerals, medicinal herbs, rare orchids,  
and trees and fields and waters,  
all these, and all else.*

– Paul Lyngdoh (2003): ‘For Sale’

Resource control in northeastern India is a particularly tangled web, enmeshed with the emergence of a middle-class elite and ethnic rivalries; legal and governance issues from the local to the national levels; external and internal security concerns; and the rapid transformations being wrought by globalised market forces in the name of ‘development’. In the colonial period, many communities took advantage of the new educational opportunities; an ‘English’ education, rather than landed property, created a new elite. After Independence, the expansion of political administration into the region, military and developmental works and the aspirations of sections of the people led to intense competition for limited government jobs and contracts. In Arunachal, for instance, a nexus evolved between the new elite, government functionaries, contractors and politicians, fuelling a culture of ‘easy money’ (Krishna 1998a: 154–156; 2004: 377). Apurba K. Baruah analyses this hegemonic process in Assam (1994) and the NER (2015), pointing out that identity assertion is ‘indicative of middle class competition for control over resources’ (2015: 17). He notes that in ‘situations of inter-community conflicts’, a community may even ‘trample the individual rights’ of its own members (ibid: 21–22). Modernity brought ethnic consciousness, but Western education, liberal constitutional democracy and capitalist development ‘imposed from above in North-east India have created a situation in which the traditional elites lost power to this newly emerging western educated middle class’ (ibid: 23). Kaustubh Deka (2021) argues that, although political patronage continues to be significant, the role of the new middle class in neo-liberal Assam is ambivalent due to uncertainties and insecurities specific to the region.

Among the relatively egalitarian tribal communities, water sources, forests, grazing lands, and settled/shifting cultivation fields were treated as commons, ensuring fairly equitable and sustainable usage. This changed as the British negotiated with kings and chiefs, through force or inducements, to gain control over community resources – forests were cleared for tea plantations; timber was logged for railway sleepers and tea chests; land was mined for coal, oil and gas. The tussle for resources between the state and the people continued after Independence. Tribal majority Nagaland, Meghalaya, Mizoram and Arunachal, the Autonomous Districts (under the Sixth Schedule of the Constitution), and the hill areas of Manipur strove to retain control over community forests and cultivable lands. In Tripura, however, following the enactment of the Tripura Land Reforms and Land

Revenue Act, 1960, all land that was not privately owned became government land, even in the tribal-inhabited hill areas. After nearly two decades of agitation, the Tripura Tribal Areas Autonomous District was formed under the Sixth Schedule, but effective control of community lands had passed out of their hands. In Manipur, rival Naga and Kuki tribes have now joined together to demand new legislation to strengthen Constitutional provisions for the hill areas that have remained on paper for half a century.<sup>7</sup>

The British took over community lands to build roads for military movements (see L. Dzuvichu 2013a). And this process continues as lands are acquired for military infrastructure and operations, and for ‘development’. Land alienation takes place despite laws to prevent this, with new legislation enabling privatisation rather than protecting community lands and resources. In Arunachal there are apprehensions that the Land Settlement Act, 2018 (Sharma and Borgohain 2019) will dispossess tribals. Fernandes\*\* (2017) has argued that the law itself facilitates the appropriation of resources by the Indian state, often without compensating those whose subsistence depends on the land and that this precipitates ethnic conflicts. Indeed, Sanjay (Xonzoi) Barbora’s\*\* (2017) research in the autonomous Bodo Territorial Area Districts (Assam) highlights that ethnic assertion and the quest for political representation are not causes of ethnic violence but emerge in the course of conflicts over land.

Since the mid-1970s, academics and activists have argued that state-control diverts resources for urban-industrial purposes overriding local community needs (see S. Baruah 2012). Hoinelhing Sitlhou\*\* (2015) says forest policies and legislation have negated the Kuki community’s rights in Manipur. Siddhartha Krishnan (2021: 135) points out that in the protected eastern Himalayan forests of North Bengal, the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 does not ensure individual and community freedoms; he argues that forest dwellers should not be treated as ‘passive, needy recipients’ but as citizens with capabilities. Not all local communities are alike, nor is any particular community entirely homogeneous. Mibi Ete’s\*\* (2017) study of a small tribe in eastern Arunachal suggests that local people are not always ‘victims’ of development projects. Without valorising large dams, she notes that communities leverage their indigeneity; contestations are a means of negotiating for benefits, of gaining concessions from the implementing agency.

In British India, ‘undivided’ Assam was linked by river and rail to Chittagong and Calcutta (now Kolkata). Partition hemmed-in the region by international borders with Tibet–China, Myanmar and Bangladesh (formerly East Pakistan), and the connection to ‘mainland’ India was restricted to the narrow Siliguri corridor. The Look/Act East Policy was designed to revive the NER’s trade links with southeast Asia and to strengthen India’s strategic interests in the wider region. Atul Sarma (2017) has highlighted the impediments and the high transaction cost of doing business in a land-locked region. As Falguni Rajkumar\*\* (2016) points out, even as the ‘continental’ overland route remains constrained, trade by the sea route between



‘mainland’ India and southeast Asia has grown. He also cautions (ibid. 149–150) that ‘progress and development’ will mean ‘improved infrastructure’, roads, electric power, industries, jobs and the ‘hope of a better life’, but also ‘loss of identity, changes in environment, ecology and means of livelihood, expropriation of lands in some areas and a host of imponderables’. Such changes could be ‘irreversible’, so ‘people of the region must be psychologically and physically prepared to open up to the “outside” world for commerce and business’.

For some who live along the India–Myanmar border, the ‘outside world’ is already there. Soma Ghosal and Snehashish Mitra\*\* (2019) found that three frontier towns have become ‘gateways’ between India and southeast Asia. Traditionally open to cross-border exchanges, Champai (Mizoram), Moreh (Manipur) and Tamu (in Myanmar, formerly in Manipur) have grown as transit points for labour, capital and resources. Intermingling populations, as also distress migration and cross-border drug trafficking pose health challenges, as Anasua Basu Ray Choudhury and Sreeparna Banerji\*\* (2019) argue. They suggest cooperative structures of health management and disease control between the States on either side of the India–Myanmar border.<sup>8</sup>

External and internal security are interwoven as the international borders cut through natural features, villages and fields, dividing people who have familial, ethnic, cultural and economic links. So, opening up or securing a border cannot be seen only as a trade or military issue. Phanjoubam\*\* (2015) argues that the ‘extremely vulnerable physical location’ of the NER determined the nature of militarisation in the region but that India today needs to confidently put aside its fears and not continue to depend on laws such as the Armed Forces Special Powers Act, 1958 that provides impunity to armed action in notified ‘disturbed areas’ (see also Bhaumik 2007; Subramanian 2016). Archana Upadhyay\*\* (2017) sees a paradigm shift in the concept of security towards human security but says the diversified governance structures and political practices in the NER pose difficult challenges. Underlining the linkages between security and development, Rakhee Bhattacharya\*\* (2015, 2021) argues that security should encompass human wellbeing and environmental sustainability, resource rights and resource sharing.

In a globalised world, no place however remote is unaffected by the penetration of market forces that impact resource sustainability and rights. Dhruvad Choudhury’s\* (2012) research shows that hill farmers do need better incomes but plantation ‘cash’ crops have reduced the area available for subsistence, impoverishing jhum farmers and impacting the matrilineal Garo and Khasi women’s rights. Further, Choudhury (2021) notes that although there is no reliable data to assess the extent of reduction in the area under shifting cultivation in the NER, ‘second generation’ issues of this transformation are becoming apparent:

- a) [S]teady reduction in seasonal food availability and resultant depletion in dietary diversity (with serious long-term implications for nutritional security and community health, particularly of women and

children); b) drastic reduction in forest cover and ecosystem services with long-term implications for ecosystem, societal and planetary health; and c) increasing insecurity of tenure depriving the poor and disadvantaged among shifting cultivators of access to land resources, in several cases depriving the community of territorial rights over their ancestral territories.

Deepak K. Mishra's\* (2015) study of the ongoing transformation of Arunachal's agrarian economy under global capitalism reveals the complex interplay of state, market and community institutions, with the emergence of a 'rentier class' and new arrangements between landlords and migrant labour. He argues that capital has entered Arunachal to strengthen state power rather than for raw materials, labour or markets. Indeed, the state has an interest in sustaining local identities and the diversity of institutions (see also Harriss-White, Mishra and Upadhyay 2021).

As Virginius Xaxa\* (2018) has pointed out, stratification and 'labour markets' existed in pre-colonial times – forced labour in the plains and slavery in the hills. The British paid wages, but plantation labour were not legally 'free' and government jobs were filled by migrant Bengali and Assamese. Xaxa says much has changed after Independence but because of the scarcity of land, rural people are increasingly moving out to seek work. Consider Siliguri, India's 'gateway' to the NER. Samir Das's\* (2018) study shows that its tea estates have been replaced by housing 'estates' and former tea plantation labourers are jobless (see also Chatterjee 2001; Mishra, Upadhyay and Sarma 2012). Dalits, tribals and Muslims are in penury, and women are migrating or being trafficked in a global sex trade. Das says Siliguri is 'nobody's city' with absentee settler-landlords and evicted labour and that global capitalism has entered the area, independently of the state.

Despite high rainfall in the NER, water sources, rivers, ponds, wells and springs, are often distant or difficult to reach in rural areas. Water-scarcity, contamination, wastewater and solid waste disposal are severe problems causing insanitary conditions and an avoidable disease burden (reflected in maternal mortality, infant and under-five mortality rates). Drinking water supply may be limited and particularly in hill towns, access is unequal. A study of Shillong by Bankerlang Kharmylliem and Ngamjahao Kipgen\*\* (2020) shows that traditional institutions like the Khasi dorbar shnong, despite problems with their composition and functioning, are close to the people and could manage urban water supplies more equitably.

Overlaying complex geographical and historical diversities, and the NER's multifarious ethnic problems, is the trajectory towards cultural homogenisation and religious proselytisation (see Longkumer 2021; Thomas 2021). Analysing the response of creative writers to alienation, conflict and violence, K. B. Veio Pou\*\* (2017: 242) also comments that people 'feel a sense of intimidation' by the 'upsurge of a majoritarian culture'. He points out that poets and novelists are drawing upon their own oral traditions and heritage and using the English language for political

expression. Khasi poet Paul Lyngdoh's (2003) satirical lament that the region is 'for sale' echoes widely.

Development in the NER seems focused on infrastructure for resource extraction. Of the mega-dams coming up in her home State, Arunachali novelist Mamang Dai (2010) writes: 'No one is against development, but the break-neck speed at which the hydropower initiative is being pursued is like an invasion'. The question is whether and how people can fulfil their aspirations through democratic governance without the processes and systems themselves being undermined.<sup>9</sup> In an Independence Day 'thought', the Assamese writer Harekrishna Deka (2019) put it tersely: 'In a representative democracy, whom do the political representatives represent? An elite or a people?'

### Special Note

\*\* Chapters included in this book.

\* Chapters included in *Routledge Readings on Colonial to Contemporary Northeastern India: Customary Practices, Gender, and Livelihoods*.

See list below:

#### Part I Colonial Encounters

- 1 Cast of Colonialism: Constructing the Peculiar North East India  
*Arambam Noni*
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- 3 What is Axamiyā? Understanding an Interethnic Identity  
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- 4 War, Nationalism and Conversions  
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#### Part II Customary Law, Gendered Practices

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*Bornali Borah*
- 14 Agrarian Relations and Institutional Diversity in Arunachal Pradesh  
*Deepak K. Mishra*
- 15 The Moving City  
*Samir Kumar Das*

## Notes

- 1 Lower case 'state' refers to the nation-state (the power exercised by the Union Government), upper case 'State' denotes constituents of the Union.
- 2 The Constitution does not define 'tribal' but provides for Scheduled Tribes (ST), and Scheduled and Tribal Areas for their 'special care and welfare'. The Constitution's Hindi translation of tribe is *adimjati* (primitive race). 'Adivasi' is now generally preferred, but in the NER adivasi is used for migrant plantation labour as distinct from tribe for ethnic indigenous groups.
- 3 Schedule V of the Constitution (applicable to central India) was meant to further 'cultural assimilation', and Schedule VI (applicable to the NER) to administratively integrate tribal areas.
- 4 Shürhozelie Liezietsü related this story to me (Krishna 1991: 1); J. H. Hutton *The Angami Nagas* (1921) records another version.
- 5 The 73rd Amendment Act, 1992, exempts Nagaland, Meghalaya, Mizoram, Manipur hills and areas under Schedule VI (Government of India 1993a, 1993b). Article 371A protects customary law and procedures in Nagaland; further sections have similar provisions for other States.
- 6 Registered women voters outnumber men in Arunachal, Manipur, Meghalaya and Mizoram. Yet, in 2019, only three of the 25 Lok Sabha seats from the eight States were won by women (from Assam, Tripura and Meghalaya). Three other women stood for election in Arunachal, Mizoram, and Sikkim (one in each State) – all lost.
- 7 Article 31C provided for a Hill Areas Committee constituted by all members of the Manipur Legislature representing the hills. The Committee has tried (unsuccessfully) to introduce the Manipur (Hill Areas) Autonomous District Council Bill, 2021. [http://www.hornbilltv.com/north\\_east\\_stories/hill\\_areas\\_committee\\_introduces\\_manipur\\_adc\\_bill\\_2021-1499](http://www.hornbilltv.com/north_east_stories/hill_areas_committee_introduces_manipur_adc_bill_2021-1499) Accessed 7 Jan. 2022.
- 8 In 2018, India and Myanmar 'quietly' agreed on a 'free movement regime' for people 'ordinarily resident on the border' to a distance of 16 km. on either side. See Sujana Dutta (25 Oct. 2018). <https://theprint.in/diplomacy/india-and-myanmar-quietly-open-up-their-border-for-villagers-and-trade/139877/> Accessed 16 Dec. 2021.
- 9 Some argue that the autonomy of Sixth Schedule Areas, intended to protect tribal areas, has been hollowed out, as militancy has become an instrument of negotiation with the state for personal material benefits and for gaining political office, and that the state appeases militants as a means of retaining its control of the NER's resources ('Grounded Voices: Governance, resource rights and ethnicity in Sixth Schedule Areas', National Alliance of People's Movements Webinar Series: 46; 47; 48; 49. Dec. 2021).

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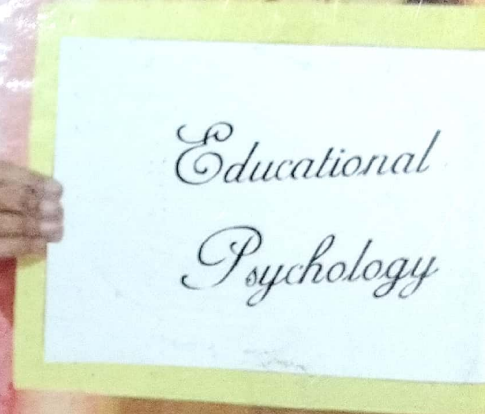
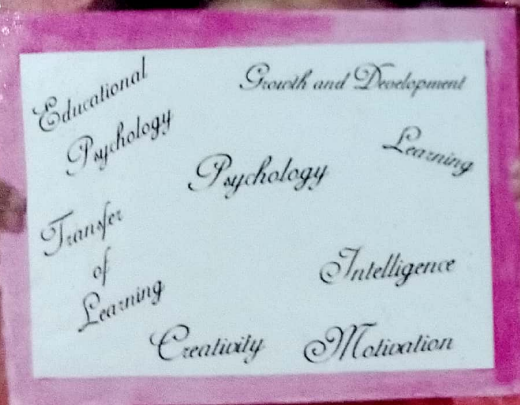
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**Results: Table no. 1 Descriptive statistic of speed, agility,  $VO_{2max}$  Resting heart rate and resting respiratory rate**

Variable	Group	Mean	SD	Upper Limit	Lower limit
Speed	Experimental	6.96	2.09	7.27	6.61
	Control	7.14	2.28	7.49	6.83
Agility	Experimental	4.86	1.01	5.26	4.72
	Control	5.68	0.82	5.82	5.28
RRR	Experimental	13.7	1.05	14.37	13.08
	Control	15.4	0.84	16.01	14.72
RHR	Experimental	61.8	3.11	62.65	59.95
	Control	66.8	2.04	68.64	65
$VO_{2max}$	Experimental	52.22	10.77	54.95	48.66
	Control	49.39	8.26	52.95	47.012

\*RRR=Resting Respiratory Rate \*RHR=Resting Heart Rate

The above table no. 1 shows the value of mean and standard deviation for the data on speed in different post control and experimental group that is  $7.1430 \pm 2.29$  s and  $6.96 \pm 2.09$  s respectively.

The above table shows the value of mean and standard deviation for the data on agility in different post control and experimental group that is  $5.68 \pm .82$  s and  $4.96 \pm 9.99$  s respectively.

The above table shows the value of mean and standard deviation for the data on RRR in different post control and experimental group that is  $15.4000 \pm .84327$  bpm and  $14.5500 \pm 1.27630$  bpm respectively.

The above table shows the value of mean and standard deviation for the data on RHR in different post control and experimental group that is  $66.80 \pm 2.04$  bpm and  $64.30 \pm 3.62$  bpm respectively.

The above table shows the value of mean and standard deviation for the data on  $VO_{2max}$  in different post control and experimental group that is  $49.3940 \pm 8.26861$  ml  $kg^{-1}$   $min^{-1}$  and  $50.8085 \pm 9.46$  ml  $kg^{-1}$   $min^{-1}$  respectively.

**Table No. 2 ANCOVA table for the post-treatment data of speed, agility,  $VO_{2max}$  Resting heart rate and resting respiratory rate**

Variables		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Speed	Contrast	0.233	1	0.233	0.943	0.345	0.053
	Error	4.298	17	0.248			
Agility	Contrast	1.511	1	1.511	9.294	0.007	0.353
	Error	2.766	17	0.163			
RRR	Contrast	13.306	1	13.306	14.378	0.001	0.458
	Error	15.733	17	0.925			
RHR	Contrast	165.608	1	165.608	42.147	0	0.713
	Error	66.797	17	3.929			
$VO_{2max}$	Contrast	13.539	1	13.539	0.684	0.42	0.039
	Error	336.463	17	19.792			

\*RRR=Resting Respiratory Rate \*RHR=Resting Heart Rate

**Table no.3 Pairwise Comparisons**

Variable	(I) GROUP	Mean Difference (I-J)	Std. Error	Sig.*	95% Confidence Interval for Difference*	
					Lower Bound	Upper Bound
Speed	Control group	0.216	0.222	0.345	-0.253	0.686
	Experiment group	-0.216	0.222	0.345	-0.686	0.253
Agility	Control group	.557*	0.183	0.007	0.171	0.943
	Experiment group	-.557*	0.183	0.007	-0.943	0.171
RRR	Control group	1.646*	0.434	0.001	0.73	2.563
	Experiment group	-1.646*	0.434	0.001	-2.563	-0.73
RHR	Control group	5.993*	0.923	0	4.046	7.941
	Experiment group	-5.993*	0.923	0	-7.941	4.046
$VO_{2max}$	Control group	-1.65	1.995	0.42	-5.858	2.559
	Experiment group	1.65	1.995	0.42	-2.559	5.858

Based on estimated marginal means.

Adjustment for multiple comparisons: Bonferroni.

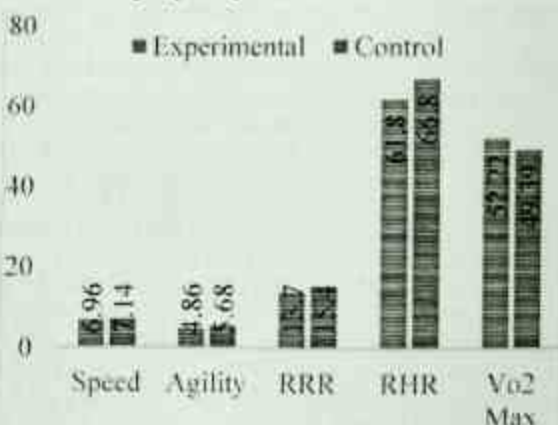
\*. The mean difference is significant at the .05 level

b. Adjustment for multiple comparisons: Bonferroni.

\*RRR=Resting Respiratory Rate

\*RHR=Resting Heart Rate

**Fig: 1 Mean Comparison on Speed, agility,  $VO_{2max}$  Resting heart rate and resting respiratory rate**



\*RRR=Resting Respiratory Rate \*RHR=Resting Heart Rate

**Findings: Physical Variables:** The result of the study shows that the experimental group (circuit training) does not show any improvement sign as compare to the control group on selected

physical variables named speed but significantly showing improvement on the Agility. According to the literature there is training improves the physical variables like speed. The circuit (2013). It seems there is no significant in this study. Several reason can be drawn regarding the results of this study. Several reason of the circuit training was not up to the mark, diet of participants were couldn't controlled, many similar factors might be influenced to the physical variable like speed. In other hand the physical variable like agility of experimental group was significantly improved through 6 weeks circuit training as many literatures have supported that the circuit training has significantly improve of agility. Circuit training, which is designed to be performed 3 days a week during 10 weeks of training, improves sprint-agility and anaerobic endurance (Tasking and Hall, 2009). There may be any other which contributes in improving the result of training including daily life activity. **Speed:** The present study shows that there was no significance difference was found. According to the researchers the eight weeks circuit training significantly improvement of motor abilities like speed (Vikash Kumar, 2016). Similarly, the combination of circuit and weight training found to be significantly improvements on physical variables like speed (Pachaiyappan, and Selvamuthukrishnan, 2017), circuit training was significantly affect on improvement of speed (Babu and Kumar, 2013). Physical fitness variable like Speed found to be significance improvement by circuit training and plyometric training (Mahesh Yadav, 2017, GovindasamyKaruppasamy, 2018). The nature of speed was improved with the responses of circuit and battle rope training (Maniazhagu et al. 2019), the variable like speed was found significantly improved after twelve weeks of circuit training (Bhawani Pratap Singh Shekhawat and GS Chauhan, 2021 and Nugroho et al., 2021). However, the present study output didn't show any significant difference the participants were didn't put their full efforts. May be also result the duration of training was failed to bring the result significant. **Agility:** According to the publisher the circuit training significantly improvement of motor ability like agility (Vikash Kumar, 2016, Pachaiyappan, and Selvamuthukrishnan, 2017). Similarly, the circuit training program improved (WiratSonchan et al., 2017, GovindasamyKaruppasamy, 2018). Physical variable like agility can be improved with the help of the circuit training (Bhawani Pratap Singh Shekhawat and GS Chauhan, 2021, and Nugroho et al., 2021). So, the present study highlighting the improvement on selected physical variable i.e agility after the Six week of circuit training. **Physiological Variables:** There are three physiological variables formulated in this study named as  $VO_{2max}$ , Resting Heart Rate (RHR) and Resting Respiratory Rate (RRR). The present study reveals that the  $VO_{2max}$  of experimental group and control group were not much differ between them. According to the literature circuit training program help in improvement of the cardiovascular system of the body which is related the oxygen carrying capacity. Specific endurance circuit training is effective in improving aerobic capacity and increases the cardiovascular fitness (B. Chittibabu and N. Akilan, 2013). May be the participants of the control group be always engaged in physical fitness activity or the participants of experimental group were maintained fitness before the training. Apart from that  $VO_{2max}$ , Resting Heart Rate (RHR) and Resting Respiratory Rate (RRR) were found to be significantly

increase with the training. Several journal and publishers have confirmed that the effect of circuit training is significantly affects on physiological variables like RHR and RRR. The improve of the RRR and RHR may be due: maintaining strict training schedule, aware of balance diet, any others daily life activities may influence the result.  **$VO_{2max}$ :** From the literature review after eight weeks of circuit training there was a significant different between the Mean of  $VO_{2max}$  pre and post data (Salierno et al., 2021). High intensity circuit has significantly impacted on the aerobic capacity (Schmidt et al., 2015). The present study reveals that there was insignificant different in the mean of  $VO_{2max}$  of pre and post data. May be the intensity of the training was not well administered. Similarly, the intensity of the training was not reach to the optimal points. May also be the reason that participants were engaged in Physical activity (aerobic). According to the Vrachimis et al., (2016) the variables like  $VO_{2max}$  was not found any significant by six weeks of circuit training. **Resting Heart Rate:** As gone through the literature it has found that the six weeks of circuit training program was significantly decrease in resting heart rate (Akilan and Chittibabu, 2013). Another study found that Six-week of Circuit Training involving bodyweight exercises has no significant impact on resting Heart Rate Variability. Further study added, this type of training might decrease the risk for development of CVD by reducing arterial blood pressure and by improving body composition, aerobic capacity, muscular endurance and strength (Vrachimis et al., 2016). The improvement was found after 6 weeks of circuit training in heart rate (Ikenna et al., 2020). The current study showing that there is a significant different between the adjusted mean of control and experimental group after six weeks of circuit training as the calculated F value is greater than tabulated value a 1, 17 i.e 41.14. It may because of intensity was up to the optimal point. **Resting Respiratory Rate:** The present study found that the six weeks of circuit training program was significantly improved on respiratory rate. Reason can be as follows – the training duration was accurate throughout the entire training schedule. The following research paper are in favour of this current study- a findings revealed that there was a difference significantly in selected physiological variable like respiratory rate (Ikenna et al., 2020). Game Specific Circuit Training and Plyometrics on Selected Physiological variable i.e respiratory rate found to be significant improvement after twelve weeks of training (Anand et al., 2016).

**Conclusion:** After a successfully completion six weeks circuit training program data were collected and analysed with help of statistical technique with the help of SPSS. It is found that; - Six weeks of circuit training significantly improvements on Physical and physiological variables i.e Agility, Resting Respiratory rate and Resting Heart rate but found insignificant in Speed and  $VO_{2max}$ .

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# EMERGING TRENDS OF PHYSICAL EDUCATION AND SPORTS SCIENCE



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## EFFECTS OF ENDURANCE TRAINING ON PHYSIOLOGICAL VARIABLES OF VOLLEYBALL PLAYERS

Khoda Bhai\* K. Rojeet Singh \*  
Ph. Laxmikumari Devi \*Gandhi Jomoh \*  
MidakBasar

**Abstract:** The objective of the study was to find out the effects of endurance training on physiological variables of volleyball players. **Methodology:** 20 male volleyball players (10 Control and 10 Experimental) were selected for the purpose of the study, the age range of selected subjects were 19-24 years. The selected physiological variables (resting heart rate, resting respiratory rate,  $VO_2$  Max) were tested before and after six weeks of endurance training. The data were analyzed by applying the Analysis of Covariance (ANCOVA) at 0.05 level of significance. **Results:** There were significant differences found in physiological variables i.e.  $VO_2$ Max and Resting heart rate. **Conclusions:** On the basis of the finding, it was concluded that the six weeks of endurance training was sufficient enough to bring the significance improvement on Resting heart rate and  $VO_2$ Max and insignificant found in Resting Respiratory Rate. The study was further recommended that further studies can also be done by increasing the numbers of variables and by increasing the number of subjects.

**KEYWORDS:** Endurance,  $VO_2$ max, Resting Heart Rate, Resting Respiratory Rate

### INTRODUCTION

There are so many types of fitness, like physical fitness, social fitness, mental fitness, emotional fitness, intellectual fitness, spiritual fitness. Every type of fitness is important for human. Physical fitness is important to all of us. It is a combination of so many factors like, speed, agility, flexibility, Power, muscle strength, endurance, and coordination. It is the important things to keep our bodies and minds healthy. Satyavati (2019) Study revealed that there are so many types of training activities that build sports fitness. The performance in sports develops through various sports training like isometric training, isotonic training, plyometric training, circuit training, fartlek training, interval training etc. The present research was related to physical fitness, Circuit training, Interval training, Continuous training and Fartlek training. Specific training prepares subjects to perform well in their respectively sports. Specific training is develops the player's ability to perform in a specific activity with a reasonable efficiency. Games and sports is a specialized field. It requires a specific, scientific and systematic type of training to improve performance of player. Every activity requires a specific type of physical fitness components; thus to improve these components. The programmed of training process is known as sports training. Sports' training is the branch of science which helps to increase sports performance Sport's training is the branch of science which helps to increase sports performance. In this study we mainly focus on physiological component which is endurance. Endurance plays one of the major roles on the field games/sports which are enhance your performance especially on the long duration

games/sports. Endurance is the character that helps sport persons resist fatigue and play energetically for long duration of time. Endurance ability is does not come with you when you are born but you can built it with the help of physical activity and specific training. The study by Farswan (2018) State that Endurance training is the act of exercising in a way that increases the body's ability to sustain activity for long periods of time. , this type of exercise training refers to any type of activity that trains the aerobic energy system as opposed to the anaerobic energy system. Endurance training performed on a regular basis induces extensive alterations in the metabolic characteristics of exercising skeletal muscles. These adaptations are accompanied by pronounced changes in energy delivery and utilization. After longlasting endurance training, exercise at a given intensity results in an enhanced fat oxidation. At given exercise loads, muscle glycogen depletion is also prevented after training due to a shift from anaerobic utilization of carbohydrates to an enhanced carbohydrate oxidation and due to an increase in fat oxidation. Singh, (1991) Study revealed that it is the training to do movements involving large number of muscles, at a slow pace for prolonged e.g., jogging, swimming, walking at moderate speed for periods lasting more than 30 minutes. Endurance training, as it depends on the aerobic process, forms the base for all type of endurance without a sufficient level of basic endurance other types of endurance are difficult to improve. According to Ortega et al. (2008) communicated that "As a rule, schools have been viewed as the best setting in which youngsters with low fitness levels can be distinguished and a healthy lifestyle can be advanced." Gabett T and Georgieff B 2007 The study emphasized the importance of lower body muscular power and maximal aerobic capacity with increased playing level in volleyball players. Thus, many research workers have emphasized various training modalities for the improvement of cardio respiratory endurance. These are rope skipping, running, walking, bicycling and various isotonic and isometric exercises. All these exercises performed at a level to bring about 60% differences in resting and maximum heart rate will definitely improve cardio respiratory endurance. A volleyball player has to be strong, powerful and skilled. It's also important for you to know that the success of a volleyball player depends a lot on his/her endurance. Endurance is something that helps volleyball players to demonstrate excellent performance on the court over a long period of time. You'll be able to achieve great results in the sport of volleyball only if you have a lot of endurance The best thing you can do to boost your endurance for volleyball is to focus on strength and conditioning. Those athletes who work hard in the weight room can minimize the stress on their joints and ligaments significantly. Doing strength and conditioning

exercises also helps athletes keep their muscles well-balanced. All of this will have a big positive impact on volleyball player's endurance and performance and from about literature the study undertaken by student to find the effects of endurance training on selected physiological variables of volleyball player i.e. VO<sub>2</sub>Max, Resting Heart Rate and Resting Respiratory Rate.

**Methodology.** 20 male volleyball players (10 Control and 10 Experimental) were selected for the purpose of the study, the age range of selected subjects were 19-24 years. The selected physiological variables (resting heart rate, resting respiratory rate, VO<sub>2</sub> Max) were tested before and after six weeks of endurance training. The data were analyzed by applying the Analysis of Covariance (ANCOVA) at 0.05 level of significance.

**Results:**

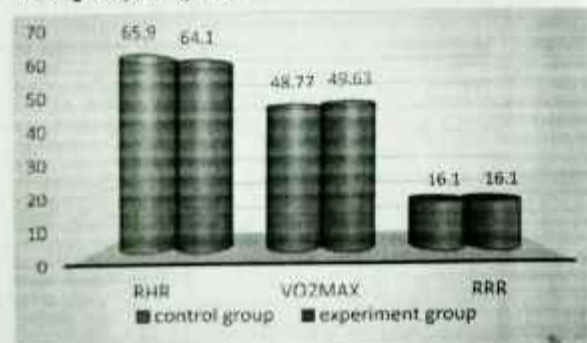
**Tables no.1 Descriptive statistic of Resting Heart Rate, VO<sub>2</sub>Max, and Rest Respiratory Rate**

Variables	Group	Mean	Sd
RHR	Control group	65.9	1.96
	Experimental group	64.1	1.37
VO <sub>2</sub> MAX	Control group	48.77	6.13
	Experimental group	49.63	6.87
RRR	Control group	16.1	0.99
	Experimental group	16.1	0.99

\*RHR= Resting Heart Rate \*RRR= Resting Respiratory Rate

The above table shows that the mean and standard deviation score of Experiment and Control group of volley ball player in relation to Resting Heart Rate has been found i.e. 64.1 + 1.37 and 65.9 + 1.96 respectively. The above table shows that the mean and standard deviation score of Experiment and Control group of volley ball player in relation to VO<sub>2</sub>Max. Has been found i.e. 49.63 ± 6.87 and 48.77±6.13 respectively. The above table shows that the mean and standard deviation score of Experiment and Control group of volley ball player in relation to Resting Respiratory Rate has been found i.e. 16.10 + 0.99 and 16.10 + 0.99 respectively.

**FIG. No.1 Mean comparison on VO<sub>2</sub>Max, Resting Heart Rate and Resting Respiratory Rate**



\*RHR= Resting Heart Rate \*RRR= Resting Respiratory Rate

**Table No.2 ANCOVA table for the post-treatment data of VO<sub>2</sub>Max, Resting Heart Rate and Resting Respiratory Rate**

Variables		Sum of Square	Df	Mean Square	F	Sig.
VO <sub>2</sub> Max	Contrast	25.354	1	25.354	31.99	0
	Error	13.474	7	0.793		
RHR	Contrast	20.42	1	20.42	12.82	0.002
	Error	27.07	7	1.59		
RRR	Contrast	0.483	1	0.483	0.76	0.396
	Error	10.817	7	0.636		

\*RHR= Resting Heart Rate \*RRR= Resting Respiratory Rate

The table shows that there are significant difference between experimental and control group of volley ball players in relation to Resting Heart Rate as obtain F-ratio is 12.82 which is higher than the tabulated value 4.45, required for F-ratio to be significant at 0.05 level with (1,17) degree of freedom. The table shows that there are insignificant difference between experimental and control group of volley ball players in relation to Resting Respiratory Rate as obtain F-ratio is 0.76 which is less than the tabulated value is 4.45, required for F-ratio to be significant at 0.05 level with (1,17) degree of freedom. The table shows that there are significant difference between experimental and control group of volley ball players in relation to VO<sub>2</sub> Max as obtain F-ratio is 31.99 which is higher than the tabulated value is 4.45, required for F-ratio to be significant at 0.05 level with (1,17) degree of freedom.

**Table no.3 Pairwise Comparisons of control and experimental group of volley ball players in relation to Post Resting Heart Rate, Resting Respiratory Rate and VO<sub>2</sub>Max**

Variables	(I) Group		Mean Difference (I-J)	Std. Error	Sig.*	95% Confidence Interval for Difference*	
						Lower Bound	Upper Bound
RHR	Control Group	Experimental Group	2.032*	0.567	0.002	0.835	3.229
	Experimental Group	Control Group	-2.032*	0.567	0.002	-3.229	-0.835
RRR	Control Group	Experimental Group	0.332	0.37	0.396	-0.458	1.102
	Experimental Group	Control Group	-0.322	0.37	0.396	-1.102	0.4558
VO <sub>2</sub> MAX	Control Group	Experimental Group	-2.267	0.401	0.000	-3.112	-1.421

Experimental Group	Control Group	2.267	0.401	0.000	1.421	3.112
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\*RHR= Resting Heart Rate \*RRR= Resting Respiratory Rate

The above table no.3 reveal that, Since F value is significant, pair-wise comparison of means has been made by using the Bonferroni correction which is shown in table 3. It may be noted that the P value associate with the mean difference between experiment and control is .002. These p values are least then .05 and the difference are significant at 5% level. The above table no.6 reveal that, Since F value is significant, pair-wise comparison of means has been made by using the Bonferroni correction which is shown in table 6. It may be noted that the P value associate with the mean difference between experiment and control is .39 These P values are greater than .05 and the difference are insignificant at 5% level. The above table no.9 reveal that, Since F value is significant, pair-wise comparison of means has been made by using the Bonferroni correction which is shown in table 9. It may be noted that the P value associate with the mean difference between experiment and control is .00 These p values are less than 0.05 and the differences are significant at 5% level.

**Finding:** The result of the study revealed that there is significantly improved in resting heart rate, because of endurance training. Tabata et al., (1996) found that moderate-intensity aerobic training that improves the maximal aerobic power does not change anaerobic capacity and that adequate high-intensity intermittent training may improve both anaerobic and aerobic energy supplying systems significantly, probably through imposing intensive stimuli on both systems. Fischer et al., (2014) study found that improved respiratory muscle endurance but had little impact on overall exercise performance. The respiratory muscle endurance was significantly increased. Mueller et al., (2006) in their study showed that six weeks of respiratory muscle endurance training performed by competitive wheelchair racing athletes increased respiratory muscle-endurance. Since there was a large observed effect size of  $d = 0.87$ , there is evidence that six weeks of respiratory muscle endurance training may also improve upper body exercise performance. In the present study, the analysis of data revealed that insignificant in the resting respiratory rate after six weeks of endurance training among the volleyball players. The potential reason for this insignificant difference may be that the intensity is less while endurance training. Although the intensity zone was same but it was calculated as per the performance of subjects on their respective level of altitudes. Eventually, the intensity was less during the moderate level training and Sokmen, (2002), concluded that interval training produced greater anaerobic benefits than continuous work.

The maximum oxygen consumption ( $VO_2$  Max.) is a determining factor in the performance of volleyball player, as well as in sports of endurance, it is necessary to sustain a rate of energy production for a long period of time, depending on a high demand for oxygen of the body in activity.(Bastos, Bonsignore 1996, 1998; Devito,1995; Evans,1997). The  $VO_2$ Max. depends on the lung capacity to absorb the oxygen heart function, the system of transport of oxygen in arterial blood, the cell CA pillarization, the ability to use oxygen in the muscles in activity and genetic potential. The physiological

responses of the sequence practice of endurance still seem to be an essential factor of study to increase the performance of volleyball player. A relatively high  $VO_2$ Max. and of extremely importance for success in the volleyball player. (RupendraFarswan 2018) it can be referred as the peak rate of consumption of  $O_2$  which is attainable during maximum exercise intensity. It is one of the most preferred measures of one's cardiovascular endurance capacity. In the present study, it is noted that the  $VO_2$  max capacity of participants increased significantly as a result of endurance training of experimental group as compared to control, in terms of mean value.

**Conclusion:** After the successfully completion of six weeks of endurance training program data were collected and analyzed with help of statistical technique with the help of SPSS. It is found that:  
- Six weeks of endurance training significantly improvements on physiological variables i.e., Resting heart rate,  $VO_2$  Max and Resting Respiratory Rate

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# EMERGING TRENDS OF PHYSICAL EDUCATION AND SPORTS SCIENCE



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# Emerging Trends of Physical Education and Sports Science

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\* RRR=Resting Heart Rate, \*SBP=Systolic Blood Pressure, \*DBP=Diastolic Blood Pressure

The above table no. 1 shows that the mean and standard deviation score of experimental and control groups of speed has been found i.e. 5.20+0.56 and 6.34+ 0.40 respectively The above table shows that the mean and standard deviation score of experimental and control groups of agility has been found i.e. 5.21+0.52 and 5.88+0.34 respectively The above table shows that the mean and standard deviation score of experimental and control groups of flexibility has been found i.e. 37.60+4.69 and 35.30+4.66 respectively The above table shows that the mean and standard deviation score of experimental and control groups of flexibility has been found i.e. 57.06+11.16 and 48.03+9.84 respectively The above table shows that the mean and standard deviation score of experimental and control groups of resting heart rate has been found i.e. 114.70+6.46 and 115.50+10.51 respectively The above table shows the mean and standard deviation score of experimental and control groups of resting heart rate has been found i.e. 73.4+3.38 and 74.3+ 6.80 respectively

Table No. 2 ANCOVA table for the post-treatment data of Speed, Agility, Flexibility, VO<sub>2</sub>max, Resting Heart Rate, Systolic and Diastolic Blood Pressure

Variable		Sum of Squares	df	Mean Square	F	Sig.
Speed	contrast	7.87	1	7.87	46.01	0.000
	error	2.91	17	0.17		
Agility	contrast	2.87	1	2.87	19.87	0.000
	error	2.46	17	0.14		
flexibility	contrast	2.84	1	2.84	0.28	0.600
	error	172.98	17	10.17		
VO <sub>2</sub> max	contrast	5.94	1	5.94	10.92	0.040
	error	9.25	17	0.54		
RHR	contrast	294.36	1	294.36	38.76	0.000
	error	129.09	17	7.59		
SBP	contrast	110.57	1	110.57	57.52	0.200
	error	326.81	17	19.22		
DBP	contrast	22.13	1	22.13	4.89	0.040
	error	76.94	17	4.52		

\* RRR=Resting Heart Rate, \*SBP=Systolic Blood Pressure, \*DBP=Diastolic Blood Pressure

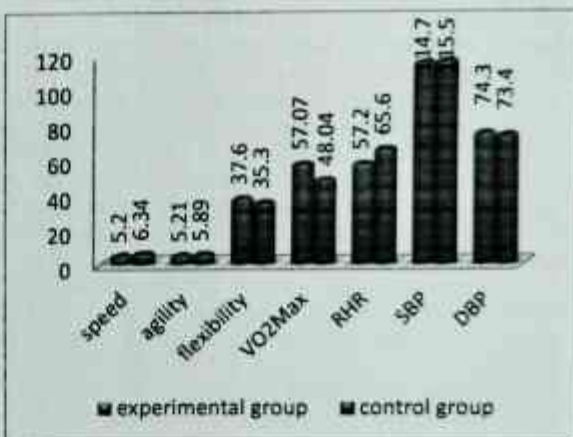
Table no 3 Pairwise Comparisons of control and experimental group of boxing players in relation to Post Speed, Agility, Flexibility, VO<sub>2</sub>Max, Resting Heart Rate, Systolic and Diastolic Blood Pressure

Variable	In Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Speed	control group	experimental group	1.134	0.196	0	0.926
	experimental group	control group	-1.134	0.196	0	-1.762

Agility	control group	experimental group	0.773	0.173	0	0.407	1.138
	experimental group	control group	-0.773	0.173	0	-1.138	-0.407
flexibility	control group	experimental group	0.774	1.464	0.504	3.982	2.314
	experimental group	control group	-0.774	1.464	0.504	-2.314	-0.982
VO <sub>2</sub> max	control group	experimental group	1.172	0.355	0.004	1.90	0.434
	experimental group	control group	-1.172	0.355	0.004	-1.424	-0.92
RHR	control group	experimental group	7.701	1.237	0	6.092	10.311
	experimental group	control group	-7.701	1.237	0	-10.311	-5.092
SBP	control group	experimental group	4.887	2.038	0.028	0.588	9.186
	experimental group	control group	-4.887	2.038	0.028	-9.186	-0.588
DBP	control group	experimental group	2.122	0.959	0.01	0.057	4.146
	experimental group	control group	-2.122	0.959	0.01	-4.146	-0.097

\*RRR=Resting Heart Rate, \*SBP=Systolic Blood Pressure, \*DBP=Diastolic Blood Pressure

Fig: 1 Mean Comparison on Speed, Agility, Flexibility, VO<sub>2</sub>Max, Resting Heart Rate, Systolic And Diastolic Blood Pressure



\*RRR=Resting Heart Rate, \*SBP=Systolic Blood Pressure, \*DBP=Diastolic Blood Pressure

Finding: The result of study shows that there is a significant improvement on the physical variable like speed. The efficacy of (speed, agility, and quickness; SAQ) method on jump shot and physical performance variables for youth handball players (Emaish, M. K. 2015). May be the study was enough in intensity was the result was positive improve. The study found that specialized SAQ equipment was not a requirement to observe significant improvements (Bloomfield, 2007) a superior method for improving speed and agility parameters; however, this study found that specialized SAQ equipment was not a requirement to observe significant improvements. The study was concluded the significant effect of Swiss ball training was found on speed and agility of football players when the experimental groups compared with the control group (Moorthy et al., 2013). May be study was enough in intensity was the result was positive improve. The result of study

shows that there is a significant on the physical variable like agility. The study was concluded the significant effect of Swiss ball training was found on speed and agility of football players when the experimental groups compared with the control group (Moorthy et al., 2013). May be study was enough in intensity was the result was positive improve. The efficacy of (speed, agility, and quickness; SAQ) method on jump shot and physical performance variables for youth handball players (Eneish, M. K. 2015). May be study was enough in intensity was the result was positive improve. The result revealed that it was found that SAQ training group had significant effect on agility (Mohanasundaram, 2013). The result revealed in this study indicated that there was significant improvement in selected motor physical fitness variable speed, balance, agility, power and endurance due to the effects of aerobic, anaerobic and combined training. Agility, aerobic and anaerobic power outputs of the players support the success in the game (Tanyeri, et al., 2020). it was revealed that the agility training of futsal players attending university for six weeks had an effect on their aerobic endurance. The result of study shows that there is no significant on the physical variable like flexibility. The find out the effects of circuit training and fartlek training on selected physical fitness variables (Mahesh Yadav, 2017). May be the study was enough in intensity was the result was negative improve the flexibility no significant proved of between experimental groups and to be improved muscular strength and muscular endurance. According to the literature it has found effects of a six-week training period of combined plyometric and resistance training that significantly affected on the physical variable like flexibility (Faigenbaum et al., 2000). The following reasons might be influenced the training duration was not appropriate, may be the participant didn't full effort during the test. The finding of the present study strongly indicates that effect of speed and agility training program have positive effect on physiological variables like heart rate and  $VO_{2max}$ .  $VO_{2max}$  and Resting Heart Rate (RHR) and blood pressure were found to be significantly increase with the training. The speed, agility and quickness training increased power. The breath holding capacities of the athletes increased. Also, they showed less recovery time since the time the training started. The result of study shows that there is a significant on the physiological variable like resting heart rate. the effect of speed, agility and quickness training on selected skill related fitness and physiological variables among inter collegiate basketball players (Pathak, et al., 2019). May the be study was enough in intensity was the result was positive improve. The effect of 12 weeks of S.A.Q. training have significant effect on selected physiological football players. (Kumaravel, V., et al.,). Find that they strongly indicate that i.e., heart rate, systolic blood pressure and diastolic blood pressure of football players. According to the literature it has found that 6 weeks speed- strength and agility training significantly affected on the physiological variable like resting heart rate (Sharma et al. 2018). Specific physiological parameter improvement-targeted training can also be designed based on this research. The effect of 12 weeks of S.A.Q. training have significant effect on selected physiological football players. (Kumaravel, V., et al.,). Find that they strongly indicate that i.e., heart rate, systolic blood pressure and diastolic blood pressure of football players. According to the literature it has found that 6 weeks speed- strength and agility training significantly affected on the

physiological variable like  $VO_{2max}$  (Sharma et al. 2018). Specific physiological parameter improvement-targeted training can also be designed based on this research. The present study shows that there is a significant on the physiological variable like  $VO_{2max}$  pressure. the effect of speed, agility and quickness training on selected skill related fitness and physiological variables among inter collegiate basketball players (Pathak, et al., 2019). May the be study was enough in intensity was the result was positive improve. training AT has recently been instituted in several combat athlete communities in hopes of improving combat performance as well as general fitness (Walker, T. B., et al., 2010). There were strong trends toward the agility group improving more than the traditional group on  $VO_{2max}$ . According to the study it has found that 6 weeks speed- strength and agility training significantly affected on the physiological variable like blood pressure, (Sharma et al., 2018). Specific physiological parameter improvement-targeted training can also be designed based on this research. The present study shows that there is a significant on the physiological variable like blood pressure. the effect of speed, agility and quickness training on selected skill related fitness and physiological variables among inter collegiate basketball players (Pathak, et al., 2019). May the be study was enough in intensity was the result was positive improve. In this Present study researchers has attempted to discover the impact of S.A.Q. training protocol on blood pressure level of female soccer players (Sumal, R., et al., (2018). results strongly confirm that, six weeks S.A.Q. training put significant effects on systolic and diastolic blood pressure of female soccer players. The effect of 12 weeks of S.A.Q. training have significant effect on selected physiological football players. (Kumaravel, V., et al.,). Find that they strongly indicate that i.e., heart rate, systolic blood pressure and diastolic blood pressure of football players.

**Conclusion:** It is concluded that the six weeks speed and agility training program is having a positive influence at both the experiment and control group. There is a significant difference in experiment groups on physiological variables such as resting heart rate and  $VO_{2max}$  and blood pressure also significant difference in physical variables such as speed and agility. The result of the study indicated that physical and physiological variables increased due to training effect on experiment group. When compared between the experimental and control groups, it is found that the mean difference of experimental group is higher than the control groups for physical and physiological variables selected for this study. It is also evident that all depended variables the experimental group has performed better than that of control group. It shows that the training program speed and agility training has positive effect on boxers. Furthermore, it is found that speed and agility training considered in this study are ineffective in flexibility.

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# EFFECT OF FOUR WEEKS FARTLEK TRAINING ON VO<sub>2</sub> MAX OF COLLEGE & UNIVERSITY GIRL'S

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## ABSTRACT

*Objective of the study was to find out the effect of four weeks fartlek training methods on Vo<sub>2</sub> Max. Methodology: 20 girls' runners (10 Experimental Group and 10 Control Group) from Rajiv Gandhi University, Itanagar with age ranging from 20 to 24 years of age were selected and randomly distributed as Experimental Group (10) and Control Group (10). The experimental group went through four weeks of fartlek training and whereas the control group attain all the regular activity classes. To measure the Vo<sub>2</sub> Max of the both the experimental (pre and post) and control (pre and post) group the 12 Minutes Cooper Run/walk test was used and adopted the following equations  $VO_{2max} = (22.351 \times \text{distance in kilometers}) - 11.288 \text{ ml/kg/min}$ . Descriptive statistic was used and to compare the mean of experimental and control group the Analysis of Covariance (ANCOVA) was employed at .05 level of significance by using SPSS. Result: the finding shows that the four week of fartlek training cannot bring the significant changes to the girl's runner on Vo<sub>2</sub> Max. Conclusion: The present study shows that there exists insignificant*

*difference among the selected groups of runners, the reason may be the duration of training may be short or the level of motivation and sincerity may affect the results of the study. Further is also recommended that continue study should be done by increasing the numbers of physiological and psychological variables to know the actual cause of insignificant improvement in the present study.*

**Keywords:** *Girl's Runners, Vo<sub>2</sub> Max, Experimental Group, Control Group & Fartlek Training Method*

**Introduction:** Sports men and women have to train throughout the year in a process of so-called periodization or training plan. In this they have to trained with different types of training methods. Fartlek, developed in the 1930's, comes from the Swedish for 'Speed Play' and combines continuous and interval training. Fartlek allows the athlete to run whatever distance and speed they wish, varying the intensity, and occasionally running at high intensity levels. This type of training stresses both the aerobic and anaerobic energy pathways. The fartlek training method is also one of the trainings which is very popular for its speed variation by managing own pace by the athletes which means the control of athletes is not by the coach but by the athlete's self. It differs from traditional interval training in that it is unstructured; intensity and/or speed vary, as the athlete wishes. Fartlek training is generally associated with running, where it is also called "wind sprints," but can include almost any kind of exercise. This training can be performed at hilly path, River bed, Forest, muddy roads and sandy paths etc. In Fartlek change pace or speed is not free planned so some exercises can also be included in this method by the athlete's self. The type of exercises that can included running are hopping, jumping, squat jump, double hop jump etc. in this training programmed, running is decided by setting a time period from 20 minutes to 1 hour, according to the standard of athletes or runner. Hence, time period is the basic factor in this training. It is the best method of conditioning for most the sports in which endurance is the basic requirement. Fartlek training methods can improve not only the physiological variables like cardiovascular endurance, cardio-respiratory endurance but also can improve the various factors of physical fitness components and psychological abilities and well-being which lead to boost up the immune system as well as entire systems of the human being.

**Methodology:** 20 girls' runners (10 Experimental Group and 10 Control Group) from Rajiv Gandhi University, Itanagar with age ranging

from 20 to 24 years of age were selected and randomly distributed as Experimental Group (10) and Control Group (10). The experimental group went through four weeks of fartlek training and whereas the control group attain all the regular activity classes. To measure the  $VO_2$ Max of the both the experimental (pre and post) and control (pre and post) group the 12Minutes Cooper Run/walk test was used and adopted the following equations  $VO_2max = (22.351 \times \text{distance in kilometers}) - 11.288 \text{ ml/kg/min}$ . Descriptive statistic was used and to compare the mean of experimental and control group the Analysis of Covariance (ANCOVA) was employed at .05 level of significance by using SPSS.

**Findings of the Study:**

**Table 1: Descriptive Statistics for Experimental and Control Group**

Group	Mean	Std. Deviation	Lower Bound	Upper Bound
Experimental	35.65	4.83	35.68	45.07
Control	38.33	17.56	28.91	38.30

**Table 2: Adjusted Post Test Mean and Levene's Test for Equality**

Group	Mean	SD	Levene's Test of Equality of Error Variances			
			F	df1	df2	Sig.
Experiment	40.375 <sup>a</sup>	2.23	11.647	1	18	0.003
Control	33.605 <sup>a</sup>	2.23				

Table 2 shows the adjusted mean value by adjusting the existed mean value.

**Table 3: Test of between-Subject's Effects**

Source	Type I Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2255.144	2	1127.57	25.065	.000
Intercept	27365.202	1	27365.20	608.305	.000
PRE	2064.367	1	2064.37	45.889	.000
<b>Group</b>	<b>190.776</b>	<b>1</b>	<b>190.78</b>	<b>4.241</b>	<b>.055</b>
Error	764.762	17	44.99		
Total	30385.107	20			
Corrected Total	3019.905	19			

a. R Squared = .747 (Adjusted R Squared = .717)

Table 3 shows that the test of between subjects' effects is insignificant.

**Table 4: Pairwise Comparison between Experimental and Control Group**

Group		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Experimental	Control	6.771	3.288	.055	-.166	13.707
Control	Experimental	-6.771	3.288	.055	-13.707	.166

Table 4 shows that there is no significant difference exists in the pairwise comparison which implies that the similarities exist between the experimental and control group.

**Table 5: Univariate Analysis between Experimental and Control Group**

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	190.776	1	190.776	4.241	.055
Error	764.762	17	44.986		

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means. Table 5 shows the univariate analysis between experimental and control group have no significant differences exists.

**Discussion of Finding:** The continuous running, fartlek training and interval training have improved the speed and coordination, endurance and cardio-vascular endurance (Sundar et al., 2014, Pradeep Kumar, 2015, Deba Prasad Sahu, 2016, Ramdas Radhav, 2016, Palanisamy, A., 2019, Chaudhari, N. D., 2017). Nimeshkumar (2017) also state that Sand training can improved the speed and cardio respiratory endurance. Prasanna & Vaithianathan, (2019) study also revealed that combine training of continuous running, alternate pace run and fartlek training methods can improve physiological variables of the athletes. The fartlek training have significantly improved in cardio respiratory fitness and muscular endurance in young adults than aerobic training (Shingala & Shukla, 2019). Fartlek training improve early endurance ability in male kho-kho players and also enhanced recovery phase and delayed early fatigue (Salgaonkar et al., 2020). But the present finding shows that the four week of fartlek training cannot bring the significant changes to the girl's runner which implies that the duration of the training is too short to bring the significantly effect on the endurance of the runners. Another reason may be the training scheduled may need to be modified as the

process of loading and the outcomes of the training may need some more time to show the improvement. And the sincerity and motivation during the training may be low as they may not be serious and think just trained for the purpose of the study. The sincere and positive training on fartlek can improved not only the cardio-respiratory endurance but also found contributed to other components of physical fitness (Fahmi et al., 2014). Muryadi et al., (2021) state that the circuit training and fartlek training method have similar impact on the endurance performance. On the other hand, other training method should also be implemented with the fartlek method to bring the significant improvement if the duration of the training is less (Hermanzoni, H., 2019 and Akbar, 2021). Eleckuvan, M. R. (2014) also state that there is significantly improved in oxygen uptake capacity after twelve weeks of fartlek training.

**Conclusion:** The present study shows that there exists insignificant difference among the selected groups of runners; the reason may be the duration of training may be short or the level of motivation and sincerity may affect the results of the study. Further is also recommended that continue study should be done by increasing the numbers of physiological and psychological variables to know the actual cause of insignificant improvement in the present study.

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# EMERGING TRENDS OF PHYSICAL EDUCATION AND SPORTS SCIENCE



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# Emerging Trends of Physical Education and Sports Science

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## RESULTS

Table no.1 Descriptive statistic of Resting Heart Rate, Vo2 Max, Speed, Agility, and Strength

Variables	Group	mean	SD
RHR	Experimental group	57.60	5.03
	Control group	59.00	5.16
Vo2 Max	Experimental group	55.72	9.37
	Control group	55.11	8.24
Speed	Experimental group	4.91	0.26
	Control group	4.85	0.50
Agility	Experimental group	12.67	0.50
	Control group	12.57	0.48
Strength	Experimental group	46.86	4.51
	Control group	45.67	4.19

The above table shows that the mean and standard deviation score of experiment and control group of badminton player in relation to Resting heart rate has been found i.e. 57.6+5.03 and 59.0+5.16 respectively. The above table shows that the mean and standard deviation score of experiment and control group of badminton player in relation to Vo2 Max has been found i.e. 55.72+9.37 and 55.11+8.24 respectively. The above table shows that the mean and standard deviation score of experiment and control group of badminton player in relation to speed has been found i.e. 4.91+0.26 and 4.85+0.50 respectively. The above table shows that the mean and standard deviation score of experiment and control group of badminton player in relation to agility has been found i.e. 12.67+0.50 and 12.57+0.48 respectively. The above table shows that the mean and standard deviation score of experiment and control group of badminton player in relation to strength has been found i.e. 46.86+4.51 and 45.67+4.19 respectively.

Table No.2 ANCOVA table for the post-treatment data of Resting Heart Rate, Vo2 Max, Speed, Agility and Strength

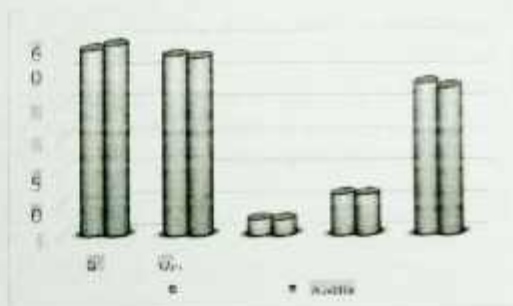
variables		Sum of square	Df	Mean square	F	Sig.
Vo2 Max	Contrast	25.968	1	25.968	3.447	0.081
	Error	128.086	17	7.534		
RHR	Contrast	12.850	1	12.850	10.370	0.005
	Error	21.066	17	1.239		
speed	Contrast	0.010	1	0.010	0.627	0.439
	Error	0.274	7	0.016		
Agility	Contrast	0.013	1	0.013	0.501	0.489
	Error	0.455	17	0.027		
Strength	Contrast	6.874	1	6.874	10.753	0.387
	Error	10.867	17	0.639		

Table no.3 Pairwise Comparisons of control and experimental group of badminton players in relation to post resting heart rate, Vo2 Max, Speed, Agility and Strength

Variables	(I) Group	Mean difference (I-J)	Std. error	Sig. b	95% Confidence interval for difference
	Experimental	-1.604	0.498	0.005	-2.654 - .553
	Control				

RHR	Control	Experimental	1.604	0.498	0.005	.553	2.654
Vo2 Max	Experimental	Control	2.292	1.234	0.081	-3.13	4.896
	Control	Experimental	-2.292	1.234	0.081	-4.896	0.313
speed	Experimental	Control	0.045	0.439	0.439	0.075	0.165
	Control	Experimental	-0.045	0.439	0.439	0.165	0.75
strength	Experimental	Control	1.173	0.358	0.004	0.418	1.927
	Control	Experimental	-1.173	0.358	0.004	-1.927	-0.418
Agility	Experimental	Control	0.052	0.073	0.489	0.103	0.207
	Control	Experimental	-0.052	0.073	0.489	0.207	0.103

Figure No. 1: Mean Comparison on Vo2 Max, Resting Heart Rate, Speed, Agility and Strength



## Findings

According to the study's findings, endurance training has a considerable positive impact on resting heart rate. According to Tabata et al. (1996), adequate high-intensity intermittent training may significantly improve both anaerobic and aerobic energy supplying systems. This is probably accomplished by applying intense stimuli to each system. Moderate intensity aerobic training that increases maximal aerobic power does not alter anaerobic capacity. According to the researcher (Raman, D., and A. Nageswaram, 2013) The study's findings demonstrated that circuit training considerably enhances strength training. It has been determined that there is no discernible change in vo2 max between the experimental and control groups. The non-significant difference may be caused by the length of the training period; a significant difference may occur if the training is for at least 10 weeks and lasts longer than 6 weeks. Therefore, it would seem appropriate for the experimental and control groups' pre- and post-mean values to have been similar. Lack of a serious, committed, and wholehearted effort on the side of the subjects while undergoing training could be another factor contributing to minor differences (Kapur, A., 2017). The six-week training programme greatly increased speed and agility, according to barber-westin, SD, et al. (2015), but my investigation found no difference in speed or agility that could be

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considered significant. Lack of a serious, dedicated, and sincere effort on the part of the subjects while undergoing training could also be a contributing reason to the unremarkable results.

**Conclusion:** Following the successful completion of a six-week conditioning training programmed, data were collected and evaluated using statistical methods and SPSS.

Strength and resting heart rate are found to differ significantly between the experimental and control groups, but the remaining physical and physiological variables are shown to differ not significantly.

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# EMOTIONAL WELL-BEING OF KARATE AND FOOTBALL PLAYERS OF STATE SPORTS ACADEMY; A PROFILE STUDY

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## ABSTRACT

*Objective of the study was to assess the emotional well-being of football and karate players. Methodology: The purpose of the study was to analyze emotional well-being among different young women sports person, for achieve purpose thirty-two women athletes i.e. sixteen from karate and sixteen from football from Sangay Lhaden Sports Academy, Arunachal Pradesh. The age range of the players were ranging from 15 to 20 years old. For the assessment of the emotional well-being the emotional well-being questionnaire PANAS-SF (the positive and negative affect schedule). The descriptive statistics and descriptive profile was used to describe the emotional well-being of karate and football players. Result: The present study shows that there is a big scope for improvement in emotional abilities of the players in terms of achieving the high performance from the level they have attained now. Conclusion: the emotional well-being (positive and negative) of both football and karate scores are having wide range from each other and recommend that the psychological training should be involve in their daily training schedule to fulfill gap amongst the level of achievement.*

**Keywords:** Emotional Well-being, Karate Players, Football Players, Negative & Positive Emotion.

**Introduction:** Emotions are part of the fabric of everyday life but there is an unsettling ledger of limits to our understanding of positive emotions in sport performance (McCarthy, 2011). Sports and vigorous physical activities are positively associated with the emotional wellbeing irrespective of sex, social class and health status (Steptoe & Butler, 1996). Control over emotions and maintaining concentration that contribute to success in sports. These factors can be learned and improved with instruction and practice by the athletes as well as to become a successful citizen of the society also (Larcombe, 2016). The player's with positive emotions during matches enhanced the win rate of a competition; conversely, a nervous or anxious emotional state negatively affected the bad result of the competition (Lesyk, 1998). Larcombe (2016) rightly said that sport is also a big play field to associate with positive minded people who lead a group of players used to working hard, constantly improving, and believing they can achieve future goals. These athletes will climb up and challenge the competitions in different levels. It's also important that non-sports playing friends and family are supportive and believe in what you are trying to achieve. The mass media is also helping to develop a positive emotion wellbeing and encouragement to increasing in the raking table of the players. So, it is necessary to identify and cultivate that positive emotional wellbeing which is most conducive to sports and a great extent to determine the athlete performance. Sport psychology itself has long been making its impact in the field of sports for many years. Many teams around the world have been utilizing mental techniques in the improvement of performance. A lot of sports officials, coaches, team managers, and athletes talk about the benefits and significance of sports psychology but rarely include it in their training regimen. Athletes with high levels of positive emotional wellbeing, take part in sport because athletes feel better when they achieve something. The embryonic research on positive emotions has lifted the curiosity of researchers from psychology, sociology, philosophy, neuroscience, psychiatry, biology, and anthropology to passionately pursue answers to critical conceptual and empirical questions that have hitherto impeded this research.

**Methodology:** The purpose of the study was to analyze emotional well-being among different young women sports person, for achieve purpose thirty-two women athletes i.e. sixteen from karate and sixteen from football from Sangay Lhaden Sports Academy, Arunachal Pradesh. All the subjects were participating regularly and related from team game

and individual games of football and karate who has participated in state level competitions were selected as the subject of the study the age range from 15 to 20 years old, the study was confined to the emotional wellbeing questionnaire PANAS-SF (the positive and negative affect schedule). The entire questionnaire was demonstrated and explained to all the subjects by the scholar himself. Subjects were asked to read the questionnaire and also instructed the procedure to filled the questionnaire. The descriptive statistics and descriptive profile was used to describe the emotional well-being of karate and football players.

**Findings of the Study:**

**Table 1: Descriptive Statistics of Karate and Football Player on Emotional Well-being**

		Karate Positive	Karate Negative	Football Positive	Football Negative
N	Valid	16	16	16	16
	Missing	0	0	0	0
Mean		35	25.38	35.13	27.19
Std. Error of Mean		1.76	1.64	1.95	1.45
Median		37.5	25.5	34.00	27.00
Mode		38	27	32.00 <sup>a</sup>	23.00 <sup>a</sup>
Std. Deviation		7.02	6.56	7.80	5.79
Variance		49.33	43.05	60.92	33.50
coefficient of variance		40.11%	51.69%	44.40%	42.58%
Skewness		-2.08	0.57	0.36	0.02
Std. Error of Skewness		0.56	0.56	0.56	0.56
Kurtosis		4.89	-0.62	0.22	-0.65
Std. Error of Kurtosis		1.09	1.09	1.09	1.09
Range		28	20	28.00	20.00
Minimum		14	17	22.00	16.00
Maximum		42	37	50.00	36.00

**Figure 1: Descriptive Profile of Emotional Well-being of Karate and Football Players**

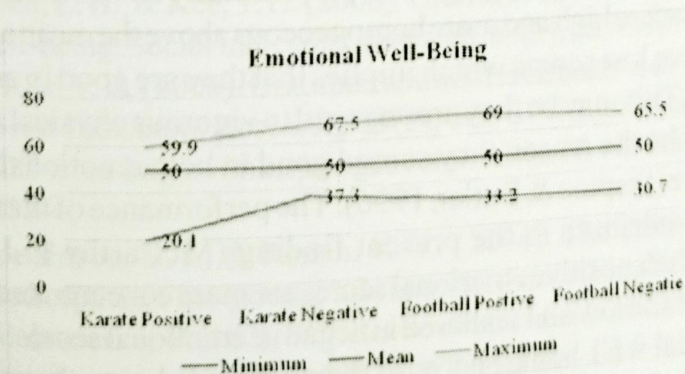


Table 1; shows that the skewness of karate positive (-2.08) is negatively skewed which implies that the majority of the Karate positive score are above the mean value, and karate negative is positively skewed (0.56) which implies that the scores are below the mean. The skewness value of karate positive is significant as the calculated value (-2.08) is greater than the twice of the standard error of skewness ( $2 \times 0.56 = 1.12$ ) which implies that the median score of the karate positive is considered as the representative score. The kurtosis value of the karate positive is positive which implies that the more homogeneity of scores. And the calculated kurtosis value of karate positive (4.98) is significant as the value is greater than the twice of the standard error of skewness ( $2 \times 1.09 = 2.18$ ), which resembles that the score are more concentrated around the model values. The coefficient of variance of karate positive and karate negative are 40.11% and 51.69% which implies very wide range of variation. Further it is eminent that the score of karate players on positive and negative emotional well-being were range between 14 to 42 and 17 to 37. The skewness value of football positive and negative are positively skewed which implies that the score are lies below the mean value. The kurtosis value of the football positive is positive which implies that the more homogeneity of scores. The skewness and kurtosis of both football positive and negative (0.22 and -0.65) are insignificant as the calculated scores are lesser than twice the standard error of skewness ( $2 \times 0.56 = 1.12$ ) and standard error of kurtosis ( $2 \times 1.09 = 2.18$ ). The coefficient of variance of football positive and football negative are 44.40% and 42.58% which implies very wide range of variation among the scores. Further it is eminent that the score of football players on positive and negative emotional well-being were range between 22 to 50 and 16 to 36.

**Discussion of Findings:** The present study shows that the karate positive has score high and more homogeneous above the mean and karate negative have low scores which implies that they are good in emotional well-being. This may be they are engaged to vigorous physical activities so this may be the reason they scored good in both emotional positive and negative (Stephoe & Butler, 1996). The performance of the athletes may also contribute to the present finding (McCarthy P. J., 2011). Moreover, their positive emotional scores are more concentrated towards model value and low and scattered in negative emotional scores. Whereas the emotional well-being scores of the positive is lower than the mean

value which indicate wide scope for the improvement and the emotional negative score is low which implies that good in negative emotional well-being. The athletes are having a special kind and understanding of self-attitude and this might nurture constructive reactions to emotionally difficult sport situations (Ferguson et al., 2015). This may be the reason footballer are good in controlling the negative emotion. Donaldson & Ronan (2006) also state that exercise and physical activities improve physical fitness as well as emotional well-being. A good relationship within and outside sports also developed positive emotional well-being amongst the youth (Reverberi et al., 2020). So, it is necessary to identify and cultivate that emotional positive wellbeing which is most conducive to sports and a great extent to determine the athlete performance. Madsen et al., (2021) also state that there is a credible positive relationship positive affect among the people over time. The team satisfaction amongst the players can reduce the negative emotion among the team mates (Chen & Kee, 2008). The improvement of the psychological skills, psychological well-being has positively interrelated with the sporting performance (Edwards & Steyn, 2008). Above all the reasons karate players have good level emotional well-being and football players also having good abilities of controlling negative emotions.

**Conclusion:** the emotional well-being (positive and negative) of both football and karate scores are having wide range from each other and recommend that the psychological training should be involve in their daily training schedule to fulfill gap amongst the level of achievement.

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**Estimating the Economic Impact of  
Tourism on a Mountain Tourist Spot:  
A Study of Tawang, Arunachal Pradesh**

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# Non-Wood Forest Products of Asia

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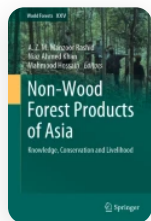
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# Ethnomedicinal Knowledge of *Tangsa* Community from Patkai Hills Region of Changlang District in Arunachal Pradesh, India

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[Pyonim Lungphi](#), [A. P. Das](#) & [Victor Singh Ayam](#) 

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## Abstract

This chapter depicts considerable information on traditional uses of medicinal plants by *Tangsa* tribe in Changlang district of Arunachal Pradesh, India. This is the first quantitative ethnobotanical study from the area. Data were collected by interviewing 64 local informants and 07 traditional health practitioners from 11 villages of Changlang district. Medicinal uses of 56 species representing 47 genera and 36 families were documented. Demography of informants; plant habit-groups, parts used, preparation and application methods and ethnomedicinal uses were documented. Collected data were analysed using quantitative tools like Fidelity Level (FL), Use

Value (UV), Informant Consensus Factor (ICF) and Relative Frequency Citation (RFC). *Clerodendrum glandulosum*, *Curcuma longa*, *Mikania micrantha*, *Psidium guajava* and *Zingiber officinale* were recognised as most popular medicinal plants. Recorded ailments were classified into 11 disease categories based on ICF values. The study reveals the preservation of knowledge on folk medicine by *Tangsas* in their folk songs and through oral transfer to their descendants. Quantitative evaluation shows the high impact of traditional knowledge of Tangsa tribe. However, medium to low values of some of the data like FL (<50%), UV (<0.5), and RFC (<0.5) in certain species having claims of curing more than two or three diseases requires further scrutiny through phytochemical characterization before promoting their wider uses.

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# **Trends and Issues in Education**

## **Editors**

Dr. Prasanta Kumar Barik

Dr. Tayum Saroh

Dr. C. Siva Sankar

Prof. Prasanta Kumar Acharya

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## **Fear of COVID-19 Significantly Affected the Students Mental Health: A Review**

Sandeep

### **ABSTRACT**

*The article is based on review of literature and some of the earlier studies in this areas. The fear of COVID-19 significantly affected the mental health problems all the people's lives. Peoples are facing lot of difficulties during this current time and they are dealing with the uncertain time about their career and students about their higher education. No doubt, there are many factors related to it but fear about COVID-19 is one of the major factors which affect the overall mental health of students. The article concluded that the emotional adjustment and day time sleepiness, depression, stress are some of the factor which significantly affect the mental health among the students. There was need in the lockdown and undoubtedly psychologist played a great role in this pandemic situation. Psychological intervention is more important to deal with the fear of covid-19 so that the mental health problems can be treated appropriately. Based on the review studies, it can be concluded that the fear of COVID-19 significantly affected the mental health problems among students. There are some important psychological factors like Day Time Sleepiness, Emotional Adjustment, Depression, Anxiety, and*

*Stress. Therefore, this pandemic situation created a burden on the mental health among students. So, the mental health awareness and intervention is needed to cure these issues.*

**Keyword:-** *Fear of COVID-19 & Mental Health Problems*

## **Introduction**

### ***(A) Conceptual Background***

This current pandemic situation exhibits the tough time for everyone all over the world wide. Many people are suffering directly or indirectly with this COVID-19 situation. Initially, people are very fearful about its severed impact not only on physical health rather on mental health also due to the losses of family members and related one. The Fear of COVID-19 is significantly impact on the mental health problems particularly among students because many challenges related to academic and career. This pandemic becomes more serious diseases due to listen news about its severe consequences which precipitate fear among them and students start over think on the outcomes. There are many psychological factors which are related to the fear of COVID-19 are mental health problems among students such as stress, anxiety, depression, emotional adjustment, sleep related problems, and other unknown factors.

### ***(B) Meaning of Fear of COVID-19***

Fear is a kind of adaptive reaction in any dangerous situation. It is also learned behaviour because it is observed by the people and imitated in terms of learning process. But, when it uncertain and for a long time it may become so chronic. Study which focus on predictors of fear of COVID-19 done with a sample of 439, during the 14 March to 17 March 2020. The results showed that uncertainty intolerance, worry, and anxiety related to health, and risk for loved ones, social media uses and risks related to loved ones (Gaetan Mertens, et al., 2020). There are some researches

which focus on the fear related to COVID-19 and its link to the mental health problems. Study by Hall et al. (2008) showed that during the any pandemic time people may exhibit fear related to infection of a particular virus or disease, people also experience stress, depression and higher anxiety. Another study, Shete and Garkal (2015) reveal medical students reported high level of stress. They also conclude the different factors which are related to stress; specifically the gender and age are important factors which affect the stress levels among students.

### **Fear of Covid-19 and Review of Related Studies**

Now-a-days researchers are studying the various aspects of COVID-19 and its impact on mental health issues on different sample. In this regard, we are mentioning here few of related studies here. A recent study that has been conducted on students by using Generalized fear of COVID-19 Scale, The Epworth Sleepiness Scale (ESS) and Adolescent's Emotional Adjustment Inventory (AEAI). Results showed the fear of COVID-19 significantly positive related to Day Time Sleepiness ( $r = .19$ ) and Emotional Adjustment ( $r = .31$ ) among students. Study also found fear of COVID-19 ( $R^2 = .09$ ) is most significant predicative factor in emotional adjustment among students (Panchal & Yadav, 2020). Another recent study, Panchal and Kumari (2021) reveal fear of COVID-19 significantly correlated with depression and stress among students. Further, the stepwise multiple regression analysis showed that fear of COVID-19 is a significant predictor of stress among students. Another study focused on fear of COVID-19, stress, anxiety, and depression during lockdown among undergraduates. Sample included 640 undergraduates, with age range 18 to 47 years. Results indicated high levels of fear related to COVID-19 among female than men. The results also showed that depression is predictors of

fear related to COVID-19 and it has the both direct and indirect relationship with fear related to COVID-19. They concluded and highlighted the important aspect of relation among fear, anxiety and stress that play an important role in the development of depression symptoms (Rodríguez-Hidalgo et al. 2020). In one of articles, which focused on impact of COVID-19 on mental health issues suggested that psychological issues and important effects on stress, depression, frustration and uncertainty about the time are the some of psychological factors which affects the mental health of the individuals (Serafini, et al. 2020). In another study, Octavius, Silviani, Lesmandjaja, Angelina and Juliansen (2020) conducted a systematic review to know the COVID-19 effects and its causal factors, particularly during lockdown time in connection with adolescents' mental health. They incorporated that COVID-19 was a potential risk factors for mental health issues among adolescents. The adolescents who have chosen to reside at their house during this pandemic time reported less anxieties and less depression. They also concluded that the COVID-19 related mental health problems should be managed properly. In another article, Rajabimajd, Alimoradi and Griffiths (2021) explored the impact of pandemic on the occupation. The collected sample consisted of 1654 respondents from different country. They reported that fear of COVID-19 was related to high levels of anxiety related to future career, insecurity related to job, organizational and professional turnover intentions, and low levels of job satisfaction. Syndrome related to COVID-19 anxiety was correlated to social adjustment and work behaviour. The study concluded that more studies should be done in various organisation and job so that some fruitful results can be obtained. Based on the mentioned studies above it may conclude that the fear related to COVID-19 really affected the mental health problems of diverse population.

## **Gaps in Researches**

Recent times the covid-19 situation creates a burden on the students and there are many factors involves due to these factors the fear related to COVID 19 may be developed. Since, the students are facing a lot of problems and uncertainty about their career and also about their higher studies because of their multiple issues the pandemic situation that creates burden on them. Therefore, the current article was planned to insight on the Fear of COVID-19 and its significant effect on mental health problems at diverse levels.

## **Mental Health & Its Relationship with Fear of Covid-19**

Mental health can be understood in terms of individuals effective adjust towards this pandemic situation. If the person is able to deal effectively with the problems and free from the illness. There are many factors involve in mental health, it is very important aspect of individual life. Some of the studies which are related to mental health issues which showed stress, anxiety and depression among various national people during this pandemic of Covid-19. Particularly, the psychological distress such as anxiety, stress, and depression are common mental disorders for all the suffering people (Wang et al. 2020). Further, stress, depression, and anxiety were also observed common mental health problems among people (Leung et al. 2003). Health professionals are also at high risk of having the psychological distress and chronic stress (McAlonan et al. 2007). Roy et al. (2020) revealed higher anxiety among people who are facing this pandemic time. More than 80 % of the people were preoccupied with the thoughts of COVID-19 and 72 % reported the need to use gloves, and sanitizers. The perceived mental healthcare need was observed in more than 80 % of participants. There is

a need to intensify the awareness and address the mental health issues of people during this COVID-19 pandemic. One of the recent studies showed effect of the pandemic situation on mental health and quality of life among Middle East and North Africa (MENA) general population areas. Sample includes 6142 adults, sample collected from the eighteen countries within the MENA region by using online tools in the months of May and June 2020. Results indicated thirty percent people reported severe levels of psychological stress. Further, forty percent reported increased stress related to financial and work related issues. The study concluded that COVID-19 pandemic was associated with mild psychological impact while it also encouraged some positive impact on family support and mental health awareness among adults in the MENA region (Al Dhaheri, et al. 2021). In a study, Qiu et al. (2020) reported the gender difference on the psychological distress. In another important study, Bakioglu, Korkmaz and Ercan (2020) found positive correlated factors with the fear of COVID-19, the factors are, intolerance of uncertainty, depression, anxiety, and stress. Moreover, they also found negative relationship between fear of COVID-19 and positivity. They concluded that there was a mediating role of intolerance of uncertainty, depression, anxiety, and stress in the relationship between the fear of COVID-19 and positivity. Eliminated the uncertainty from the fear of COVID-19 will lead to the reducing depression, anxiety and stress, and increasing positivity.

There are many researches related to mental health problems among students, more specifically the depression, stress and anxiety. There are also some causal factors for these problems like social, psychological and bio-logical. Studies related to stress and depression in relation to fear of covid-19 conducted by Shahid, et al. (2020), females reported high level of anxiety stress and depression in comparison to male group.

Another study, Pfefferbaum, et al. (2020) indicated public health emergencies significantly affect the well-being of the society and living individuals. Their effects have a wide range of emotional, unhealthy and noncompliance behavioural reactions. In another research, it has been found that stress and depression increases when the working hour increase in this COVID-19 situation (Rumeysa, et al. (2020). Further, another study, gender difference has found on the variable of anxiety depression and stress in COVID-19 patients. The female mean values for anxiety, depression and stress, were observed higher than the males group (Rehman, Shah Nawaz and Uniyal (2020). Similarly, people who were facing lockdown and pandemic situation report more about depression and anxiety (Grover, et al., 2020).

### **Role of Psychologist in this Pandemic Time**

Role of psychologists and mental health professionals are more and more important to provide a significant help in terms of social and emotional support to the people who are suffering from this current pandemic. Certainly, the psychologists giving more emphasis on psychological factors which are disturbing the human adaptive behaviour, because of these environmental stress people or specially the students are having the disturbance related to mental health issue and their academic related activity and routine. The current pandemic stressors have impacts on students at behavioural and emotional levels (Inchausti et al., 2020), Some of the researchers recommended the psychologists should consider some of the points while dealing the COVID-19 suffering people, the fixed or inflexible though about the pandemic and its outcomes, and the individual frustration intolerance and individual global evaluation in terms of emotion and intense feeling about one-self and the environment (Chong, et al., 2020). Psychologist offering

counselling, psychotherapies, behavioural intervention, assessments and talking cure to help the client in a manner so that he or she can adjust to this current pandemics time more effectively. No doubt the psychologist job is very challenging in this tough time, with the challenges and changing nature of behaviour the psychologist providing effective and sound services to the people at all levels.

## **Conclusion**

The objectives of the study were to explain the linkage between the fear of COVID-19 and mental health problems and factors related to mental health problems among students. The review of studies showed that the fear of COVID-19 affected the mental health problems significantly because this pandemic situation creates lots of burden on the students and there are many factors like psychological, social and environmental factor, due to these factors the fear related to COVID 19 may developed among students. Specifically, Psychological factors include Day Time Sleepiness, Emotional Adjustment, Anxiety, Depression and Stress. Since, the students are facing a lot of problems and uncertainty about their career and also about their higher studies because of their multiple issues the pandemic situation that creates burden on them. The studies also showed that how students are facing uncertainty about the career as well as the higher study examination which is the chronic feeling that lead to the stress and depression which certainly affect the mental health of the students. Undoubtedly, psychologist played a great role in this pandemic situation. Further, psychological intervention is more import to deal with the fear of COVID-19 so that the mental health problems can be treated appropriately. Therefore, the mental health awareness and intervention are needed to cure these issues.



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# 13

## FOLKTALES OF ABOTANI: A PSYCHOLOGICAL ANALYSIS

*Leeyir Ete and Dharmeshwari Lourembam*

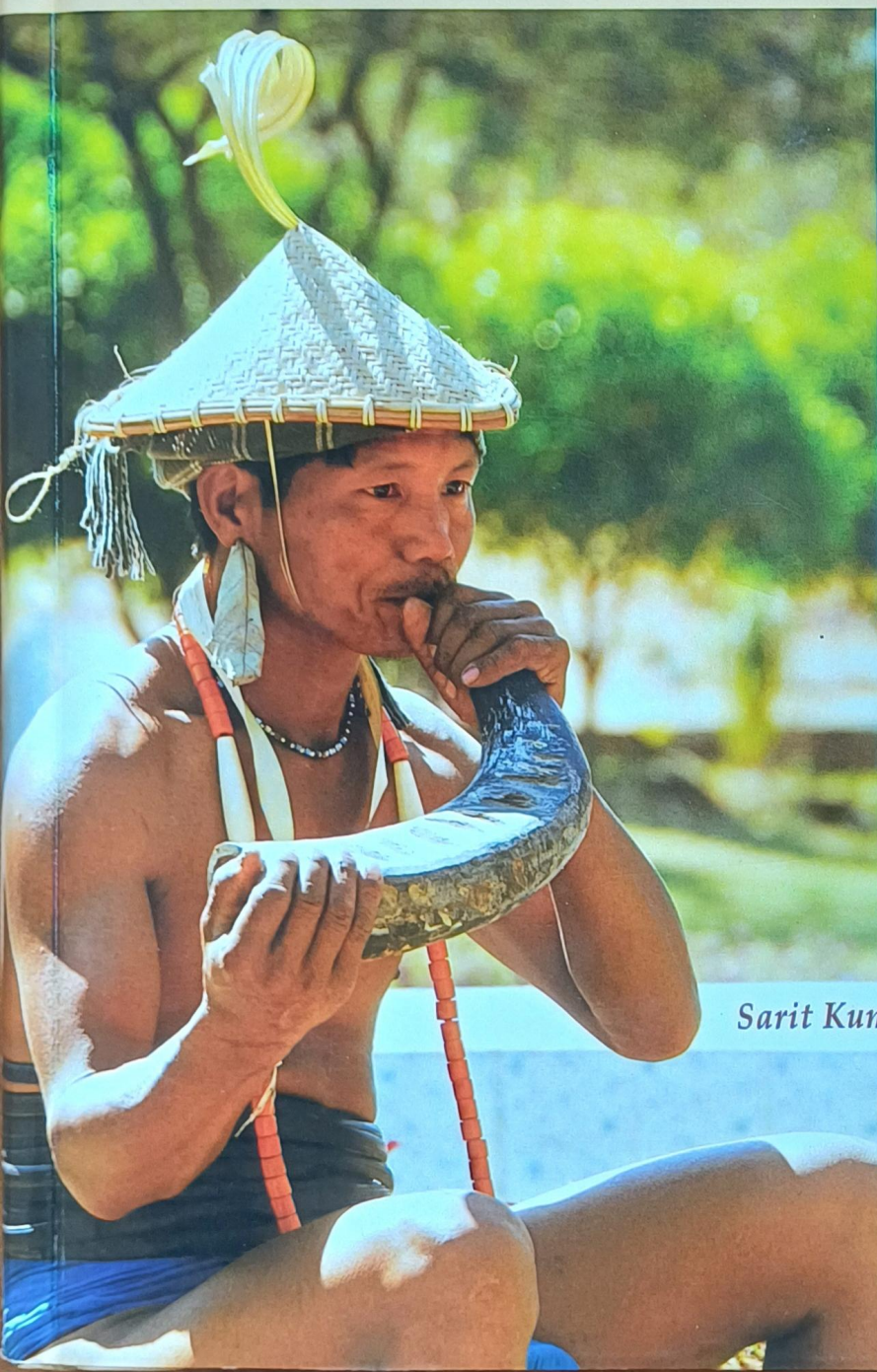
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### INTRODUCTION

Folktales in tribal communities play more than just the role of entertainment. They are foundational in shaping the human persona and reflect crucial information about the community's socio-psychological processes of interpersonal relationships, ideologies and life governing principles. They mould the psyche of the listeners and are utilised as prime sources of education about various morals, virtues and social facts. Folklorist Ruth Bottigheimer defines folktales as a reflection of the belief system and the world of its intended audience. These are tales about events, experiences and ideas of people from the indigenous past. According to William Bascom (1965), another folklorist, narrative forms can be classified into myths, legends, and folktales. Myths, possessing an authoritative undertone are the "truthful accounts of what happened in the remote past". Legends belong to a period less remote than myths and represent a local history of a person or a place. In contrast, folktales are timeless imaginary narratives, conceived by unknown sources with the sole intent to entertain their listeners (Frazer, 1921). It is the only narrative prose that includes tales of episodes and experiences that are only significant from the individual's subjective point of view with a protagonist confronting difficulties (Propp, 1968) or existential dilemma (Bettelheim, 1976). Another

# UNDERSTANDING TRIBES OF NORTHEAST INDIA

*Issues and Challenges*



## **EDITORS**

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## CHAPTER 16

# FREQUENT SWITCH IN THE MODE OF EDUCATION: A PSYCHOSOCIAL INTROSPECTION

*Koj Rinyo<sup>1</sup> & Dr. Dharmeshwari Lourembam<sup>2</sup>*



### **Abstract**

The COVID-19 pandemic has brought huge shift in the education sector, with class rooms turning virtual and traditional mode of teaching becoming remote and online. But in recent time with the pandemic getting under control, schools have started transitioning back to offline mode. This transition has resulted in the disruption of the new rhythm that both students and teachers were getting used to. The present study aims to understand the various challenges experienced by the school teachers with the transition of education mode through qualitative research. The data was collected through telephonic interview using semi-structured questions. The sample consisted of 30 secondary and higher secondary school teachers, age ranging from 24 to 50 years, of Itanagar Capital Region, Arunachal Pradesh. Thematic analysis was carried out which revealed that the most prominent challenge was little to no participation from the students during online classes. It made it hard for the teachers to access the effectiveness of their teaching leading them to feel unsatisfied with their work. Many expressed to have felt a sense of relief with the schools getting back to face-to-face mode.

**Keywords:** *Pandemic, virtual, mode of education, transition, challenges.*

### **I**ntrouction

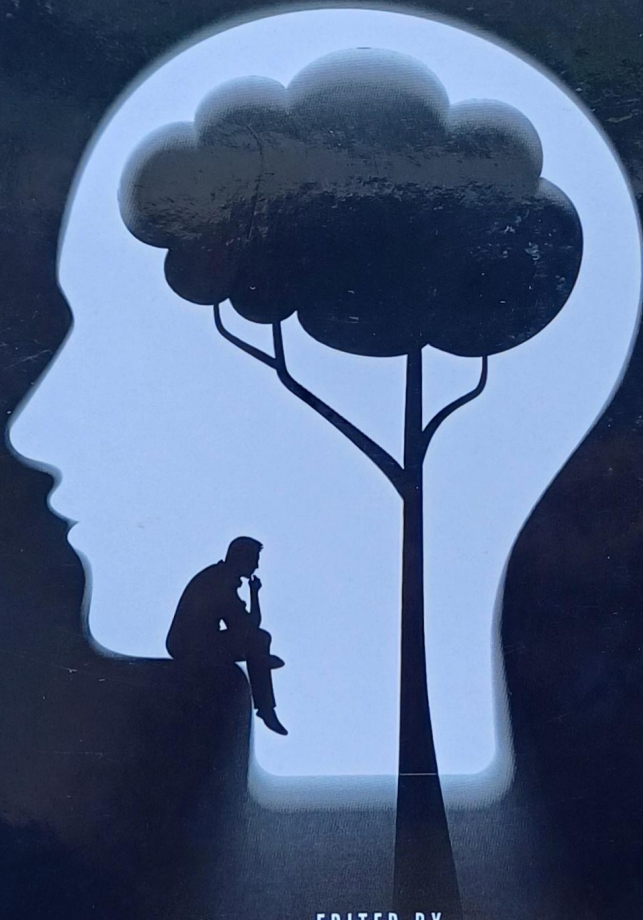
The COVID-19 pandemic had put halt to all the spheres of our human life. In order to contain the spread of virus, a nation-wide lockdown was put in place which forced all the schools, offices, industries, and organization to shut down. With the whole new normal

---

<sup>1</sup> Research Scholar, Dept. of Psychology, Rajiv Gandhi University, Arunachal Pradesh

<sup>2</sup> Corresponding author & Assistant Professor, Dept. of Psychology, Rajiv Gandhi University, Arunachal Pradesh

# PSYCHOLOGY AND CURRENT TRENDS



EDITED BY

**DR. THIYAM KIRAN SINGH**  
**DR. NARENDRA NATH SAMANTARAY**  
**DR. MVR RAJU**

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by: *Dr. Thiyam Kiran Singh, Dr. Narendra Nath Samantaray, Dr. MVR Raju*

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**Working Paper No. CDS/11/2022**

**Functioning of Agricultural  
Labour Market in the Brahmaputra  
Valley of Assam**

**Anup Kumar Das**



**Centre for Development Studies  
Department of Economics  
Rajiv Gandhi University  
Rono Hills, Arunachal Pradesh**

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Brahmaputra Valley of Assam  
Author- Anup Kumar Das

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Fungal Biology

Amritesh Chandra Shukla *Editor*

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Entrepreneurship with Fungi



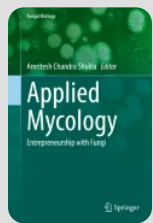
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# Fungal Endophytes: A Potential Source of Low-Cost Entrepreneurship

| Chapter | First Online: 27 April 2022

| pp 39–73 | [Cite this chapter](#)



## [Applied Mycology](#)

[Richa Sharma](#), [Amrutesh Chandra Shukla](#) & [Sumpam Tangjang](#)

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## Abstract

Plants are a potential reservoir of original microbes primarily known as endophytes, which can live inside their tissue without causing any visible harm. Fungal endophytes are abundantly reported from all tissues such as buds, flowers, stems, bark, leaves, roots, fruits, and seeds. Moreover, fungal endophytes can be grown with relative ease, making production at the large scale. Currently, research into the valuable use of fungal endophytes has been increased globally. The unique attributes of fungal endophytes thus herald huge promise for their application in biotechnology and various industries. In this chapter, the production of a wide range of new bioactive compounds or secondary metabolites from fungal endophytes that are a potential alternative resource of



secondary plant metabolites as well as natural producers of much needed medicines. Current development that has been assemble the selection of fungal endophytes for the manufacture and popularize of precise biologically active new compounds originate from fungal endophytes. Many fungal endophytes provide the important medicinal compounds such as Taxol, Huperzine, Vincristine, Vinblastine, Podophyllotoxin, and other globally significant novel secondary metabolites, and they remain an untapped resource with enormous industrial potential.

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# Sustainable Remedies for Abiotic Stress in Cereals

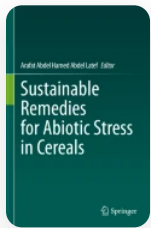
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# Heat Stress in Cereals and Its Amelioration by Biostimulants

| Chapter | First Online: 18 November 2022

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## Sustainable Remedies for Abiotic Stress in Cereals

[Vinay Shankar & Heikham Evelin](#) 

 363 Accesses

## Abstract

Human population is dependent on cereals for half of their calorie requirements. Likewise, cereals occupy 50% of the world's cultivated area. Pseudocereals, the superfoods, also contribute to the nutritional requirement of the world population. On the other hand, the global human population is escalating at a rapid pace, likely to reach 10.9 billion by 2050. At the same time, the mean annual temperature is rising across the globe. Simulation studies project a huge decline in cereal production owing to the increasing global temperatures. Of much concern is ensuring food security of the world population as high temperature stress impedes the growth and productivity of cereal crops. This calls for a sustainable approach to increase crop production even under high temperature stress. Plant biostimulants (PBs) are extremely dynamic and can improve the growth, flowering, productivity, and nutrient use efficiency of plants. They are also known to impart

tolerance to extreme environmental conditions. Thus, PBs can be a suitable candidate for increasing crop production even under temperature stress.

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*Research Challenges and Prospects*



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# Impact of Service Quality on Tourists' Satisfaction: A Case of Himalayan State

Mudang Tagiya<sup>1</sup> and Odang Mara<sup>2</sup>

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**Abstract:** *The study aims to understand the impact of service quality offered by hotel/resort on tourist satisfaction in Himalayan state of North-East India. It is a fact that a satisfied tourist tends to return back again to the destination visited and promote it among others. Also, tourist satisfaction is important for successful destination marketing because it influences the choice of destination, the consumption of products and services, and the decision to return. Studies shows that there are many factors that affect tourist satisfaction viz. service content, price, convenience, corporate image, equipment, staff and procedure etc. One of important factor that influence the tourist satisfaction is service provided by the service industry in the destination. The hospitality industries in the destination plays and important role in this and adds value to the tourist satisfaction.*

*This current research was empirical study based on primary as well as secondary data. The study was carried out in the capital city of Arunachal Pradesh, India. The primary data was collected from the tourist staying in the hotel/resort and availing the service offered by the hotel/resort in the study area. Structured questionnaire was used as instrument for data collection. The outcome of the study shows that service quality has a significant relation with tourist satisfaction. The result of this study gives insight to the policy makers, stake holders, hospitality agencies etc. too understand the significance of service quality in relation with tourist satisfaction in the study region.*

**Keywords:** *Service Quality, Tourist Satisfaction, Arunachal Pradesh, Capital Complex, Himalayan State*

## INTRODUCTION

For a successful hotel and restaurant business, the right presentation and continuous enrichment of quality services become necessity that meets the expectations of the guest and customers availing the services in the hotel and restaurants. Quality of service is a feature which influence the behavior of the customer/tourist from pre-booking to post-stay. Quality service offered by the hospitality unit gives a pleasant experience and memory to the customer and enhance their recreation. Quality of service



of Alignment found in Temples of  
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**Section: D (Living Games & Sports)**

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# Universal Happiness through Enabling Ecosystem

**Evidence Based Perspectives**

***Editors***

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# 5

## Indispensable Essentiality of Uniform and Universal Health and Education for A Self-Reliant India

////////////////////////////////////  
Ravi Ranjan Kumar\*  
Gunjesh Kumar Gunjan†  
Toko Jiri‡

### *Abstract*

*India is a youth abundant nation. We have nearly 50% of our population below 28-year age group and nearly 66% i.e. two third below 35-year age (National Youth Policy, 2014). Most health problems and lifestyle risk factors for disease in later years emerge during these formative years but because adolescence is “generally thought to be the healthiest” phase of life, and hence young people have attracted too few resources. Adolescents aged 10-24 years have the poorest health-care coverage among any age group (Global Burden of Diseases Report, 2013). Credible sources like those of Lancet highlight self harm or suicides as among the leading causes of death among youth in India. The figure could also be under-reported because of the stigma attached to suicides.*

- 
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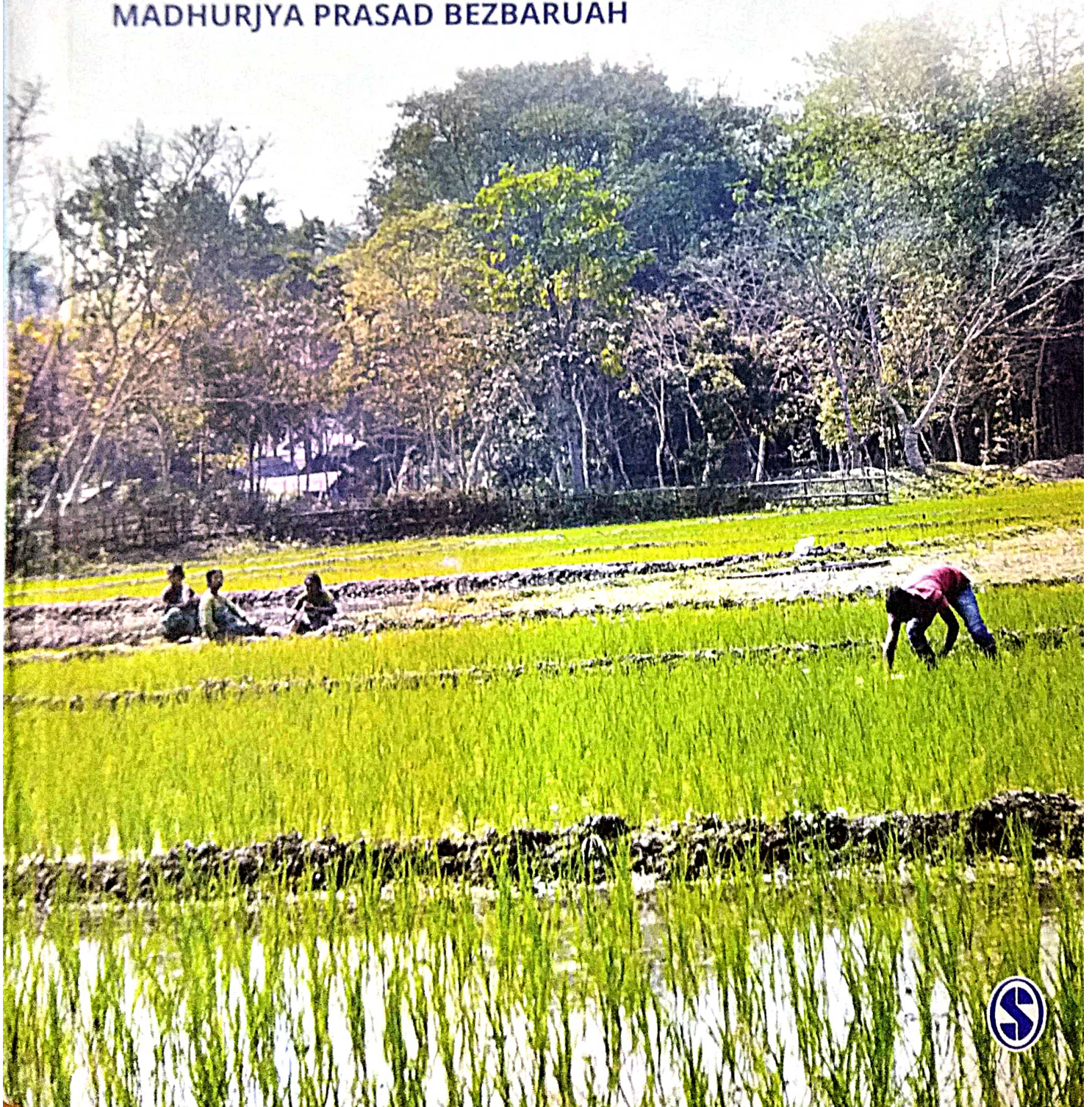
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# AGRICULTURAL FACTOR MARKETS AND INDIA'S SMALL FARMERS

EDITED BY

ANUP KUMAR DAS | BINOY GOSWAMI

MADHURJYA PRASAD BEZBARUAH



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## Chapter 8

# Agricultural Credit in India

## The Dominance of Informal Sources

Abhijit Sharma and Prasenjit Bujar Baruah

### 8.1. INTRODUCTION

One of the characteristics of the agricultural sector is that it needs investment in the initial period of production and gets the return after harvesting. Small and marginal farmers have low level of income, so they have lower savings. They need more capital than they can generate through savings. Thus, access to adequate and affordable credit is the precondition for agricultural development. Das and Bezbaruah (2020) report that access to credit has a positive impact on cropping intensity, crop diversification and agricultural production. Credit is not a primary factor of production. But access to other factors is linked to their access to credit. Farm households need credit for different purposes. First, they need credit for capital investment, that is, for investment in agricultural capital goods, such as tractors, power tillers, construction of guard wall around the paddy ground and building irrigation infrastructure. The absence of credit facilities may adversely affect the adoption of new technology in agriculture (Samah et al. 2009). Although credit for fixed investment is necessary for the growth of agriculture, the credit for working capital expenditure and consumption purposes is more important for the small and marginal farmers. Rapid commercialization



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# c0008 Magnetic susceptibility as proxy to [AU1] [AU2] air pollution: A case study from Durgapur industrial township, West Bengal, India

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## s0010 8.1 Introduction

p0015 Industrial growth and heavy traffic in fast developing countries coupled with accelerated urbanization and rapid population growth are the medial spine of the agents that contribute toward the highly polluted environment in the Indian subcontinent, especially in industrial cities (Goddu et al., 2004; Hoffman et al., 1999). Durgapur, the dream city of Dr. Bidhan Chandra Roy is no way left out from such traps dispersed of polluted environment. This is causing the gradual degradation of the environmental quality of this beautiful city.

p0020 Streets and roads of such affected cities are highly pollution-prone areas which are contaminated by particulate matter emitted due to automobile discharge from the traffic which includes motor vehicle emissions, abrasion by tyres, cycling of dust in suspension (Gautam et al., 2004, 2005). On release of such toxic materials into the atmosphere, the remains within the air for some time and eventually gets deposited on the road forming a considerable part of the road dust, thereby making the roadways of highly populated cities potential corridors for environmental contaminants (Gautam et al., 2005). Apart from these gaseous environmental killers, heavy metals in the atmosphere remain associated with windblown soil and fly ash particles (Petrovsky et al., 2000). A large proportion of these environmental contaminants is magnetic and possesses one or more origin. Magnetic minerals that are present within the magnetic contaminants may be of lithogenic origin (derived directly from the weathering and erosion of the rocks), pedogenic origin (developed during soil formation) and finally due to anthropogenic causes (Boyko et al., 2004). Magnetic properties such as grain size, composition and

## 2 Spatial Modeling of Environmental Pollution and Ecological Risk

magnetic properties can help in specifying the precise source of the magnetic contaminants (Goddu et al., 2004). Studies by various workers (Boyko et al., 2004; Kapicka et al., 1999; Gautam et al., 2005; Petrovsky et al., 2000; Goddu et al., 2004) suggest that the contribution by anthropogenic causes, which mainly constitutes of secondary magnetic minerals, is much more than the natural processes like lithogenesis or pedogenesis. Among all anthropogenic factors, vehicle pollution is the highest among all others (Hunt, 1986).

### s0015 8.2 Magnetic susceptibility as a proxy for pollution: The present state of knowledge

p0025 Environmental magnetism plays a commanding role in understanding paleoclimatic changes which can be retrieved from the magnetic properties of the loess, lake, and marine sediments (Waden, 2004). Furthermore, environmental magnetism can act as a precise and nondestructive tool for assessing pollution (Foster et al., 1991). Magnetic techniques for investigation of environmental pollution have acquired tremendous attention from the scientists in the past decade. The principle of applying magnetic techniques in analysing environmental pollution is to measure the magnetic properties (magnetic susceptibility in the present case) of the samples under consideration (viz. soils, sediments, or dust) and characterize them accordingly. It is already well established that the ferromagnetic magnetite is a very common component of roadside dust (Hoffman et al., 1999) and thus susceptibility measurements are swift means of analysing environmental pollution rather than tedious and monotonous chemical analysis. Besides the magnetic measurements provide better sensitivity and facilitate even very low concentration of magnetic material. The sensitivity of the magnetic techniques as pollution analysis factors can be considered equivalent to as fine as ppb scale in chemical analysis. More precisely, the magnetic segments of anthropogenic pollution are stronger than any other techniques and the sources of pollution can be discriminated (Hoffman et al., 1999).

p0030 Magnetite stands to be the most important ferromagnetic mineral on the Earth, crystallizes in cubic system with a spinel structure (Dunlop and Ozdemir, 1997; Petrovsky et al., 2000). Primarily magnetite occurs in the continental and oceanic crust as primary or secondary mineral in igneous, sedimentary, and metamorphic rocks; in the soils and sediments the magnetite may also occur as results of bacterial activity and finally in the atmosphere, magnetite comes from fuel combustion, from industrial machineries or from automobiles (Petrovsky et al., 2000). Magnetite, because its cubic structure, can provide the accommodation space to the various toxic elements within its crystal lattice. Anthropogenic magnetite is generally transported through the atmosphere in the form of a plume traveling in the down-wind direction however with a complex behavior controlled by meteorological condition (Kapicka et al., 1999). Thus, the magnetite which is associated with the road dust can be considered as store house of

Chapter 8 • Magnetic susceptibility as proxy to air pollution 3

environmental contaminants (Petrovsky et al., 2000). Thus, there exists a positive correlation between the concentration of magnetite and intoxicating elements in the road dust. The concentration of magnetite on the other hand can be estimated from the bulk and/or mass susceptibilities of the road dust samples which can finally serve as a proxy for the intensity of the environmental pollution (Hunt et al., 1984).

p0035 Apart from all the above-mentioned advantages of magnetic methods (magnetic susceptibility studies) for pollution analysis, certain disadvantages are also associated with the process (Hoffman et al., 1999). First, the environmental magnetism depends on bulk measurements and thus only average magnetic parameters can be obtained. Secondly, samples of dust, sediments, or soils may have a wide range of grain size, magnetic mineralogy and these may provide unexpected ambiguous results because the above-mentioned factors have a tough control over the common magnetic parameters used in magnetic pollutant study (Dunlop and Ozdemir, 1997).

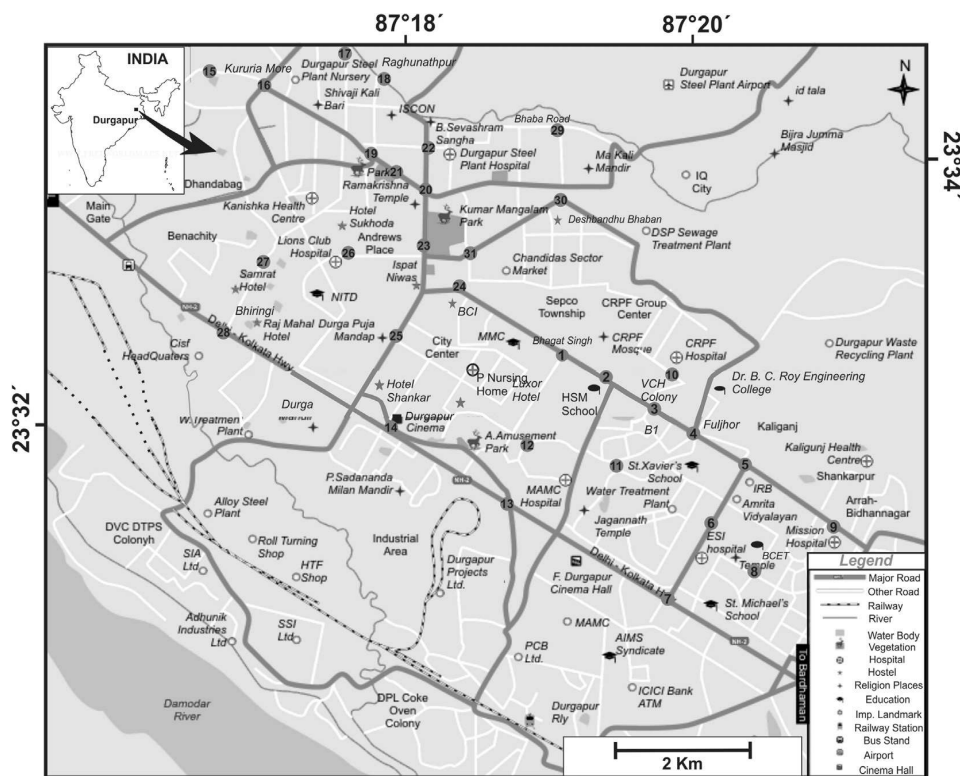
p0040 Despite of all these hurdles, environmental geoscientists throughout the globe have opted magnetic susceptibility measurements as keys toward pollution analysis which of course led to successful inferences. The first remarkable application of magnetic techniques was made by Thompson and Oldfield (1986) which paved the pathway toward the use of magnetic susceptibilities as pollution indicator (Petrovsky et al., 1999). Kapicka et al. (1999) studied fly-ash pollution of soils by proxy mapping of magnetic susceptibility in and around a coal-burning power plant, Czech Republic. Hoffman et al. (1999) mapped the roadside pollution in the southern part of the Tuebingen city, Germany, from magnetic susceptibility measurements which yielded interesting relationships between pollutants and magnetic particles. Petrovsky et al. (2000) also summarized the exposure of various ecosystems to pollution by using low field magnetic susceptibility as a proxy for the same. These workers also suggested that the history of environmental degradation can be traced by magnetic susceptibility profiling of soils and sediments. Boyko et al. (2004) carried out magnetic susceptibility measurement of top soil for validating the long-term reproducibility of the process of using magnetic techniques as means for pollution intensity studies.

p0045 India, the country which consists of world's 17.5% population and ranks among top industrialized countries, is in severe need of pollution assessment and industrialized cities of India are ideal places for applying magnetic techniques of analysing pollution. Goddu et al. (2004) studied the magnetic properties of road dust from Visakhapatnam city in relation to industrial pollution and road traffic. Similar studies were carried out by Mondal et al. (2017) in and around Bandel and Triveni areas (Hooghly district, West Bengal) with an aim to study the pollution caused due to automobile emission and industrial pollutant due to Bandel Thermal Power Station (BTPS). In the present study, the authors are aiming toward demarcating the degrees of environmental pollution by mapping the magnetic susceptibility from the road dust samples collected throughout the residential areas of Durgapur, the steel city of West Bengal. This study can potentially expose the highly polluted areas from the generation of the pollution maps based on magnetic susceptibility values.

#### 4 Spatial Modeling of Environmental Pollution and Ecological Risk

### s0020 8.3 Study area, sampling techniques, and measurement

p0050 Collection of road dust samples were carried out during the months of January and February 2017 in two phases. The months of January and February were selected because during these months there are very low chances of rainfall and dry road dusts are easily available for collection. The precise locations for sampling within the city were selected in an unbiased way. Thirty-one such road crossings were opted for collection of dust samples. The locations plotted on the map of the study area are provided in Fig. 8.1. Samples were collected by using nylon brush and scrapers as tools. To avoid external contamination, the samples were put in standard sized air-locked polythene bags. Although the samples were collected when dry rainfall-free weather prevailed, the samples were further dried in the laboratory at room temperature to avoid even very minute contamination by moisture. The reason for avoiding such moisture contamination is that the moisture (H<sub>2</sub>O) has a negative susceptibility and thus can decrease the susceptibility value for the whole sample leading to dubious results. After the drying



f0010 **FIGURE 8.1** Road map of Durgapur area. The blue numbered dots demarcate sampling sites.  
[AU3]

process, the samples from each site were put into identical nonmagnetic cubical boxes with volume of  $\sim 8.69 \text{ cm}^3$ , which are designed to fit perfectly with the adapter of the susceptibility measuring instrument.

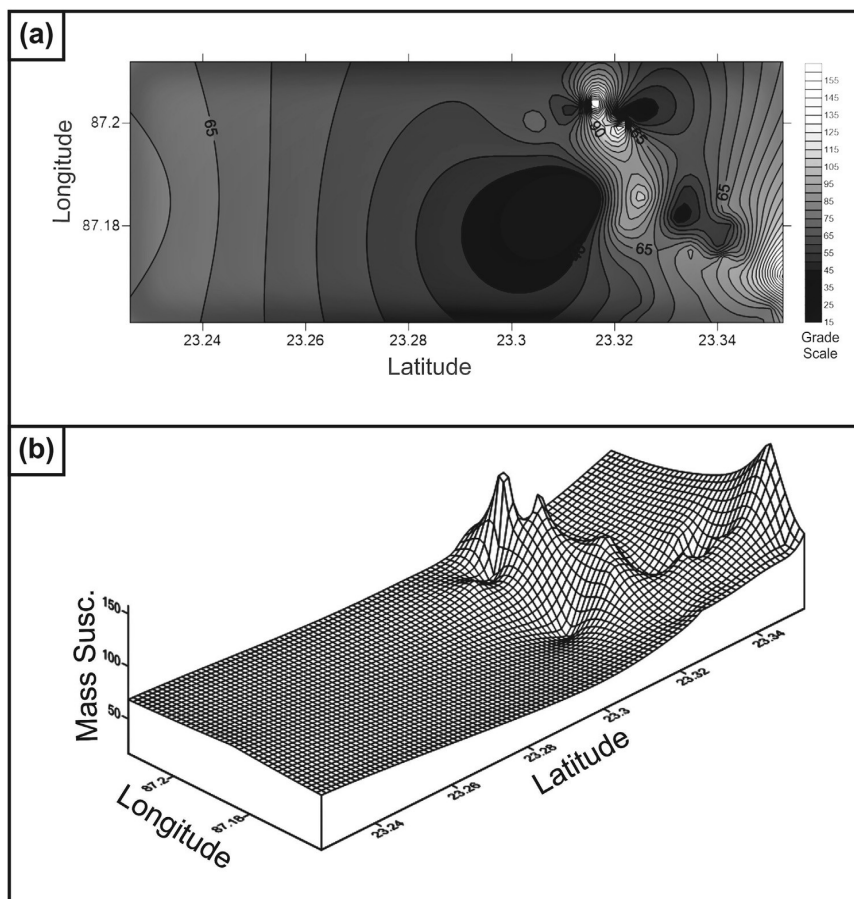
p0055 The samples thus prepared for magnetic susceptibility measurements were then subjected to low field magnetic susceptibility measurements using the Bartington Susceptibility Meter (MS-2) (Oxford, England) at the Geophysics Laboratory, Department of Geological Sciences, Jadavpur University, Kolkata. The susceptibility thus obtained is the bulk/volume susceptibility of the samples. From the volume susceptibility so obtained, the mass-specific susceptibilities were obtained by dividing the volume susceptibilities by density of the samples. These are further represented graphically to unravel the variation of the susceptibility in the areas. Further, to understand the spatial distribution and variation of magnetic susceptibility 2D and 3D contouring was done using the software SURFER which provided very appropriate representation (Fig. 8.2). In the 2D contour diagram each line can be termed as *iso-suscep* (Mondal et al., 2017), i.e., lines connecting areas of equal magnetic susceptibility. Similarly, in case of the 3D contour diagrams, the whole area is represented in terms of latitude and longitude (the horizontal axes) and the susceptibilities are represented in the horizontal axis. Thus, the culminations and depressions on the diagram represent the nature of susceptibility value and thus intensity of pollution.

## s0025 8.4 Results and discussions

p0060 The data obtained from the low field magnetic susceptibility measurements (both bulk/volume susceptibility and mass specific susceptibility) from all the 31 locations are summarized in Table 8.1. The high values for variance (1238.58) and standard deviation (35.19) very clearly indicate the wide distribution of the susceptibility values throughout the city. The volume and mass susceptibilities of road dust bear direct proportionality (Mondal et al., 2017). However, the mass specific susceptibilities are more intrinsic properties and thus for correlation of susceptibility values and pollution prone areas, the mass-specific susceptibilities are used here.

p0065 The highest value of mass-specific susceptibility,  $160.26 \times 10^{-6}$  CGS units, is observed at location-17, which is near Durgapur Steel Plant nursery and the lowest value,  $16.98 \times 10^{-6}$  CGS units is obtained in location-12, at B-2 crossing in MAMC township. Besides peaks of susceptibility are observed in location-3 and location-5. Again, the locations 4, 12–13, 18, 23, 24 are having much lower values of susceptibility than the average value. Further, from the Magnetic Susceptibility Mapping the whole region can be segmented into two parts: The northern high susceptibility region and the Southern low susceptibility region, with a steady rise in susceptibility in the central position. This effectively proves that the peak susceptibility values are clustered in the Northern portion of the studied sector which is mainly the Durgapur Steel Plant (DSP) township.

## 6 Spatial Modeling of Environmental Pollution and Ecological Risk



f0015 **FIGURE 8.2** (a) 2D mapping of magnetic susceptibility for the studied area; (b) 3D mapping of magnetic susceptibility for the studied area.

p0070 Now, the high susceptibility in the northern portion and the locations with abnormally high or low values than the average require precise explanation. For this, the vehicular frequency of the studied area and the wind direction in the area during the season of sample collection were considered. First, the wind (monsoon) direction during the month of May in the region is from SW to NE and thus capable of carrying the toxic industrial exhausts from the industries like DSP, Alloy Steel Plant (ASP), NSPCL and Durgapur Projects Limited (DPL) in suspension and deposit them within the DSP township. Secondly, the vehicular density mapping also reveals that the frequency is much higher in the northern portion of the studied area (with highest traffic density at

**Table 8.1** Magnetic susceptibility values (mass susceptibility and volume susceptibility) for corresponding sampling sites.

Location no.	Latitude (DD MM SS)	Longitude (DD MM SS)	Vehicles/minute	Bulk susceptibility (10 <sup>-6</sup> CGS)	Mass (M)	Density (p)	Mass susceptibility (10 <sup>-6</sup> CGS)
DGR - 1	23 32 59	87 18 47	20	125	18.4845	1.68439037725533	74.2108252860505
DGR - 2	23 32 53	87 18 57	8	148.5	17.045	1.55321669400401	95.6080375476679
DGR - 3	23 32 15	87 20 02	10	229	17.18	1.56551849826864	146.277415599534
DGR - 4	23 32 11	87 20 10	15	32	16.635	1.51585565882996	21.1101893597836
DGR - 5	23 31 59	87 20 36	7	258	17.845	1.62611627483142	158.660240963855
DGR - 6	23 31 38	87 20 30	13	72.5	17.31	1.57736468015309	45.9627383015598
DGR - 7	23 30 52	87 20 01	8	94.5	17.435	1.58875523965737	59.4805276742185
DGR - 8	23 31 13	87 20 27	6	70	18.555	1.69081465281575	41.4001616814875
DGR - 9	23 31 12	87 21 19	8	83	17.155	1.56324038636778	53.0948411541825
DGR - 10	23 32 31	87 20 00	4	72	17.835	1.62520503007108	44.302102607233
DGR - 11	23 31 59	87 19 36	14	70	17.667	1.60989611809732	43.48106663949737
DGR - 12	23 31 49	87 18 51	9	27.5	17.775	1.61973756150902	16.97805907173
DGR - 13	23 31 42	87 18 38	18	30	17.11	1.55913978494624	19.2413793103448
DGR - 14	23 32 12	87 18 05	13	107	14.87	1.35502095862949	78.9655682582381
DGR - 15	23 35 13	87 16 13	5	130.5	17.685	1.61153635866594	80.9786259541985
DGR - 16	23 35 00	87 16 38	7	119.5	16.98	1.54729360306178	77.2316254416961
DGR - 17	23 35 27	87 17 03	2	200	13.695	1.24794969928923	160.26286966046
DGR - 18	23 34 46	87 17 44	4	94	14.55	1.32586112629852	70.8973195876289
DGR - 19	23 34 32	87 17 13	7	149	18.79	1.7122289046838	87.0210750399149
DGR - 20	23 34 04	87 17 56	6	64.5	15.41	1.40422817568799	45.9327060350422
DGR - 21	23 34 13	87 17 41	8	133	17.56	1.60014579916165	83.1174259681093
DGR - 22	23 34 25	87 18 08	10	80.5	18.33	1.67031164570804	48.1945990180033
DGR - 23	23 33 48	87 17 55	9	116.5	16.565	1.50947694550756	77.179052218533
DGR - 24	23 33 23	87 18 16	7	49.5	16.3	1.48532895935848	33.3259509202454
DGR - 25	23 32 38	87 17 20	10	96	18.45	1.68124658283215	57.1004878048781
DGR - 26	29 33 51	87 16 59	25	97	16.745	1.52587935119373	63.5699014631233
DGR - 27	23 32 42	87 16 52	23	86.5	18.095	1.64889739383999	52.4592981486599
DGR - 28	23 32 58	87 16 12	27	96.5	16.49	1.50264260980499	64.2201940570043
DGR - 29	23 34 30	87 18 14	7	85	14.665	1.33634044104246	63.6065461984316
DGR - 30	23 34 15	87 18 30	4	81	12.695	1.15682522325497	70.0192201654195
DGR - 31	23 33 38	87 18 68	8	60	15.96	1.45434663750683	41.2556390977444

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## 8 Spatial Modeling of Environmental Pollution and Ecological Risk

Bhiringi crossing on NH-2) and immensely contribute toward the contamination of the environment. Hence the high susceptibility values in the northern portion are supported by the pathway of the industrial wastes released in the air and the observed vehicular frequency.

p0075 The abnormally high values at locations 3, 5, and 17 corresponding to the locations Phuljhore More (near Carmel Convent School), Mahalaxmi Park (near India Reserve Battalion), and Durgapur Steel Plant nursery. Phuljhore More and Mahalaxmi park are neighboring areas with many schools and colleges located there. This causes a huge traffic density and the public transports are maximum in these areas accounting for high pollution and thereby high pollution in the areas. On the other hand, the low values are observed in locations 4, 12, 13, 18, 23, and 24. Locations 4 and 12 correspond to B-1 and B-2 crossings in MAMC township. MAMC is a shuttered down enterprise and thus the township is devoid of rapid urbanization and industrial pollution. Also, due to stagnation of this region, traffic and public transports are also minimum here and thus low susceptibility and thus low pollution are characteristics of such area. Locations 18, 23, and 24 correspond to Raghunathpur, Exalt's Kumar Mangalam Park area, and near Bidhan Chandra Institution. These areas are moderately populated with optimum levels of traffic. However, these areas are covered with dense gardens with broad leaved trees even on the roadsides. Thus, the contaminants in the air are preferably accumulated on the broad leaves of the trees rather on the road, leaving the road dust relatively uncontaminated thereby explaining the lower values of susceptibility. However, location – 13 (DVC Crossing), showing low susceptibility value, suffers regular high-density traffic and is also located close to NH-2. Such inversion can be addressed toward high degrees of dispersion, i.e., availability of large space for spreading of the polluted road dust, leading to a virtually low susceptibility value.

### s0030 8.5 Conclusions

p0080 Application of magnetic susceptibility studies on road dust in Indian industrial cities is gaining importance in serving as proxies for pollution (Mondal et al., 2017 and references therein). The present study in Durgapur area also proved to be useful and bears significance. The distribution of the magnetic susceptibility has strong correspondences with the degrees of pollution in the studied area. Also, this clearly indicates that the reason for the degradation of the environmental quality is simply due to anthropogenic causes, especially, emissions from vehicles and industries.

p0085 Magnetic susceptibility studies thus proved to be a relatively low-cost potential measure to determine detrimental effects to our environment caused by anthropogenic activities. It is also strongly recommended that a magnetic susceptibility mapping should be carried out prior to detailed analysis as it can demarcate the regions which are endangered by environmental contamination.

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**Non-Print Items**

**Abstract**

Urbanization and industrial development in India are curses in disguise and cause environmental degradation. Magnetic susceptibility can provide suitable proxies for detecting pollution which is discussed in this paper, with a case study in Durgapur, West Bengal, India. This is because susceptibility sensitive magnetite is storehouse of toxic elements. The mass and bulk susceptibilities in the region show range of variation with number of locations higher than average value. Magnetic susceptibility mapping shows higher susceptibility values in areas with adverse vehicular traffic and other polluting sources, revealing anthropogenic activities to be the major reason for the environmental degradation.

**Keywords:**

Durgapur, Magnetic proxies, Magnetic susceptibility, Pollution, Road dust.

# Fruits and Their Roles in Nutraceuticals and Functional Foods



Edited by  
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## 5 Mango

Varun Kumar, Amarjeet Kumar, and Deependra Rajoriya

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### 5.1 INTRODUCTION

Mango (*Mangifera indica* L.), family Anacardiaceae, is a fruit plant grown widely in the tropical and subtropical countries of the world. Mango is one of the most important commercial crops worldwide in terms of production, marketing, and consumption. Mango trees thrive in tropical and subtropical regions, are evergreen, grow to a height of around 18 meters, and produce fruit 4–6 years after planting. It is pleasant in taste, aroma, and rich in nutrition (Ibarra-Garza et al., 2015). Mango production is second to bananas in terms of quantity and value among internationally traded tropical fruits, and fifth in terms of overall production among major fruit crops worldwide (Tjiptono et al., 1984; Yaacob and Subhadrabandhu, 1995). Mango production is expected to reach around 26 million tons per year worldwide (FAO, 2007). The world production of mango is estimated at 42 million tons per year; India is the largest producer of mango with 1,525,000 tons per year, followed by China, Kenya, Thailand, Indonesia, Pakistan, and Mexico. Mexico is the largest exporter with 287,771 tons per year (FAOSTAD, 2015). It is known as the “King of Fruits” due to its chemical composition, and it is the world’s second most traded tropical fruit and fifth in total production (FAOSTAD, 2015). Mango, whether fresh or processed, is a nutritionally and satiating alternative for a balanced diet. Figure 5.1 shows how it can be divided into three parts: Pulp (Mesocarp), peel (Epicarp), and seed kernel (Endocarp). It is considered to be high in bioactive compounds (BaCs), which have potential nutritional and health-promoting properties. It has been recommended that



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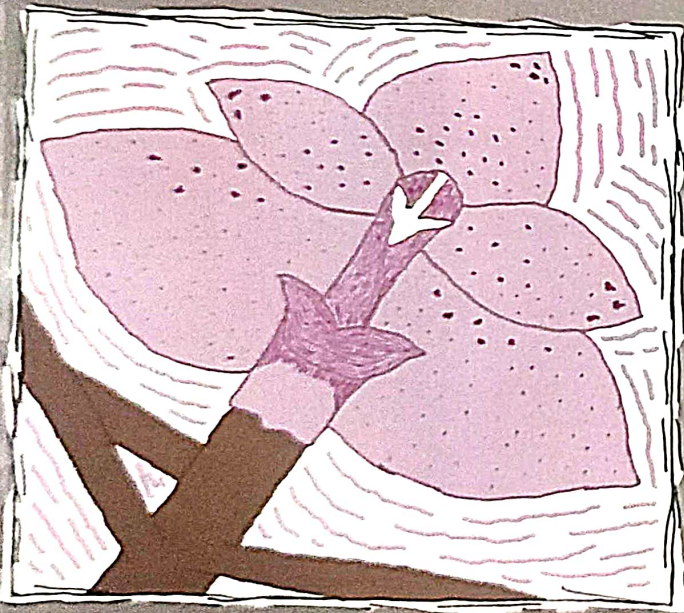
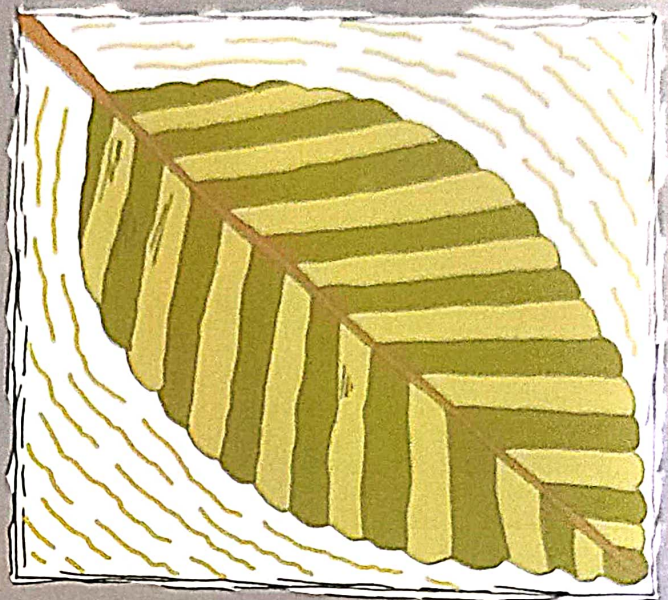
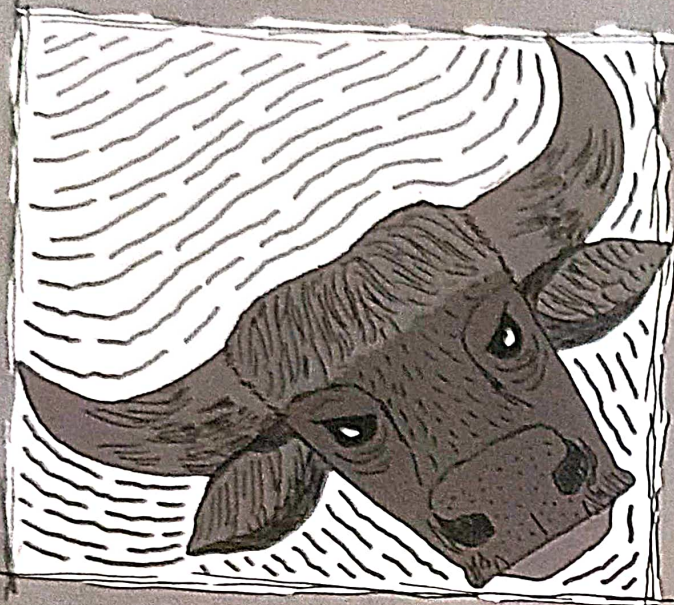
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# MATRIX ANTHOLOGY



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# A LABYRINTH OF THOUGHTS ON THE CROSSROAD

Bompi Riba

\*\*\*

An event that stays in the memory; that evokes a conundrum and enlightens one to see one's culture in a new light is worth documenting. But it is seldom done so when it involves an ordinary person who is but an insignificant member of a community of a prodigious state of a big country. He is but a diminutive voice like a tiny globule of the Universe. His story surely does not affect the course of the Nation's history or even the State's history and remains just 'his' story and fades into oblivion. And his death, whether natural or unnatural is again an insignificant event except for his family members who will gradually recover from that unpleasant experience and move on.

The event that led to the germination of this deep reflection was the death of a tribal man, a Galo to be precise. The mysterious events or just pure imaginations that were associated with the poor man's untimely death

# Apatani

CHANGE AND CONTINUITY



EDITED BY:

NENDING OMMO | DR. PADI HANA | DR. KIME MAMUNG | NANI UMIE

# **APATANI**

## **Change and Continuity**

**Mr. Nending Ommo**  
**Dr. Padi Hana**  
**Dr. Kime Mamung**  
**Ms. Nani Umie**



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# **Myoko: Embracing Social and Cultural Change in the Apatani Community**

**Dr. Padi Hana**

## **Introduction:**

The Apatani community is an indigenous community residing in the Ziro Valley of Arunachal Pradesh. The Myoko celebration holds great importance for the Apatani people. It is a vibrant festival that blends religious, cultural, and social elements, showcasing the community's unique traditions. The Apatani community of the Ziro in Arunachal Pradesh celebrates the lengthy festival known as Myoko. A community's identity and ideals are vividly reflected in its cultural festivities. They offer a venue for upholding customs, promoting social harmony, and appreciating the beauty of cultural diversity. One of the key components of the Apatani community's socioreligious festival is Myoko. The celebration is designed to strengthen the bond between humans and deities (Kaning, 2008, 169). Myoko is a holiday celebrated by the community, the village, and the clan. Three groups—Hari-Bulla, Niichi-Niit, and Hangu village—celebrate Myoko Day in a cyclical pattern each year.

Myoko is a social institution. The every aspects and parts of the Myoko ritual and ceremony has a procedures which is generally accepted and followed by the community. Myoko celebration is sanctified and sacred. Myoko festival has got several distinct components for socio-religious activities. The basic structure of Myoko celebration remains the same in today's time but there are few traditional practices that are modified by the community bodies and changes occur at the individual level. This paper shall be looking at the social and cultural changes taking place at the general and family level during the time of celebration.

There should be a proper distinction between cultural and social change to understand the changing aspects in the society. There is common understanding among the layman about the meaning of cultural and social change and they used it interchangeably in their social situation.

## What's in a name? Contextualising naming patterns amongst the Apatani

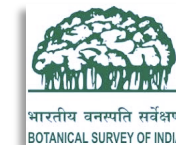
Nani Umie

### Introduction

It is widely accepted that, in all societies, personal naming practices and culture are intertwined. Given that culture is not static, but dynamic and ever-changing, personal names have undergone a major transformation due to socio-cultural and political factors. As societies diversify, the naming patterns can be examined in the context of cultural identifications and acculturation strategies used by individuals exposed to other cultures. Much as names are considered personal choices yet the names chosen are a reflection of the consequent cultural amalgamation. A review of the literature shows that researchers have tended to be more concerned with the outcomes of having particular names, rather than the process through which these names are chosen. Thus, the process through which these names are chosen is an important aspect to be examined especially in the light of society and culture that is in transition. It is in this light and context that the paper seeks to examine the predictors of baby-naming choices. After all, a name is not just a name, it is an expression of who we are and an important reflection of how we define ourselves. As such, it may be considered an extension of the individual and the society and culture to which one belongs.

### Context

The Apatani narratives begin north of the Himalayas and recount an ancient migration path defined by a series of locations. Migration is traced through a succession of halting locations, each of which symbolizes the occurrence of a significant event: the performance of an important rite, a natural calamity, or the surmounting of a challenge, according to Apatani traditions (Blackburn, 2003, p. 26-27-28). Further, these predominantly divided into seven major villages. Further, these villages are categorized into three groups. Hong as constituting



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## Chapter - 3

### Nickel and Copper Catalyzed Suzuki Coupling in Organic Synthesis

Amarjyoti Bhuyan, Bhaskar Jyoti Borah and Lakhinath Saikia

#### Abstract

Among the C-C coupling reaction, Suzuki coupling reaction is the most frequently used reaction in pharmaceutical industry due to its high tolerance towards various functional groups. High success rate of Suzuki coupling attracts the researchers to developed new combination of catalyst and ligand for the purpose. Traditionally palladium is used as a catalyst for the transformation but scientist developed much cheaper copper and nickel catalyst for the same. Herein this chapter we have discussed about copper and nickel catalyzed Suzuki coupling reaction.

**Keywords:** Nickel catalysis, copper catalysis, Suzuki coupling, C-C coupling

#### 1. Introduction

A variety of reaction where two fragments are joined together with the aid of a metal catalyst and involve the formation of carbon-carbon or carbon-heteroatom bonds is called coupling reaction.

Usually, two types of coupling reactions have been recognized-

- i) Homo coupling reaction in which two identical organic fragments are coupled together.
- ii) Cross-coupling reaction in which two different organic fragments are coupled together <sup>[1]</sup>.

Cross-coupling reactions are reactions that can generate new C-Z (Z = C or heteroatoms including N, O and S) bonds from pre-existing bonds. The first reported coupling reaction is generally contributed to the copper catalyzed Ullman reaction, in which an aryl halide is homo-coupled to form a biaryl product <sup>[2]</sup>. The reaction presented a new methodology that received much attention.

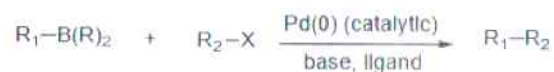


The field of catalytic cross-coupling started to experience renewed interest due to emergence of organometallics as a field, leading to a "renaissance" of catalytic cross-coupling reactions in the 1970's. It is during this decade that the Heck reaction and the Suzuki reaction were first developed. The Heck reaction was emphasized the first reaction to use non-activated organic substrates in a coupling reaction by using olefins and coupling them to aryl halides using a palladium catalyst. These two reactions laid the foundation for the discovery of the Suzuki reaction in 1979, which quickly grew as one of the most effective C-C bond formation reactions. In 1979, A. Suzuki and N. Miyaura reported the stereo selective synthesis of arylated (E)-alkenes by the reaction of 1-alkenylboranes with aryl halides in the presence of a palladium catalyst [3]. The palladium-catalyzed cross-coupling reaction between organoboron compounds and organic halides or triflates provides a powerful and general method for the formation of carbon-carbon bonds known as the Suzuki cross-coupling.

Despite the availability of other cross-coupling reaction like Heck reaction, Stille reaction to name a few, but due to various conditions like

- i) Milder reaction conditions.
- ii) Commercial availability of the diverse boronic acids derivatives that are environmentally safer than the other organometallic reagent.
- iii) The inorganic byproducts are easily removed from the reaction mixture.
- iv) The coupling is generally stereo and regioselective.
- v) Tolerant toward various functional groups.

These features have allowed researchers to utilize it in a wide variety of applications, from natural product synthesis to the development of polymeric materials. Due to its impact in such a variety of fields, Akira Suzuki together with Richard F. Heck and Ei-Ichi Negishi, was awarded in September 2010 the Nobel Prize in Chemistry "for palladium-catalyzed cross couplings in organic synthesis". Since then, excellent and thorough reviews covering specific aspects of this reaction have been published. The general reaction scheme for Suzuki cross-coupling reaction is shown in following figure-



R = alkyl, OH, O-alkyl ; R<sub>1</sub> = alkyl, allyl, alkenyl, alkynyl, aryl  
R<sub>2</sub> = alkyl, aryl, alkyl ; X = Cl, Br, F, OTf

The Suzuki cross-coupling reaction has been considered as a very powerful, versatile and popular tool for selective construction of carbon-carbon bonds in organic chemistry. During the past decades numerous efforts have been made to develop efficient catalyst systems for Suzuki cross-coupling reactions. Pd(0) complex together with ligands (phosphine) is the most popular catalytic system. However, most of the phosphine ligands are toxic and sensitive to air and moisture and expensive Pd complexes tend to be difficult to manipulate and recover. Furthermore, the cross-coupling products are frequently contaminated by residual palladium black and ligands, which can be difficult to separate from the final products. Therefore, the task of recycling and development of phosphine free and palladium free catalytic system is a current important challenge in organic chemistry. In this way, the use of a cheaper metal instead of Pd provides another attractive route. Of these, copper and nickel-based alternative are particularly attractive, due to their order of magnitude lower cost and harmfulness to the environment than any other noble metal.

## 2.1 Nickel based system for Suzuki coupling

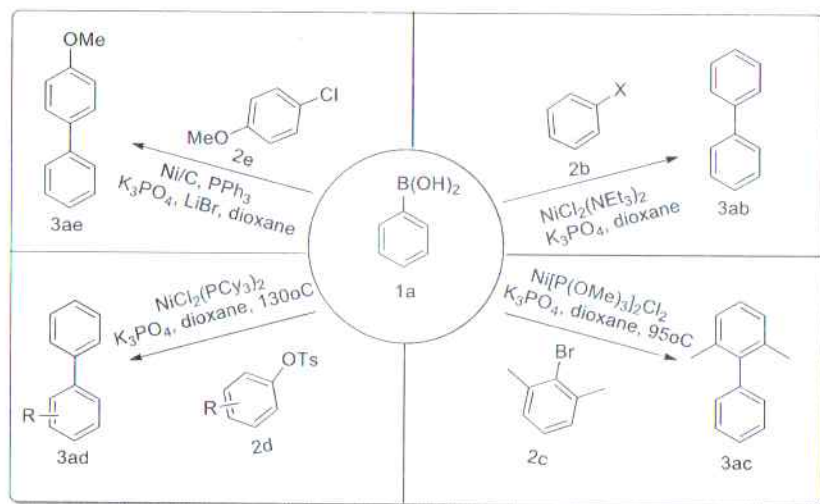
Over the past few years Ni catalysts have received much attention due to their unique chemistry. It can readily access various oxidation state ranging from 0 to +IV, due to single electron transfer process. It was found that Ni(II) intermediate are too stable for facile reductive elimination. Their air stability, ease of preparation and separation of the catalyst mixture from the product at the end of reaction sequence are some advantages of Ni catalyst. For the preparation of sterically hindered Biaryls Ni complexes have been found to better catalyst. The high catalytic activity of the Ni-complexes ensures greater success in the cross-coupling reaction with various aryl chlorides having electron rich and electron poor substrates and there are no side reaction or scrambled products with the phosphine bound aryls of the Ni catalyst.

### 2.1.1 Catalytic, ligand and ligandless system

In 1995, first example of Ni catalyzed Suzuki coupling was reported by Percec and coworkers by allowing various aryl sulfonate with phenyl boronic acid in the presence of NiCl<sub>2</sub>(dppf) as catalytic system [4]. An increasingly growing interest in the use of Ni catalyst has led to important development in this area.

The Ni(0) complex, Ni(PPh<sub>3</sub>)<sub>4</sub> is difficult to handle as it is air sensitive and highly toxic and it is therefore not commonly used in Suzuki cross-coupling. In 2000, a more efficient and cheaper catalyst was reported by

Miyaura and Inada, by allowing arene chlorides and boronic acid in the presence of  $\text{NiCl}_2(\text{PPh}_3)_2$ , with the assistance of two equivalents of  $\text{PPh}_3$  as external supporting ligands and in the presence of  $\text{K}_3\text{PO}_4 \cdot n\text{H}_2\text{O}$  and toluene [5]. Leadbeater and Resouly have developed two phosphine free Ni-complexes  $\text{NiCl}_2(\text{Net}_3)_2$  (Fig1(1)) and  $\text{NiCl}_2(\text{bipy})$  (Fig 1(2)) to carry out metal mediated biaryl formation [6]. They used these complexes to assessed for their activity in the coupling of a wide range of aryl halides (2b) with phenylboronic acid (1a) under optimized condition (Scheme 1). The best results were obtained using the  $\text{NiCl}_2(\text{Net}_3)_2$  compared to  $\text{NiCl}_2(\text{bipy})$ . Leadbeater and Griffiths have shown that using  $\text{Ni}(\text{dppf})\text{Cl}_2$  (Fig1(3)) and  $\text{Ni}\{\text{P}(\text{OMe})_3\}_2\text{Cl}_2$  (Fig1(4)) complexes facilitated the coupling of more sterically demanding aryl halides (2c) [7]. The best results were obtained with trimethylphosphite as a ligand (Scheme 1).



Scheme 1: Unit of temperature ( $^{\circ}\text{C}$ )

Monteiro and co-workers have reported the use of  $\text{NiCl}_2(\text{PCy}_3)_2$  (Fig1(5)) catalyst in Suzuki coupling reaction of variety of aryl tosylates (2d) with aryl boronic (1a) acid under mild reaction condition (Scheme 1) [8].  $\text{NiCl}_2(\text{Pcy}_3)_2$  is a stable complex and easy to prepare and manipulate. Monteiro and Zim have reported the coupling of aryl bromides or iodides with phenylboronic acid using  $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$  as catalyst precursor and found the product in good yields [9].  $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$  is cheap, widely available and used without any auxiliary ligand or reducing agent. In 2006, a very mild procedure was reported by Hu and co-workers, who described that  $\text{Ni}(\text{cod})_2$  (cod = 1,5-cyclooctadiene) with the assistance of ferrocenylmethyl

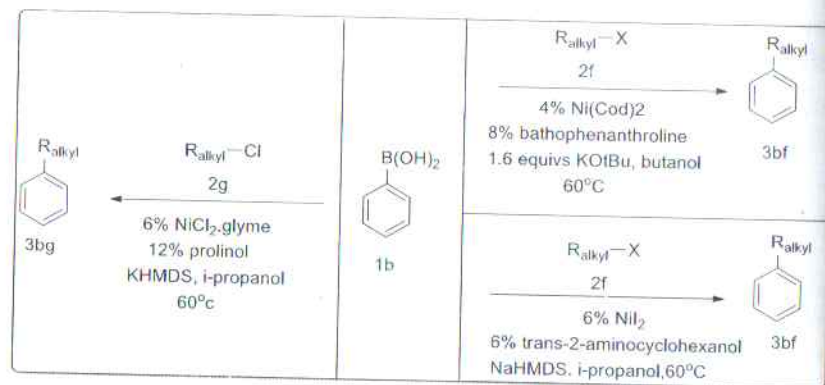
phosphine ligands could catalyze the cross-coupling of aryl chlorides and boronic acids at room temperature [10]. A range unactivated aryl chlorides cross-coupled efficiently with aryl boronic acids in high yields with this catalytic systems. Percec and co-workers demonstrated that by employing a catalyst system composed of 6 mol%  $\text{Ni}(\text{cod})_2$  and 18 mol% of  $\text{Pcy}_3$  ( $\text{Pcy}_3$  = tricyclohexylphosphine), the weakly nucleophilic neopentylglycolborate ester could also be coupled with an aryl chloride at room temperature [11].

While these developments have greatly advanced the Ni-catalyzed Suzuki-Miyaura reaction, the requirement of a relatively high catalyst loading (typically 3-10 mol%) as well as the presence of an excess amount of external supporting ligands (typically 1-5 equiv.) were common problems. More recently Han and co-workers developed a much more effective and readily available nickel catalyst  $\text{NiCl}_2(\text{dppp})$  [ $\text{dppp}$  = 1,3-bis(diphenylphosphino)propane] [12]. This catalyst allowed for very general and efficient cross-coupling of a rich variety of aryl bromides as well as the less reactive aryl chlorides with a catalyst loading of lower than 1 mol%. An array of substrates having electron-rich and deficient substituents was well tolerated when using  $\text{K}_3\text{PO}_4$  as the base in dioxane. Moreover, sterically hindered aryl and heteroaromatic halides were also viable partners.

In the field of transition-metal-catalyzed transformations, the separation, recyclability, and reusability of the catalysts are always one of the major concerns. This issue is solved by the fixation of the catalysts on a solid support. In 2000, Lipshutz and coworkers has reported biaryl coupling using a heterogeneous Ni-catalyst (Ni/C) between functionalized aryl chloride (2e) and arylboronic acid (1a) in good isolated yields (Scheme 1) [13]. After considerable experiments a useful set of reaction condition (i.e. Ni/C, 4 $\text{PPh}_3$ ,  $\text{K}_3\text{PO}_4$ , LiBr, dioxane, reflux) has been developed which could be applied to a variety of substrates. Tricyclohexyl phosphine, tri iso-butylphosphene,  $\text{dppf}$ , BINAP,  $\text{dppe}$ ,  $(\text{t-Bu})_3\text{P}$  and  $\text{Ph}_3\text{As}$  appear to inhibit the extent of coupling.

Moreover, the phosphine free catalytic systems for the Suzuki cross-coupling of aryl halides with arylboronic acids were also demonstrated, there are some drawbacks such as moderate yield, high temperature, longer reaction time and an environmentally unfriendly solvent in the reaction. Most recently, Fu and Netherton developed a coupling of unactivated secondary alkyl bromides and iodides (2f) with a variety of functionalized unsaturated boronic acid catalyzed by  $\text{Ni}(\text{Cod})_2$ -bathophenanthroline (Fig1(6))(Scheme 2) [14]. However, primary and secondary alkyl chlorides, primary alkyl bromides and hindered arylboronic acid cannot be efficiently

coupled in the presence of this catalyst. Fu and Bobes have reported the first Suzuki reaction of unactivated alkyl halides including secondary alkylchloride (2f) with arylboronic acid (1b) in the presence of amino alcohol as ligand [15]. They have found that unactivated secondary bromides of five, six, seven and eight membered carbocycles and heterocycle cross-coupled with an array



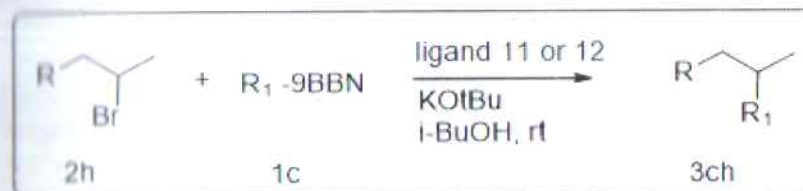
Scheme 2

of arylboronic acid including or *ortho* substituted and electron rich substrates in the presence of  $\text{NiI}_2/\text{trans-2-amino cyclohexanol}$  under optimized condition (Scheme 2). They also demonstrated that when prolinol rather than *trans-2-amino cyclohexanol* was employed as ligand, the cross-coupling of unactivated secondary and primary alkyl chlorides (2g) proceed in good yields (Scheme 2).

N-heterocyclic carbene (NHC) is an important class of ligands in organometallic chemistry. The easy preparation and handling of their precursors, their high modularity and their strong  $\sigma$ -donor properties allow them to form strong NHC-metal bonds that prevent ligand dissociation have rendered them extremely popular as supporting ligand in transition-metal catalyst. Cavell and McGuinness first reported on the use of monodentate N-heterocarbene-Ni(II) complexes,  $[\text{Ni}(\text{tmly})_2]_2$  or  $[\text{Ni}(\text{tmly})_2(\text{o-tolyl})\text{Br}]$  (*tmly* = 1,3,4,5-tetramethylimidazol-2-ylidene) to catalyze the cross-coupling reaction of 4-bromoacetophenone and phenylboronic acids [16]. In 2006, Inamoto and co-workers developed a nickel-pincer complex derived from the imidazole N-heterocyclic carbene ligand [17]. They have found the coupling of aryl bromides containing both electron-deficient and electron-rich substituents could be coupled with phenyl boronic acid in good yields with this complexes. However, there were some drawbacks like a long reaction time and with a relatively high reaction temperature needed with

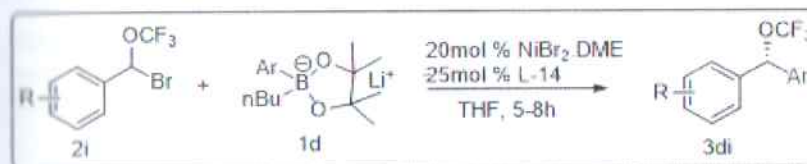
this complex. Wang and co-workers have reported Ni-NHC complexes shown good activities for the coupling of arylboronic acid with aryl or alkyl halides including unactivated aryl chlorides [18]. They examined coupling reactions of aryl chlorides with phenylboronic acid by using complex 7 and 8(Fig1) as the catalyst precursors in the presence  $\text{K}_3\text{PO}_4$  as base and toluene as solvent. The Ni-complexes 7 is more efficient for the coupling reaction of phenylbromide in the absence of additional ligand. Attracted by the unique properties of NHC, Tu and co-worker reported on the use of complex 9(Fig1) in combination  $\text{PPh}_3$  for the coupling of aryl bromides, chlorides, tosylates and mesylates with phenylboronic acid in good to excellent yields [19]. Roglans and co-worker reported on the use of a series of Ni(0)-complexes of polyunsaturated azamacrocyclic ligand 10(Fig1) for the coupling of arylboronic acids and aryl halides [20].

Fu and co-worker reported the Ni-catalyzed Suzuki coupling achieving the asymmetric coupling of unactivated alkyl electrophiles at room temperature. The catalyst was formed in situ by combining either ligand 11 or 12(Fig1) and  $\text{NiBr}_2 \cdot \text{diglyme}$ . Later the same group reported on the using of ligand 13(Fig1) in a similar system for coupling of unactivated tertiary alkyl electrophiles (Scheme 3) [21, 22].



Scheme 3

Shenand co-workers developed a coupling of easily available  $\alpha$ -bromobenzyltrifluoromethylethers with a variety of aryl pinacolboronates with high enantiomeric excess in the presence of complex 14 (Fig1) [23].



Scheme 4

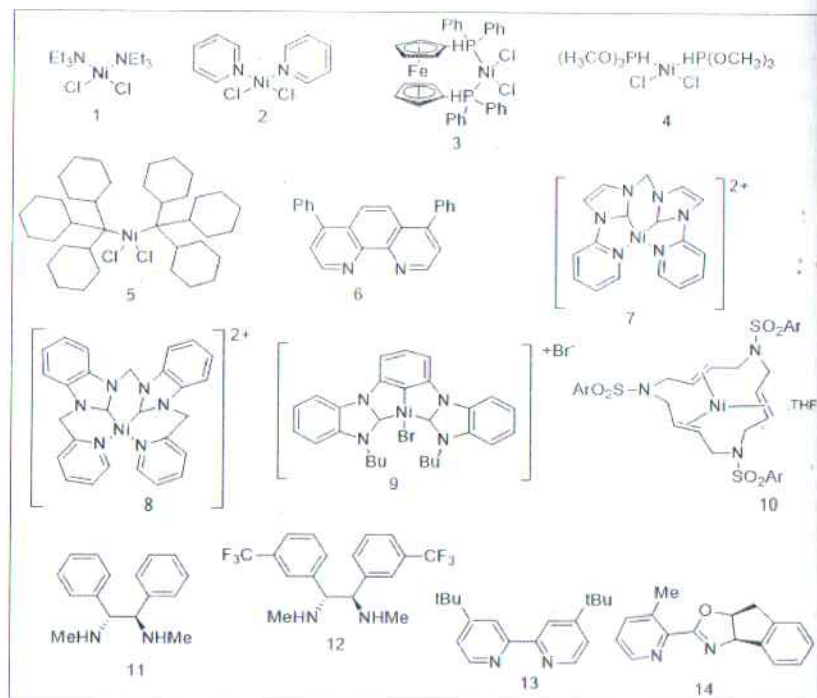


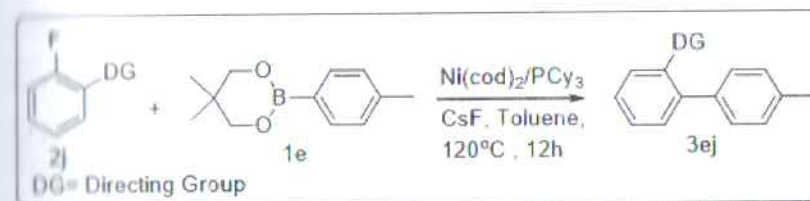
Fig 1: Ni-complexes and ligands used in Suzuki coupling

### 2.1.2 Coupling partner

Before 1995, the palladium-catalyzed Suzuki coupling reaction of arene bromides and iodides was successfully achieved with broad generality and high efficiency [24]. However, reactions for the more economical and widely arene chlorides are sluggish due to their low reactivity. In 1996, by overcome to this issue, Miyaru and co-workers reported for the first time Ni-catalyzed Suzuki coupling of various aryl chlorides with boronic acids [25]. The reaction was carried out under heating in the presence of  $K_3PO_4$  as base and Ni(0), prepared in situ by reducing the  $NiCl_2(dppf)$  with BuLi. In 1997, Indolese demonstrated without the need of external reductants,  $NiCl_2(dppf)$  could also catalyze the coupling reaction of various aryl chlorides and boronic acids [26].

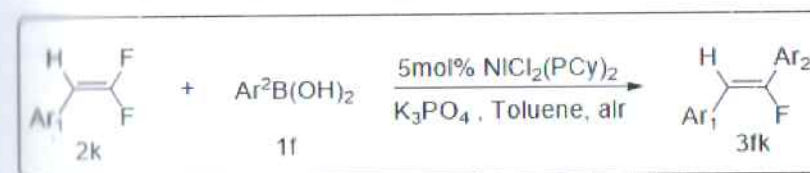
Although aryl fluorides also belong to the aryl halides, this class of substrates is extremely inert as electrophiles in transition metal-catalyzed cross-couplings. The coupling reaction of aryl fluorides was often investigated as a subject independent of aryl iodides, bromides and chlorides. Radius and co-workers first reported the Ni-catalyzed Suzuki coupling of aryl fluorides with phenyl boronic acid [27]. They demonstrated that

perfluorinated arenes such as octafluorotoluene and perfluorobiphenyl, effective coupling with aryl boronic acids by using a NHC-based nickel complex  $[Ni_2(i-Pr_2Im)_4(COD)]$  where (i-Pr<sub>2</sub>Im) = 1,3-di(isopropyl)imidazol-2-ylidene. Chatani and co-workers developed the Suzuki protocol of aryl fluorides utilizing a combination of  $Ni(cod)_2$ ,  $PCy_3$ ,  $ZrF_4$  and CsF base, a range of deactivated aryl fluorides could be coupled smoothly with aryl boron reagents in toluene. Directing groups that contain  $sp^2$ -hybridized nitrogen atom, including pyridine, pyrazole, and oxazoline successfully promoted the cross-coupling reaction with an array of aryl and alkenylboronic esters (Scheme 5) [28].



Scheme 5

Wu and Cao developed a stereo-selective Ni-catalyzed Suzuki coupling of (2,2-difluorovinyl)benzene derivatives with arylboronic acids in the presence of 5 mol%  $NiCl_2(PCy_3)_2$  and  $K_3PO_4$  and significantly expands the substrate scopes of Suzuki cross-coupling reactions (Scheme 6) [29].

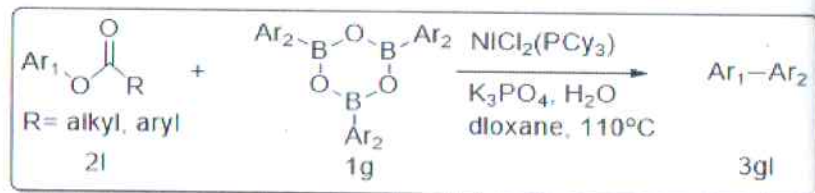


Scheme 6

In 2009, Garg and co-workers reported the first successful Suzuki coupling of aryl sulfamates under 5 mol% of  $NiCl_2(PCy_3)_2$ , 4.5 equivalents of  $K_3PO_4$  base in toluene at 110 °C [30]. A rich range of aryl sulfamates including fused and nonfused substrates and those modified either by electron-withdrawing or electron-donating groups were coupled in very high yields. Kappe and co-workers reported a procedure, which improved the originally published methods by Garg and replacing the mode of bath heating with microwave and the reaction time could be shortened remarkably 10 min [31]. But the issues for the requirements of relatively high catalyst loading and the presence of a large excess of  $K_3PO_4$  base remained unsolved. Percec and co-workers developed the Suzuki protocol of aryl sulfamates [32]. In the

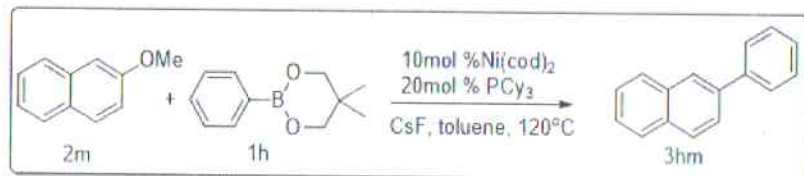
presence of 6 mol% of  $\text{Ni}(\text{cod})_2$  and 12 mol% of  $\text{PCy}_3$ , aryl sulfamates and a slight excess of neopentylglycolborate esters could be coupled efficiently at room temperature. Excellent yields were observed for various combinations of a rich range of sulfamates and borate esters including electron-rich and electron-deficient, ortho substituted, and heteroaromatic partners.

In 2008, Shi and co-workers reported the first time Ni-catalyzed Suzuki cross-coupling of aryl carboxylates with arylboroxines in the presence of  $\text{NiCl}_2(\text{PCy}_3)_2$  using  $\text{K}_3\text{PO}_4$  as the base in dioxane at 110 °C (Scheme 7). A rich range of aryl carboxylates underwent smooth coupling to afford the biaryls in good yields [33].



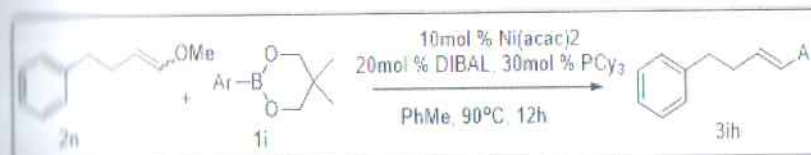
Scheme 7

Relative to aryl halides, much attention has been paid to coupling with aryl C-O electrophiles due to their ready availability from natural source and chemical synthesis. In 2008, Chatani and co-workers reported the first time Ni-catalyzed Suzuki coupling of aryl methyl ethers with aryl boronic esters in the presence of a catalytic amount of  $[\text{Ni}(\text{cod})_2]$  and  $\text{PCy}_3$ . Fused aromatic substrates, i.e., electron deficient aryl methyl ethers, could be coupled in good yields using  $\text{CsF}$  as a base in toluene [34]. (Scheme 8)



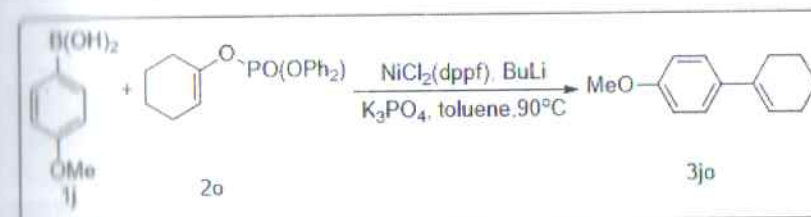
Scheme 8

Jin and co-workers developed the Suzuki cross-coupling of heteroaryl ethers with arylboronic acids in the presence of air stable  $\text{NiCl}_2(\text{dppf})$  catalyst under  $\text{K}_3\text{PO}_4$  as base and toluene at 110 °C and proved the tolerant of extensive functional groups [35]. Marek and co-workers established a highly *E*-selective Ni-catalyzed Suzuki cross-coupling of alkenyl ethers with aryl boronic esters under optimized conditions (Scheme 9). Both acyclic and cyclic alkenyl ethers and various aromatic and heteroaromatic boronic esters successfully employed in this transformation [36].



Scheme 9

Phenol and enol derivatives activated by phosphorus groups are also important electrophiles in the Ni-catalyzed Suzuki cross-coupling reactions. In 1999, Yang and co-worker reported first time the Nickel-catalyzed cross-coupling reaction of cyclohexenylphosphate with a variety of aryl boronic acids under optimized condition (Scheme 10) [37].



Scheme 10

### 2.1.3 Solvent systems

Organic solvents comprise up to 85% of the waste produced from a drug synthesis. It has been found that many solvents are environmentally unfriendly. So the use of the green solvent is especially desirable. The Ni-catalyzed Suzuki coupling need to make industrial processes more environmentally friendly, Garg and co-workers explored coupling reaction in green solvents. Employing with different green solvents, tert-amyl alcohol was found excellent solvent for the cross coupling. They also found that ethereal solvents like methyl-tert-butylether (MTBE) and 2-Me-THF and acetonitrile led to the desired product in good to excellent yields [38].

From environmental, economic and safety point of view, the use of water as solvent in organic reaction is clear goal, although challenging and in most case requiring of high reaction temperature. In 1999, Genet reported a water-soluble nickel catalyzed Suzuki coupling that was capable of affecting the cross-coupling of aryl or vinyl chlorides and boronic acids using water as a cosolvent [39]. Lipshutz and co-worker reported the coupling of arylbromides with phenylboronic acid using various nickel catalyst along with trimethylamine as a base in aqueous solution containing 2wt % of the commercially available designer-surfactant TPGS-750-M at 45 °C. Designer-surfactant TPGS-750-M were engineered to remain in water and the products

undergoes in-flask extraction with minimum amounts of organic solvents. Studies were also conducted to assess the potential for recycling of the reaction media<sup>[40]</sup>.

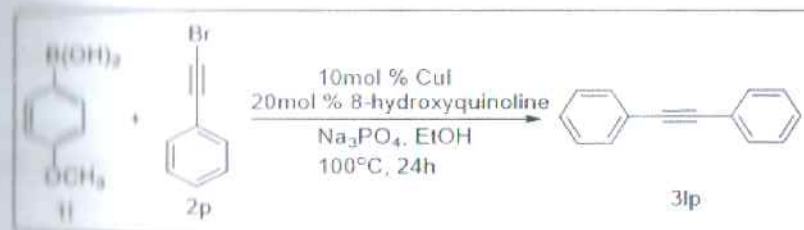
Recent efforts have been focused on green chemistry, sustainable development for academic and industrial research, the development of Suzuki reactions protocols based on atom economy and environmentally-friendly media. Chu and co-workers developed a Ni-catalyzed Suzuki coupling for the preparation of biaryl derivatives using ionic liquid as solvent and found the desired products in good yields<sup>[41]</sup>.

## 2.2 Copper based system for Suzuki coupling

### 2.2.1 Coupling partner, copper sources, ligand and ligand less system

In 2002, Rothenberg and co-workers firstly reported copper-catalyzed Suzuki coupling reaction of aryl halides with phenylboronic acid using copper and copper based nanocolloids<sup>[42]</sup>. Only the coupling of aryl iodides were investigated when the catalyst was copper alone and they applied copper nanoclusters in the reaction and extended the scope to the activated aromatic bromides without aid of any ligand. They found that designed copper and copper-based nanocolloids can catalyze the Suzuki reaction. Li and co-workers developed an inexpensive and highly efficient CuI/DABCO for the cross-coupling reaction of aryl halides with aryl boronic acid. The CuI/DABCO system emerged as an attractive alternative to the Pd-ligand catalyst system, which is general for a variety of aryl halides and tolerated well several functional groups like amino, methoxy and fluoro groups<sup>[43]</sup>.

Deng, Paone and co-workers evaluated copper source and ligand in the coupling reaction between 2-heterocyclic boronates and aryl halides<sup>[44]</sup>. It was found that the reactivity of copper salts followed by the order  $\text{CuCl} > \text{CuBr} > \text{Cu}_2\text{O} > \text{CuI}$ . DPPF (Fig: 2(16)) was found to be the optimal ligand with DMF and  $\text{Cs}_2\text{CO}_3$  as preferred solvent and base. They found that reaction of aryl iodides proceeded in high yield with CuCl (89%) and without CuCl the products yields only 22%. When the reaction was carried out with less reactive bromides and triflate electrophiles, no conversion was observed without the use of CuCl and high yields with CuCl. Wang and co-workers reported CuI-catalyzed Suzuki cross coupling reaction of organoboron compounds with alkynylbromides to generate cross-coupling products in good to excellent yields in the presence of an effective N, O-ligand 8-hydroxyquinoline (Fig: 2(17) (Scheme 11)<sup>[45]</sup>.



Scheme 11

When P-ligand such as  $\text{Ph}_3\text{P}$  or DPPF was added to the reaction system, it was found that  $\text{Ph}_3\text{P}$  accelerates the reaction to yields products 85% and DPPF decelerates the reaction to yields product 71%. When bidentate aromatic N, O-ligand such as 8-hydroxyquinoline was added to the reaction, the yield of the product was increased up to 99% and CuI was the most effective catalyst for the reaction.

Fu and co-workers commenced their study by choosing benzylchloride and phenylboronate as model substrate under optimized condition<sup>[46]</sup>. They improve the yields of the product by screening different ligands and DMF used as a solvent. Among the various ligands, the ligand 2,2,6,6-tetramethylheptane-3,5-dione (Fig: 2(18)) produced the products with high yields. Giri *et al.* reported a versatile Cu-catalyzed cross-coupling between aryl or heteroarylboronate ester and aryl or heteroaryl iodides that affords biaryl products in good to excellent yields using 2mol % catalyst/ligand loadings. To developed the Suzuki reaction, they have synthesized a rare CuI species ligated to *o*-(ditertbutylphosphino)-*N,N*-dimethylaniline (PN) (Fig: 2(19)) ligand that generates the active catalyst  $[(\text{PN})\text{CuF}]_2$ . This ligand is an electron rich and sterically hindered ligand. When they applied this ligand to the coupling of phenylboronate ester with *p*-iodotoluene afforded the product in 95% yields<sup>[47]</sup>. Li and co-workers developed Suzuki cross-coupling reactions with ultra-low Cu-loading. They have synthesized 2,2',7,7'-tetra(4-pyridyl)-9,9'-spirobifluorene (psf)(Fig2(20)) ligand and assembled a kind multilayer film as a catalyst reservoirs capable of progressively releasing amount of high catalytic active Cu-species<sup>[48]</sup>. Mino and co-workers reported the Cu-catalyzed Suzuki reaction by using *o*-(bromoethynyl)-cinnamylbenzene and *p*-tolylboronic acid as model substrates. They used  $\text{K}_3\text{PO}_4$  as a base and isopropanol as a solvent and screening different bis(hydrazone) ligand to found the corresponding product, namely 1-cinnamylbenzene-2-(*p*-tolylethynyl)benzene. Among the various bis(hydrazone) ligand, the phenyl/methyl bis(hydrazone) (Fig: 2(21)) ligand led to the complete consumption of the alkoxy group and afforded the corresponding product in good to excellent yields<sup>[49]</sup>.

The copper salts used in Suzuki coupling are not reusable, whereas such possibility exists with copper chalcogenides. Among these chalcogenides, copper selenides are unique as they found in many phases and structural forms with different stoichiometries such as  $\text{CuSe}$ ,  $\text{Cu}_2\text{Se}$ ,  $\text{Cu}_3\text{Se}_2$ ,  $\text{Cu}_5\text{Se}_4$  as well as in non-stoichiometric form such as  $\text{Cu}_{2-x}\text{Se}$ . Due to unique properties like large thermal power and superionic conductivity,  $\text{Cu}_2\text{Se}$  has attracted considerable attention out of the different selenides. The  $\text{Cu}_2\text{Se}$  is also envisaged as an interesting material as it can be synthesized in various crystallographic forms—monoclinic, cubic, tetragonal, hexagonal and orthorhombic, in which cubic phase is thermodynamically stable and tetragonal phase is metastable. Singh and co-workers have reported a synthetic method for  $\text{Cu}_2\text{Se}$  nanoflakes and investigated their catalytic application for Suzuki coupling reactions. They found that  $\text{Cu}_2\text{Se}$  catalyze the coupling reaction at 1mol % (Cu) in the presence of TBAB efficiently and was reusable [50].

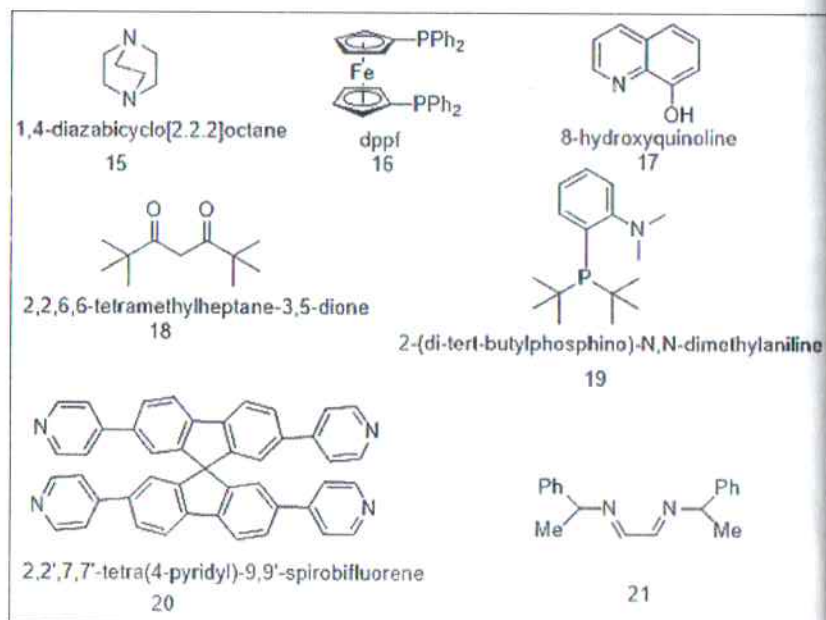


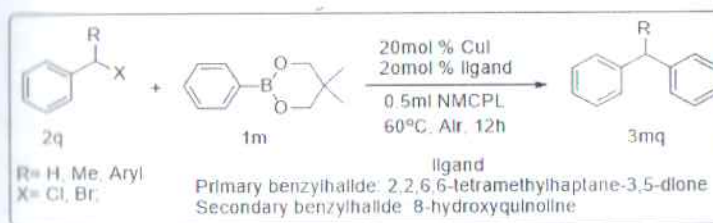
Fig 2: Ligand used in Cu-catalyzed Suzuki coupling

### 2.2.2 Solvent and base systems

It is estimated that around 80% of the chemical waste from a reaction mixture corresponds to the solvent. To meet the demands for recyclability and environmental concerns, Mao and co-workers used a nonvolatile and low toxicity liquid such as poly(ethylene)glycols (PEG) for the coupling of aryl iodides and arylboronic acid under  $\text{K}_2\text{CO}_3$  as base and used copper

powder and molecular iodine. The yields of the coupling products were enhanced to 84% and when the reaction was run for 12h, almost quantitative coupling product was obtained (99%). The results showed that PEGs acted not only as recycling solvent but could also accelerate the coupling reaction [51].

Wang and co-workers screening different solvent in the coupling reaction of organoboronic acids with alkynyl bromides in the presence of  $\text{CuI}$  and  $\text{Na}_3\text{PO}_4$  [45]. Among the solvent tested ethanol, nitromethane and dichloroethane were the most suitable reaction media for the model reaction. They also found that there was no cross-coupling product isolated when the reaction was carried out in water. They examined the effect of base on the model reaction and found only  $\text{Na}_3\text{PO}_4$  was the effective base. Due to strong basicity of  $t\text{-BuOK}$ ,  $\text{Cs}_2\text{CO}_3$  and  $\text{NaOH}$  were no longer effective bases. Fu and co-workers reported the coupling reaction of benzylchloride with phenylboronate using 2,2,6,6-tetramethylheptane-3,5-dione as a ligand [46]. Using DMF as a solvent they have found the corresponding products of the yields 75%. To increase the yields of the desired products they used N-methylcaprolactam (NMCPL) as a solvent. They examined the coupling of primary and secondary benzyl halides (2q) with aryl boronate (1m) (Scheme 12). After investigating the scope of the transformation, they found not only primary benzyl halides but also a series of synthetically relevant functional groups including ether, naphthyl, meta-/para-substituted methyl/phenyl, ester, trifluoromethoxy, trifluoromethyl, ketal, olefins are well tolerated and converted successfully into the desired products. Secondary benzyl halide with  $\beta$ -hydrogen or extra steric hindrance also performed well in coupling reactions. Anil Kumar groups reported ligand free Cu-catalyzed Suzuki coupling of alkynyl bromides with boronic acids under microwave irradiation and they tested various solvent and bases. Further screening of solvents, revealed that polar protic solvent ethanol was the most suitable one for this reaction. Among the screened bases, inorganic bases gave considerably good yields compared to organic bases and  $\text{K}_3\text{PO}_4$  was found most effective one [52].



Scheme 12

Huang and co-workers allowing less toxic and environmentally friendly solvent dimethylsulfone (DMSN) in the coupling reaction of aryl halides with phenylboronic acid in the presence of CuI, K<sub>3</sub>PO<sub>4</sub> as a base and nitrogen atmosphere. Working with this solvent they found good yields of the desired products. DMSN is an organosulfur compound with high polarity and thermal stability and is a safe solvent. It was efficiently prepared with high purity and used as an efficient solvent for reaction. It was not only environmentally friendly and even used as a food additive, but is easily recoverable and reusable due to its crystalline nature<sup>[53]</sup>.

### 3. Conclusions

Almost 40 years of its discovery, the Suzuki reaction is more present than ever in the laboratories of researchers from various disciplines. The various groups develop new methodology (new catalyst, new coupling partners) and apply it in their field (materials, synthesis). The present review summarized the progress in Ni and Cu catalyzed Suzuki cross-coupling reaction since 1995. Most recently, we have observed an explosive development of this chemistry. Of particular importance is that the coupling reactions of broad range of electrophile have been achieved by using purpose-designed Ni and Cu catalysts. Despite these remarkable progresses, many more challenging works still await further investigation. Many of the newly developed reaction still require high catalyst loading paired with the use of a large excess of phosphine or NHC ligands. Moreover, some catalysts are air and moisture sensitive. These shortcomings limit the practicality of the methods in potential industrial processes. Although there is a clear disconnection between the newest catalyst development and its application in other areas, fortunately the use of more active and selective catalysts that can couple more challenging substrates. Chemists have created great achievements, but they are facing more challenges.

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Innovations in Agricultural  
& Biological Engineering

# Novel Processing Methods for Plant-Based Health Foods

Extraction, Encapsulation, and  
Health Benefits of Bioactive Compounds



*Editors*  
Megh R. Goyal | N. Veena | Ritesh B. Watharkar

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## CHAPTER 9

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# NUTRACEUTICALS WITH HEALTH-PROMOTING ACTIVITIES

SANGEETA SAIKIA, NIKHIL K. MAHNOT, and KULDEEP GUPTA

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### ABSTRACT

For consumers, nutraceuticals are delivered as any dietary supplement with naturally derived bioactive components with health benefits. Nutraceuticals in disease management is a new alternative to modern medicine and has gained preference in the present society. The bioactive components exhibit many health-promoting properties, such as antioxidant, anticancer, anti-inflammatory, antibacterial, antidiabetic, antihypertensive, etc. The nutraceuticals are generally categorized based on their sources and chemical properties and their mode of action. The bioactive compounds like phenolics and flavonoids are commonly derived from plant-based sources, although other components like unsaturated fatty acids (MUFA and PUFA), biopeptides are from animals. In recent times, researchers have explored the possibility of extraction and application of novel bioactives obtained from medicinal plants and marine sources, which are not conventional food sources for all. This will promote the development of newer nutraceuticals with enhanced therapeutic properties to cater to the needs of the ever-changing consumers.

### 9.1 INTRODUCTION

The current society is well informed regarding the correlation of a balanced diet and health. There is an increased awareness to maintain a healthy life. Consequently, the demand for healthy and nutritious food as well as



products with added health-promoting properties has gone up. This has fueled an increase in research to determine the health-promoting properties of bioactive compounds derived from plant-based food sources as well as the production of newer products with enhanced health benefits. Generally, such products grouped under functional foods and nutraceuticals. Functional foods are those food products which impart health-promoting effects apart from fulfilling basic nutritional needs. On the other hand, nutraceuticals are isolated or purified bioactive rich components obtained from natural sources and aimed for prevention and management of chronic diseases and are delivered in high concentrations as form of tablets or pills.

The term 'nutraceutical' was coined by Dr. Stephen L. DeFelice. It refers to the combining of the field of both 'nutrition' and 'pharmaceutics.' Nutraceuticals are derived from both herbal and other natural sources. At present, nutraceuticals are the new additions in management of chronic degenerative diseases. They consist of biologically active components, termed as bioactive compounds, which has many health-promoting properties like antioxidant, anticancer, anti-inflammatory, antimicrobial, anticancer, etc.

The present chapter gives an overview on the bioactive compounds, their role in health management and as viable source of nutraceuticals.

## **9.2 BIOACTIVE COMPOUNDS**

Secondary plant metabolites are the prime sources of bioactive compounds. They are widely regarded to boost human health and have proven to be beneficial in the management and avoidance of varied chronic disorders [43, 65]. They are classified into polyphenols, vitamins, minerals, natural pigments, dietary fiber, phytosterols, bioactive lipids, bioactive peptides (BP), etc. Bioactive constituents are abundantly present in varied food sources, including fresh vegetables and raw fruits, nuts, and seeds, marine algae, meat, dairy, marine fish, medicinal plants, etc.

### **9.2.1 POLYPHENOLS**

The polyphenols comprise of one or more hydroxyl-substituted benzene ring, i.e., having a polyphenolic structure. Till date > 8,000 polyphenolic structures have been identified and studied [65]. Polyphenols can be broadly classified into flavonoid and non-flavonoid groups. The flavonoid group is further divided into sub-classes of flavones, flavonol, flavanone, isoflavones,

dihydroflavanols, flavan-3-ols, anthocyanidins, and proanthocyanidins [22]. The non-flavonoid group consists of tannins, phenolic acids, xanthones, acetophenones, chalcone, stilbenes, lignans, secoiridoids, and phenylacetic acid.

Further, the phenolic acids are sub-classed into hydroxycinnamic acid and hydroxybenzoic acid derivatives. Hydroxybenzoic acids are derivatives of benzoic acids having a C6–C1 type general, while hydroxycinnamic acids are cinnamic acid derivatives having C6–C3 type structures.

The common examples of hydroxybenzoic acid derivatives are gallic, gentisic, salicylic, ellagic and vanillic acids. Whereas ferulic, caffeic, chlorogenic, sinapic, coumaric acids, etc., belong to hydroxycinnamic acid derivatives.

Flavonoids are phenolics having a diphenylpropane skeleton (C6–C3–C6) structure, consisting of two aromatic rings linked through a heterocyclic closed pyrene ring (containing oxygen) [31]. Fruits, vegetables, and medicinal plants are major sources of polyphenols.

### 9.2.2 NATURAL PIGMENTS

Pigments are present in almost all living organisms, but the plants are the leading source of pigments. Pigments are found naturally in leaves, flowers, fruits, stems, etc. Some pigments are also present in bacteria and fungi. The pigments find their applications in medicines, foods, textile, cosmetics sector, etc. Based on color, pigments are broadly classified into chlorophyll, carotenoids, anthocyanins, and betalains. Chlorophyll is the most abundant pigment and is responsible for photosynthesis in plants.

Carotenoids are fat-soluble color pigments ranging from yellow to red through orange. Chemically, carotenoids consist of 40-carbon isoprene units covalently linked with multiple conjugated double bonds [49]. Broadly, they have been divided into carotenes and xanthophylls. Carotenes are constituted of only carbon and hydrogen atoms whereas, xanthophylls also contains oxygen. The carotenes are further grouped into phytoene, phytofluene, lycopene, and  $\beta$ -carotene. Similarly, xanthophylls are sub-grouped as  $\beta$ -cryptoxanthin, zeaxanthin, lutein, astaxanthin, and fucoxanthin [5]. Some of these carotenoid pigments are precursors for vitamin A synthesis and are needed to maintain visual health in human.

Carotenoid pigments play a predominant role as an antioxidant molecule in a lipid rich medium. Lycopene is one such carotene, it is associated with reducing blood pressure and has a protective effect on the cardiovascular

system. A diet rich in lycopene has been associated with lowering the risk of damage to the heart muscle fibers, breast, and uterine cancer [59]. Lycopene is found in high amounts in guavas, tomatoes, grapefruit, watermelon, papaya, sweet red peppers, persimmons, etc. Considerable amounts of carotenoids are present in pumpkin, carrot, grapefruit, orange, and apricots.

Anthocyanins are water-soluble pigments belonging to the flavonoid class. The glycosylated forms of anthocyanins are blue, red, or purple in color depending upon surrounding pH. In acidic pH, anthocyanins appear red while in basic pH it appears blue in color. The sugar free counterpart of anthocyanins is known as anthocyanidins and classified into cyanidin, delphinidin, pelargonidin, peonidin, petunidin, and malvidin. They belong to the flavonol subgroup of the phenolic group [38]. Light and temperature are the known factors affecting the stability of the anthocyanin pigments.

In the plant kingdom, glycosylated form of cyanidin (cyanidin-3-glucoside) is the major anthocyanin pigment and is abundant in different flowers as well as fruits (such as: berries, currants, grapes). Leafy vegetables like black carrot, red cabbage, brinjal, black, and red rice varieties, black corn, sweet potato, etc., are also high in anthocyanin. Anthocyanins are generally used as a source of natural colorant in foods and textile industries, but they also confer many health benefits. They exhibit antioxidant, antidiabetic, anticancer, anti-inflammatory, antimicrobial properties, etc.

Betalains are also types of pigments and are predominant in the vacuoles of plants belonging to the families under the order Caryophyllales [37]. The betacyanin (red-violet colored) and betaxanthin (yellow colored) are good examples. Betalains are formed due to condensation of betalamic acid [4-(2-oxoethylidene)-1,2,3,4-tetrahydropyridene-2,6-dicarboxylic acid] with amino compounds (cyclo-DOPA and/or its glucosyl derivatives) to betacyanins. If betalamic acid condenses with an amino group, betaxanthin is obtained. Researchers have reported that betalains under *in vitro* and *in vivo* conditions exhibited anti-inflammatory, radical scavenging, antidiabetic, and anticancer properties [4, 30, 37]. Beetroot, cactus pear, amaranth, red-purple pitaya contain large amounts of betalains, which can be extracted for use as nutraceuticals.

### 9.2.3 VITAMINS AND MINERALS

Vitamins are organic compounds indispensable for the growth and maintenance of optimal health in humans. Therefore, a diet enriched with vitamins is vital. Vitamins are classified as fat-soluble (vitamin A, D, E,

and K) and water-soluble (ascorbic acid and vitamin B complex). The fruits and vegetables, marine fishes, seaweeds, mushrooms, eggs, meat, dairy products, legumes as well as fortified cereals are good sources of different vitamins in diet. Depending on the type of vitamins, the functional role in the body differs. Vitamin A is vital for visual health and vitamin D aids in bone health maintenance. Similarly, vitamin E has antioxidant properties and has a beneficial effect on the nervous and cardiovascular system [18, 56].

Ascorbic acid is well known for its excellent antioxidant activity and helps in prevention of oxidative cell damage. The B-complex vitamins group is essential for the normal growth and development of the body, correct fat and carbohydrate metabolism, proper functioning of the nerves, and red blood cell formation. Importantly, the vitamin B complex acts as cofactors in various intricate biochemical reactions occurring in the body during metabolism [44].

Minerals are also vital for normal functioning of many metabolic reactions. An adequate mineral balance is required for the maintenance of teeth and bone health as well as smooth functioning of nervous and vascular systems [17]. Minerals essential for body function are divided into macro [magnesium (Mg), potassium (K), calcium (Ca), chlorine (Cl), phosphorus (P), sodium (Na), sulfur (S)] and micro minerals [manganese (Mn), chromium (Cr), selenium (Se), cobalt (Co), copper (Cu), iodine (I), iron (Fe), molybdenum (Mo), and zinc (Zn)].

In many biological reactions, minerals (Zn, Cu, K, Mn, Fe, Ca, etc.), act as a co-factor for the enzymes catalyzed reactions. Mg, P, and Mn play a role in energy production in the body while, Cu, Zn, Fe, and Se are also required for a healthy immune response. Additionally, Cu, Se, and Zn are noted for their antioxidant properties, thereby protecting the cells from going under oxidative stress [17, 25]. Nuts, meat, fish, dairy products, fruits, and vegetables are well-known sources of minerals. Lately, marine sources such as seaweed are also listed as major sources of minerals for a healthy diet.

#### **9.2.4 DIETARY FIBERS (DFS)**

Byproducts from vegetable and fruit wastes like peel, pomace, seed, and seed coats are naturally rich in dietary fibers (DFs) with health-promoting properties. American Association of Cereal Chemists [1] has defined DF as edible part of plants and analogous carbohydrates that are resistant to digestion and absorption in the human small intestine, undergoes complete or partial fermentation in the human large intestine. DFs are broadly classified

as soluble (SDF) and insoluble dietary fibers (IDF) owing to their respective solubility in water. The SDF include gums, mucilage, pectin, and hemicelluloses. While IDF consists of mainly cellulose, other types of hemicelluloses and lignin [65].

DF acts as a bulking agent, which helps in the maintenance of a healthy bowel movement. IDF help to increase fecal bulk and plays a role in decreasing intestinal transit. Additionally, DF is also associated with other health benefits such as lowering of glucose and cholesterol level in blood, maintenance of healthy body weight, prevention of cardiovascular diseases (CVDs), and diabetes. SDF cause an increase in viscosity and help to reduce plasma cholesterol and glycemic levels [2, 55, 63]. The DFs derived from vegetable and fruit wastes contain polyphenols embedded in the fiber matrix [20]. Such type of DF imparts antioxidant effect in addition to the benefits associated with consumption of fiber [65]. Another important role of DF is to increase the fecal mass as well as maintenance of colon health and also aids in preventing colon cancer. This is due to the generation of short-chain fatty acids, as inherent microflora of the large intestine ferments the DFs.

### 9.2.5 *PHYTOSTEROL*

Sterols or steroid alcohols are lipids that belong to a subgroup of steroids. They are found naturally in plants, fungi, and in animals. Sterols of plant origin are termed as phytosterol and are derived from squalene, a member of triterpene family.  $\beta$ -Sitosterol, stigmasterol, campesterol, brassicasterol are major phytosterols with functional properties [14]. Dietary intake of phytosterol helps in the maintenance of optimal health as they have anti-carcinogenic, antioxidant, anti-inflammatory properties and helps in reduction of LDL (bad cholesterol) level [32, 81, 82]. Nuts, edible seed and oils, whole grains, legumes, vegetables, and fruits are the major sources of phytosterols.

### 9.2.6 *BIOACTIVE LIPIDS*

Some lipids in addition to being a source of energy for bodily functions also have health-promoting effects and are termed as bioactive lipids or bio-lipids. A bioactive lipid usually imparts its bioactivity either through changing the fatty acid composition of different tissues or by preventing cell signaling pathways [87]. Both polyunsaturated fatty acids (PUFA) and

monounsaturated fatty acids (MUFA) are considered as bioactive lipids with an array of health-promoting properties. PUFA is classified into  $\omega$ -3- and  $\omega$ -6-fatty acid. Intake of diet rich in PUFAs (such as  $\alpha$ -linoleic acid ( $C_{18}H_{30}O_2$ ), eicosapentaenoic acid (EPA,  $C_{20}H_{30}O_2$ ), docosahexaenoic acid (DHA,  $C_{22}H_{32}O_2$ ) may impart beneficial role in metabolic function and also has preventive role in cancer, diabetes, inflammatory bowel disorders, CVDs, neurodegenerative conditions, etc. [21]. DHA is an important molecule required for proper brain development in growing years. EPA intake is shown to slow down cognitive decline and dementia associated with aging [87]. Marine fish, seaweeds, oils derived from sunflower seed, flax seed, corn, soybean, and safflower are rich in PUFA. Marine fish oils are major sources of EPA and DHA.

The  $\omega$ -7-fatty acid (Palmitoleic acid,  $C_{16:1n-7}$ ) and  $\omega$ -9-fatty acid (Oleic acid,  $C_{18:1n-9}$ ) are MUFAs, which are also beneficial for human health. Palmitoleic acid helps in reduction of hyperglycemia, hypertriglyceridemia conditions and helps in improving insulin sensitivity. Similarly, oleic acid regulates many biological processes and decreases the chance of occurrence of coronary heart diseases and other metabolic disorders [87]. Animal fat, marine fish, and oils derived from macadamia nuts, peanuts, canola, sunflower, sesame, poppy seeds, avocado, etc., are the main sources of MUFAs.

### 9.2.7 BIOACTIVE PEPTIDES (BPS)

The BPs exhibit functional properties that have a beneficial role in metabolic functions and health [11]. They can be used for treatment of many ailments of the digestive, endocrine, cardiovascular, immune, and nervous system [41, 68]. These functional peptides can be derived both from animal and plant sources. Among the animal sources, blood, a by-product of animal slaughterhouses is a promising source of BPs. From the hydrolyzed animal blood proteins, a number of peptides are obtained that showcase bioactivity like inhibiting angiotensin-converting enzyme (ACE), glucose regulation by inhibiting dipeptidyl peptidase-IV (DPP-IV), and antioxidant potential [6, 68]. BPs are also derived from cheese and bovine milk, meat, egg, and fish through chemical and enzymatic hydrolysis [51] Similarly, some sequences of peptides present in rice, wheat, and soy proteins are also used for BP production. Mushrooms [92] and seaweeds [39] derived BP exhibits antihypertensive, antioxidant, and antimicrobial properties.

### 9.3 FUNCTIONAL ROLE OF BIOACTIVE COMPOUNDS

Bioactive compounds derived from food sources as well as medicinal plants have numerous functions in the prevention and maintenance of different metabolic disorders. Therefore, these compounds play an active role in the improvement of human health; hence, quality of life. Some of the major functional role of bioactive compounds has been discussed briefly in this section.

#### 9.3.1 ANTIOXIDANT ACTIVITY

The metabolic processes in the human body led to the production of free radicals, and these free radicals play a major role in human metabolic processes and diseases. Free radicals are molecular species that contain an unpaired electron which are highly unstable, reactive in nature and behave as an oxidant. Hydroxyl, superoxide anion, peroxide, singlet oxygen, nitric oxide (NO), etc., are some free radical groups that are capable of mutilating biomolecules such as DNA, proteins, carbohydrates, and lipids in the cell which in turn could cause a cascade of unwanted biochemical reactions [42]. However, an optimal quantity of free radicals is required for normal body functions.

An imbalance in the free radical generation can trigger a health crisis due to an increase in oxidative stress. A prolonged oxidative stress could lead to the onset of many degenerative conditions like diabetes, CVDs, neurodegenerative disorders, cancer, etc. Bioactive compounds have antioxidant properties that can neutralize or control the oxidative stress in the body. An antioxidant acts as a barrier that protects the important biological sites inside the cell by scavenging or quenching the free radicals. The human body has an innate defense mechanism to overcome the free radical inflicted oxidative stress during metabolism. Enzymes like superoxide dismutase, glutathione peroxidase, and micronutrients help to remove free radical-induced damages [66].

A diet rich in bioactive compounds will therefore aid the innate antioxidant system to overcome any kind of oxidative stress. Vitamin C, tocopherols, carotenoids, and polyphenols exhibit antioxidant properties in addition to other health-promoting properties [27]. Bioactive compounds present in fruits such as strawberry can inhibit LDL-cholesterol oxidation [76]. Honey also shows antioxidant properties that can be ascribed to the presence of polyphenols, carotenoids, and ascorbic acid in them [23, 46]. Curcumin in *Curcuma longa* and resveratrol in grapes also exhibit antioxidant properties in addition to other functional properties.

### 9.3.2 HYPOGLYCEMIC ACTIVITY

Type-2 diabetes has emerged as one of the most prevalent metabolic disorders in the present society. Change in lifestyle, diet, stress, and other metabolic anomalies often lead to an increased blood glucose level. Plant bioactive compounds like polyphenols and DF have hypoglycemic activity and can bring down the blood glucose levels in diabetic conditions. Polyphenols such as phenolic acids (cinnamic, ferulic, catechin, chlorogenic, rosmarinic, and caffeic acids), tannins, flavonoids (myricetin, apigenin, quercetin, luteolin, and vitexin), stilbenoids (resveratrol, pterostilbene, and polydatin) derived from fruits, vegetables, tea, coffee, etc., have significant hypoglycemic activity [10, 50]. Depending on the type of polyphenols, they help in lowering of glucose in a number of ways such as by protection of the pancreatic islet  $\beta$ -cells, promotion of the  $\beta$ -cells proliferation and reduction in their apoptosis. They also help in stimulation of pancreatic activities and reduction of oxidative stress.

Additionally, polyphenols can inhibit the enzymes responsible for carbohydrate metabolism as well as reduce the generation of advanced glycation end products, thus regulating glucose absorption [78]. Similarly, isoflavones present in soyabean can reduce glucose intolerance and insulin resistance in blood as well as inhibit glucose uptake in the small intestine [12, 78].

DF is another plant-derived bioactive that has hypoglycemic property. They can reduce the glucose absorption by binding to the glucose molecules or alleviate insulin resistance in blood [45]. Shtriker et al. [73] reported that fiber derived from fenugreek and citrus fruits help in reduction of blood glucose level by inhibiting the function of  $\alpha$ -amylase enzyme. Additionally, Novel BPs derived from hydrolysis of meat, soy, egg, and other plant proteins also exhibit hypoglycemic effects [62] by inhibiting the activities of enzymes of concern like  $\alpha$ -amylase,  $\alpha$ -glucosidase, and DPP-IV [89]. Restricting the DPP-IV enzyme helps to stimulate insulin secretion and further inhibition of glucagon release, thus controlling the increase in blood glucose level [34].

### 9.3.3 ANTI-INFLAMMATORY ACTIVITY

Inflammation is a protective response against harmful stimuli (chemical or biological) to a cell. On injury, a varied cascade of reaction starts comprising of overexpression of cell adhesion molecules and interleukin-1, synthesis of proinflammatory cytokines, activation of transcription factor NF- $\kappa$ B, overexpression of phospholipases A2 along with release of reactive oxygen



species (ROS). Bioactive components from various foods and medicinal plants are shown to inhibit these reactions thereby subliming inflammation.

Bioactive components of foods and medicinal plant extracts have shown potent application as anti-inflammatory agents. For example, *Albizi myriophylla*-derived ethanolic extracts showed anti-inflammatory property under both *in vitro* and *in vivo* conditions. The major active compounds present in the extracts are flavonones and phytosterols, and they have a significant effect in reduction of skin swelling when tested in rat ear edema model. The proposed mechanism for its action was through inhibiting production NO [9].

Aerial parts methanolic extracts of *Ajuga laxmannii* herb may reduce inflammation in rats by inhibition of phagocytosis through reduced oxidative stress. The major bioactive components isolated from the methanolic extracts were rutin, iridoids, and phytosterols [80]. S-allylcysteine from black garlic, polyphenols from *Uncaria tomentosa*, *Myrciaria dubia*, *Harpagophytum procumbens*, *Ribes nigrum*, and citrus fruits extracts have shown significant anti-inflammatory nature in *in vitro* and *in vivo* studies [70]. More recently, a shift towards marine microalgae and cyanobacteria is seen as important sources of bioactive components which inhibit the inflammatory reaction cascade [79].

### 9.3.4 LIPID LOWERING ACTIVITY

For a proper absorption of lipid droplets in the body, emulsification of the lipid takes place in the stomach and duodenum due to emulsifying activity of bile salts and phospholipids. The gastric and pancreatic lipases act on these emulsified lipid droplets and lipolysis takes place. The rate of lipolysis is depended on the lipid emulsion stability. Therefore, to manage the lipid absorption rate in the body, the rate of lipid digestion needs to be controlled. DF can interfere with the lipolysis depending on the type, concentration, pH, and ionic strength. They act either by stabilizing or destabilizing the lipid emulsion. In both the cases, the lipid molecules become unavailable to the lipolytic enzymes and thus the rate of lipolysis can be controlled. Therefore, a diet rich in DF can help in prevention and management of atherosclerosis, obesity, and other associated ailments with increased lipid levels in the body [77].

Polyphenols derived from fruits, vegetables, and medicinal plants also have lipid-lowering properties. The lowering of lipids by polyphenols takes place either inhibiting the lipase enzymes or interfering with the emulsion droplets formation. Research has reported that polyphenols in black tea can

inhibit the emulsion droplets in the stomach and reduce the surface area hence, making them unavailable for the lipolysis [29]. Black tea polyphenols also can inhibit the activity of pancreatic lipase [57]. Polyphenols such as curcumin, cyanidin-3-glucoside, catechin, chlorogenic acid can suppress the Niemann-Pick C1-Like 1 (NPC1L1) mRNA expression while, luteolin, and epigallocatechin gallate (EGCG) inhibit NPC1L1 by binding directly [33]. NPC1L1 is a protein found on the epithelial cells of the gastrointestinal (GI) tract and hepatocytes of the liver. Hence, inhibition of NPC1L1 by polyphenols results in lowering of the blood cholesterol due to decreased absorption from the intestine [33].

### 9.3.5 ANTIHYPERTENSIVE ACTIVITY

A holistic approach consisting of simultaneous use of drug, a balanced diet with the richness of bioactive compounds, nutraceuticals, and an active lifestyle may be the key for effective treatment/management of hypertension. Many bioactive compounds have antihypertensive properties. For example, ascorbic acid, tocopherols, BPs, polyphenols, bioactive lipids, phytosterols as well as minerals-like Ca, K, and P have antihypertensive property [7]. BPs derived from milk, bovine blood, fish, seaweeds, and plants exhibit an inhibitory effect on ACE [7, 13]. The main role of ACE is to convert angiotensin I to angiotensin II (an active vasoconstrictor). ACE controls blood pressure by modulating the volume of fluids in the body, and is a central component of the renin-angiotensin system. This enzyme is a metalloprotein with Zn at its catalytic site [3]. Most polyphenols can chelate the Zn at the catalytic site of ACE thus, inhibiting the enzyme's catalytic activity [3, 85]. Garlic's bioactive compounds like allicin and captotril can inhibit the ACE activity [71]. Similarly, polyphenols isolated from *Clerodendrum colebrookianum* also showed ACE inhibitory effects [88].

### 9.3.6 ANTI-NEURODEGENERATIVE ROLE

Parkinson's disease, Alzheimer's disease, Huntington's disease, etc., are some of the common ages related neurodegenerative disorders. It is a progressive dysfunction and degradation of neurons that leads to neuronal cell damage [91]. Epidemiological studies have identified that certain components in the diet can have a therapeutic role in neurodegenerative conditions [26]. However, development of nutrient based therapeutics for neurodegeneration

is often challenged by the blood-brain barrier which hampers the efficacy of any therapy. To overcome this barrier, a proper carrier or vehicle is required for targeted delivery of the bioactive compounds. Use of nano-carriers is one such way for a successful delivery to the targeted site of action. Degeneration of neurons is triggered often due to oxidative stress, neuroinflammation, mitochondrial dysfunction, abnormal protein misfolding, apoptosis, and nerve cells death due to toxicity [52].

Natural products with bioactivity derive from Korean ginseng (*Panax ginseng*), ashwagandha (*Withania somnifera*), honey, propolis, cat's claw herb (*Uncaria rhyncophylla*), seaweeds, turmeric (*Curcuma longa*) rhizomes, fish oil, germinated brown rice are considered to have neuroprotective role [52]. The bioactive compounds present in them have antioxidant, anti-apoptotic, and anti-inflammatory properties, which may prevent or control the undesirable changes in the neuronal structures and cells that leads to neurodegeneration.

### 9.3.7 ANTIMICROBIAL ACTIVITY

Microorganisms causing infectious diseases are the main cause for creating a huge burden on the healthcare system as well as responsible for increased mortality. Due to increased resistance against commonly available antibiotics, concern to find alternatives of available antibiotics is gaining attention day by day. From ancient time plants are well known to possess medicinal value. Traditionally medicinal plants have been utilized to treat different diseases and even in avoiding food spoilage. The antimicrobial activity of compounds isolated from plants is thought to be an alternative of chemically synthesized antibiotics [28]. These bioactive compounds proved a platform to overcome the concern of developing antibiotics resistance [64]. According to their chemical structures, they are classified into alkaloids, sulfur-containing compounds, terpenoids, and polyphenols.

Bioactive constituents are divided into different groups like polyphenols, alkaloids, sulfur-containing compounds, terpenoids, etc., based on their chemical structure. Piperine, an alkaloid isolated from different piper species have shown growth inhibition of *S. aureus* and many other microorganisms alone or in combination with antibiotics [36].

Berberine (soquinoline alkaloid) can target RNA polymerase and gyrase of bacteria, fungi, protozoa, and viruses thus can inhibit their growth [17]. Other alkaloids such as Ungeremine (such as dictamnine kokusagine, Reserpine, and masculine) have also been found as potent antimicrobial agents against *Staphylococcus spp.*, *E. coli*, *Streptococcus spp.* and *Micrococcus spp.* [35].

Organo-sulfur compounds such as allicin from garlic (*Allium sativum*) is a well-known antimicrobial agent against a wide range of pathogenic microorganisms, i.e., *S. epidermidis*, *P. aeruginosa*, *Streptococcus agalactiae*, etc. [61]. Allicin can act upon alcohol dehydrogenase and RNA polymerase of the microorganisms to kill the microbes. Ajoene an organo-sulfur compound found in garlic extract has also been found to contain broad-spectrum antimicrobial activity and also have antiviral activity.

Polyphenolic bioactive compound like resveratrol is also known for its antimicrobial activity against *Campylobacter jejuni*, *Arcobacter*, and *M. smegmatis* [40]. Baicalein has been screened and found potential to restrict the multiplication and growth of varied Gram-positive and Gram-negative microorganisms like *Bacillus cereus*, *E. coli*, *S. aureus*, *Candida albicans*, and *Pseudomonas aeruginosa*. Kaempferol is a bioactive molecule against different antibiotic resistant microorganisms like fluconazole-resistant *C. albicans* and methicillin resistant *S. aureus* (MRSA) [60, 72]. Curcumin has a promising bactericidal effect against MRSA and uropathogenic *E. coli* by damaging the cell wall of these microorganisms [83].

EGCG has been found to exhibit potent antimicrobial activity against different pathogenic microorganisms. Apart from above mentioned bioactive compounds, other components like tannins, ascorbic acid, gallic acid, and coumarins are also known for their antimicrobial activity. Wu et al. [87] showed that quercetin and apigenin can target D-alanine: D-alanine ligase enzyme in *E. coli* and *Helicobacter pylori* to show their antimicrobial activity.

### 9.3.8 ANTI-CANCEROUS ACTIVITY

The development of plant-based compounds has been targeted to search some bioactive components against cancer. Several molecules from plants have been used in the cancerous cell lines *in vitro* and have shown the good efficacy, and after animal experiments, some have been sent to the clinical trials also.

Artemisinin a plant active compound from *Artemisia annua* has been found to show liver, breast, and pancreatic anticancer activity [19]. Cabazitaxel, a derivative of natural taxoid have been found to eliminate the prostate cancer in randomized open-label trial [15]. Sinani et al. [74] showed in his study that solamargine, a component of *Solanum nigrum* plant extract has the potential to eradicate human melanoma cancer by activating lysosomal mitochondrial death pathway [67].

Another active component of plant, kaempferol when form a complex with zinc (II) have been evaluated for their anticancer activity and it has

been found that it has a great potential in proliferation of lung, breast, and liver cancer cells [84]. Withaferin A, withanolide D, gingerol, colchicine, skimmianine, boswellic acid, and silymarin are some compounds which have also been tested for their anticancer activity. The source plants of these bioactive components have been considered in traditional medicine, but their scientific validation and active component analysis is quite recent, and further approaches are utilized to find out the novel drugs against the cancer.

*Curcuma longa* contains an active component, i.e., curcumin which has the ability to eliminate colon adenocarcinoma by activating STAT3 and NF- $\kappa$ B (transcription factors in immunity) signaling pathways [86]. Some other compounds which have been found to contain anticancer activity include betulinic acid, asiatic acid, gallic acid, lycopene, plumbagin, allicin, apigenin, calcaelin, and ursolic acid, etc. These components have shown prominent activity against breast, colon, lung, liver, spleen, and skin cancer.

#### 9.4 BIOAVAILABILITY AND DELIVERY OF NUTRACEUTICALS

Bioavailability in general refers to the ingested nutraceuticals fraction that become accessible to absorption in the GI tract, is metabolized and later distributed to organs and tissues. Distinctively, the bioavailability of nutraceuticals is governed by three steps: bioaccessibility, absorption, followed by transformation [47]. The first step being ‘bioaccessibility’ is defined as the fraction of nutraceutical that is available for absorption through the epithelial membrane of the intestine. This includes liberation of the active nutraceutical molecule from its matrix (food or delivery matrix); solubility in corresponding biological fluid (stomach, pancreatic, intestinal, and bile) where it is available for interacting with other components or systems.

Bioaccessibility is dependent upon the physical (solubility, size, charge, load degree, etc.), and chemical nature of the nutraceutical along with prevailing digestive environment (pH, enzymes, bile salts, FFAs, etc.). ‘Absorption’ of a biocomponent/nutraceutical takes place at the GI tract epithelial cells marking the second step for bioavailability. Absorption is governed by active or passive transport based upon the nature of the nutraceutical.

Lastly, the “transformation” of biocomponents during digestion and their metabolism in the liver also affects the bioavailability. Transformations such as curcumin degrades in alkaline conditions, cis-trans conversion of carotenoids into inactive forms or oxidations of fatty acids like PUFAs by prooxidants, etc., leads to lowering of bioavailability [16]. Thereby, in general, a lower bioactivity of nutraceuticals is observed in *in vivo* models as

compared to *in vitro* models. Considering the above-mentioned points, the limited bioavailability of the most nutraceuticals does not materialize into distinct health benefits on intake. Consequently, to improve bioavailability, researchers are on the pursuit to design delivery matrixes and systems for nutraceuticals.

Delivery matrices for nutraceuticals are designed with objectives, such as [24]: (i) protection against external factors; (ii) easier incorporation into food products; (iii) masking of off-flavors; (iv) controlled release; and (v) maximal retention of functional property in general or till the components reaches its targeted site. Encapsulation of nutraceuticals (such as carotenoids, vitamins, PUFAs, polyphenols, phytosterols, minerals, etc.), has been studied to show such benefits. Common biomaterials for encapsulation are polysaccharides, proteins, lipids, low molecular weight surfactants. Nano-delivery systems increase the surface-to-volume ratio, thus assists in better solubility and facilitate the movement of the nutraceutical through biological barriers/membranes by bypassing transformation steps, thereby increasing bioavailability. Novel nano-delivery systems (such as solid lipid nanoparticles (SLNs), liposomes nano-emulsions, nanostructured lipid carriers (NLCs), self-generating nano-emulsifying drug delivery systems (SNEDDS)) have shown promising applications for increased bioavailability of various nutraceuticals [8, 53].

Researchers have shown the dependence of size on bioavailability. Smaller size of nano-emulsion of vitamin E corresponded to augmented bioavailability [59] and similar results were also observed for  $\beta$ -carotene using SLNs [48]. SNEDDS approach has been most effective to provide higher levels of bioactive component loading, better transport, dissolution, and easier intestinal permeation whilst enhancing bioavailability. SNEDDS formulations have helped to overcome the limited bioavailability for various flavonoids, carotenoids, polyphenols, alkaloids, and vitamins leading to better final results as compared to native compounds [53].

Incorporation of enhancer molecules along with particular nutraceutical has been suggested to increase the absorption of nutraceuticals by increasing membrane permeation. Enhancers (such as: piperine, bile salts, genistein, unsaturated fatty acids, lactose esters, chitosan derivatives) have shown to increase the absorption of curcumin, vitamin D<sub>3</sub>, EGCG, ovalbumin, and salvianolic acid, respectively [24]. More recently, use of the Maillard reaction-based protein-polysaccharide conjugates have been potential encapsulant or delivery systems. This is because of their unique characteristics, such as: excellent emulsification capacity, high solubility, and antioxidant property,

stability towards a wide range of temperature, pH, and ionic strengths along with better protection of lipophilic bioactive nutraceuticals [54].

Overall, specifically designed delivery systems can substantially increase the efficacy of nutraceuticals for an intended health benefit. The systems can better regulate the bioaccessibility, absorption alongside transformation of the nutraceuticals inside the GI tract. However, further developments related to the selection of other food-grade carrier materials, delivery system, controlled release, and toxicological studies for risk assessments needs to be investigated.

## 9.5 SUMMARY

Bioactive compounds derived from food and other natural sources has ample scope to be used as nutraceuticals as therapeutics for chronic metabolic disorders viz. diabetes, cancer, hypertension, neurodegenerative diseases, CVDs, etc. Bioactive compounds such as polyphenols, vitamins, minerals, natural pigments, dietary fibers, phytosterols, bioactive lipids, bioactive peptides (BP), etc. have been identified and determined for many therapeutic properties. The bioaccessibility, absorption and transformation are the three important steps to be considered for bioavailability of nutraceuticals. The specially designed delivery system for nutraceuticals has shown a substantial potential to increase the bioavailability and bioaccessibility of varied bioactives. This will help in increasing the efficacy of the intended health benefits of the nutraceuticals. Therefore, nutraceuticals from novel bioactive compounds have immense potential in improving the quality of life by playing an important role in disease management along with conventional medicines.

## KEYWORDS

- **bioactive compounds**
- **food sources**
- **medicinal plants**
- **monounsaturated fatty acids**
- **nutraceuticals**
- **therapeutics**

Non Commercial Use

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Pradeep Verma *Editor*

# Thermochemical and Catalytic Conversion Technologies for Future Biorefineries

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*Editor*

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# Chapter 3

## Physical and Chemical Hydrolysis Methods for Breaking Down the Complex Waste Biomass to the Fermentable Sugars and Value-Added Products



**Kuldeep Gupta, Muzamil Ahmad Rather, Parmanand Kumar, Pritam Bardhan, Nikhil Kumar Mahnot, Manabendra Mandal, and Rupam Kataki**

**Abstract** Agricultural, industrial, and household practices generate a wide variety of waste biomass that is generally underutilized and often contributes significantly to environmental pollution. Such waste streams are rich in complex polysaccharides (cellulose, hemicellulose, and pectin), proteins, and lipids that can be hydrolyzed into fermentable sugars (hexoses and pentoses) or other added-value products (peptides, fatty acids, organic acids, carotenoids, etc.). However, the conversion of complex polymeric substrates into fermentable sugars is carried out by means of various physical and chemical methods. Physical methods of biomass treatment such as grinding, milling, microwave radiation, and ultrasonication are primarily aimed at reducing the size of the structural biopolymers and exposing the lignocelluloses to chemical reagents or enzymes for further hydrolysis. Conventionally, acid or alkali is used for hydrolysis of pretreated lignocellulosic biomass (such as agro and forestry residues). Other methods of physicochemical treatment such as liquid hot water treatment, autoclaving, or ammonia fiber expansion can be selected depending upon the biomass characteristics. Similarly, wastewater rich in proteins or lipids from industries such as dairy, oil refineries, and poultry is traditionally treated with

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hydrolytic enzymes (proteases and lipases) prior to anaerobic biodegradation. This chapter provides a comprehensive review of the various physical, chemical, and physicochemical methods for a breakdown of complex polymeric substrates in the waste streams into either simpler fermentable sugars or other bioproducts of commercial value.

**Keywords** Hydrolysis · Lignocellulosic biomass · Wastewater · Chemical methods · Physical methods · Hydrolytic enzymes

## Abbreviations

CAS	Conventional active sludge
COD <sub>p</sub>	Chemical oxygen demand
DES	Deep eutectic solvent
FW	Food waste
P&P	Pulp and paper
POM	Particulate organic matter
TS	Total solid
TSS	Total soluble solids
WCO	Waste cooking oil
WWTP	Wastewater treatment plant

## 3.1 Introduction

We commonly overlook waste products including food waste (FW) in our daily life. However, lately waste food materials are receiving much interest among a varied group of scientists. Globally, FW is recognized as a major problem, the waste generated has a considerable impact on society and the environment. Thus, managing FW poses a challenge. Conventionally, the FW is either dumped in landfills or incinerated posing a serious threat to the environment as well as human health, in turn causing huge economic losses. Currently, conversion into value-added products has emerged as a potential solution in managing agricultural and food waste. Largely, the agricultural and food are composed of carbohydrates (simple sugars and complex polysaccharides), proteins, lipids, along with bio-pigments and bioactive constituents, which is quite evident. Thus, wastes with such important constituents can be converted to value-added products such as phytochemicals, dietary fibers, natural colorants, and livestock feed to name a few which can play an important role in food waste management.

Bioplastics are a highly valued product that can be produced using FW. However, such conversion requires pretreatment of waste to generate monomers such as sugars that can be later converted into bioplastics by varied processes. Both acid and alkali

pretreatment help in solvation of the solid waste, i.e., depolymerization of plant polysaccharides and lignin. Also, the involvement of physical methods such as ultrasonication and heating can further improve the depolymerization process. On the other hand, using enzymes or microbial fermentation can also be efficiently utilized as pretreatment methods (Tsang et al. 2019; Bhardwaj et al. 2021; Bhardwaj and Verma 2021). Physical treatment such as heating combined with acid treatment has shown promising results in converting FW streams to generate monomers like 3-hydroxyvaleric acid which can later be polymerized into bioplastics (Ahn et al. 2016).

Alternative fuels are highly sought-after products these days, and the value of energy generated from the fuel is well recognized by all energy-intensive sectors. Food wastes specifically waste cooking oil (WCO) or grease coming out from food outlets have been shown to yield biodiesel through an alkali catalyzed transesterification reaction with alcohols. Importantly, WCOs are considered economical sources for fuel production. Methanol is the most commonly used alcohol that has been utilized for efficient transesterification reactions in presence of catalysts such as KOH or NaOH or CaO, leading to sufficient yield in biofuels. The prepared biofuels can be blended with conventional fuels to run compression ignition engines (Singh et al. 2021), and also the combustion values were within the range mentioned by American Biodiesel Standards. Researchers have met quite a success in such reactions on used cooking oils such as palm oil, canola oil, peanut oil, olive oil, or cooking oil mixtures (Sahar et al. 2018; Degfie et al. 2019; Park et al. 2019).

Emulsifiers are quite important ingredients used in the food industry specifically to produce stable oil-in-water emulsions. Emulsifiers can be extracted from food waste through both physical and chemical processes. On characterization, certain emulsifiers have been found to be made up of proteinic and poly/oligosaccharide materials. Researchers have extracted emulsifiers from FW such as winery wastes, olive mill waste or compost, etc. (Koliastasi et al. 2019).

Again, special value-added products such as poly phenolic compounds, antioxidants, and colorants have been identified as important components of fruits and vegetable wastes such as peel, pomace, and seeds. Resveratrol is a highly valued polyphenol with potent bioactivity and has been extracted at an industrial scale using supercritical CO<sub>2</sub> extraction methodology from grape pomace as a waste of the wine industry (Casas et al. 2010; Saini et al. 2021). Again, the deep eutectic solvent (DES) extraction method can significantly recover resveratrol from peanut roots (Chen et al. 2018). Carotenoids are another prominent component and are widely regarded as a natural food colorant (Goswami et al. 2021a, b; Mehariya et al. 2021). Luengo et al. (2014) suggested improved extraction of carotenoids by subjecting tomato waste to ultrasonication. Also, comprehensive reviews have suggested the employment of varied physical and chemical methods for the extraction of specialty constituents. For instance, physical methods such as high pressure and temperature treatment and ultrasound-assisted extraction with organic solvents like ethanol have assisted in the extraction of phenolic acids and flavonoids from grape skin onion and tobacco wastes. Again, microwave-assisted extraction of pectin (a soluble dietary fiber)

from the peel of citrus fruits peel and passion fruit peels also improves the extraction process and yields pectin with similar characteristics to that of industrial pectin (Yukesh Kannah et al. 2020). Also, lycopene has been extracted from dry tomato peels using supercritical CO<sub>2</sub> extraction as well as with solvents such as hexane, ethyl acetate, and ethanol (Kehili et al. 2017). Astaxanthin (a pigment) from pink shrimp waste can be recovered using water-based ultrasound treatment (da Silva et al. 2018). Many of these valued products are also a part of non-nutritive but important health-benefiting constituents as they have potent bioactivities and can be added to food products to develop functional foods (Saikia et al. 2016, 2020). Other valued products for the industry such as organic acids (citric, lactic, succinic, propionic acids, etc.), enzymes (tannase, lactase, alpha-amylases, etc.) are mostly produced using microbial fermentation (solid-state/submerged state) with the help of varied microbial strains such as *Aspergillus niger*, *Actinobacillus succinogenes*, *Lactobacillus*, *Actinobacillus succinogenes*, *Bacillus licheniformis*, *Rhizopus*, *Thermomyces lanuginosus* or their recombinants. Compilation of numerous studies has suggested the use of FW such as fruit pomace and peels, corn cobs, coffee mucilage, lipid-rich wastes, etc. for production (Verma and Shah 2022; Verma 2022). However, there is lack of studies pertaining to mixed food waste as a medium for the generation of such acids or enzymes (Merrylin et al. 2020). On the other hand, postproduction, techniques like dialysis, diethylaminoethyl (DEAE) cellulose, ultrasound-assisted enzymatic extraction, ion-exchange chromatography, and size-exclusion chromatography are commonly used for extraction, purification recovery of such valued products. Pretreatment or extraction using ultrasonication, supercritical CO<sub>2</sub> extraction, solvent extraction, pulsed electric field, etc., have also been employed to recover pigments, essential oils, and other aromatic esters from varied FW sources typically essentials oils from fruit/vegetable wastes (Sharmila et al. 2020; Devi et al. 2020). Overall, one can suitably understand that FWs can be effectively manipulated through various physical, chemical, or biological interventions and be an impactful source of varied valued constituents of use.

### 3.2 Physical and Chemical Hydrolysis Methods of Waste

Human agricultural activities have led to the production of large amounts of agricultural waste which are underutilized and dumped as litter to rot, polluting the environment (Obot et al. 2008). Large amounts of biomass accumulating annually not only deteriorates the environment but also reduces the availability of materials having an enormous potential value that can be transformed into a range of useful added products, comprising food (groundnut, cottonseed), fuel (ethanol, biogas), feed (by-products of sugarcane, sugar beets), and a variety of chemicals (pesticides, insecticides). Farming economies are rendered intricate due to mismanagement of agro-industrial residues, and these remnants are considered to be the most ample and renewable resources on earth. These agro-industrial wastes comprise cellulose (organic compound composed of  $\beta$  glucose units), hemicellulose (xyloglucans,

mannans), lignin (complex polymer comprised of aromatic alcohols known as monolignols), and other precipitates (Ghose 1956; Aberuagba 1997; Agrawal and Verma 2020; Kumar and Verma 2020a). Amid all, cellulose consists of the largest percentage which is typically found in the plant cell wall. Considering that hemicellulose and cellulose form the cell wall constituent and are lignified; therefore, there is a growing need for an efficient and inexpensive method of separating them from the cell wall. Furthermore, cellulose can be hydrolyzed for human consumption to yield glucose, which can be used as a substrate for the fermentation of valuable chemicals, such as alcohols and other organic compounds (John et al. 2007; Qi et al. 2009; Kumar and Verma 2020b). Considering the above facts, physical and chemical treatments alone or in combination may be utilized as a hydrolytic procedure to break down the wastes resulting from the agro-industrial process.

### ***3.2.1 Physical Treatment Methods***

It involves mechanical crushing, microwave treatment, ultrasonic treatment, and high-energy electron radiation methods.

#### **3.2.1.1 Mechanical Crushing**

This method comprises dry crushing (drying followed by crushing of the material), wet crushing (milling process carried out in water or liquid), and vibrating ball mill grinding (particles of the materials are crushed between porcelain or metal balls and the mill body), and compression. It often precedes other operations to make succeeding procedures easier and more efficient.

Mechanical splintering can be used to reduce the particle size of lignocellulosic feedstocks to increase the surface area that is exposed to subsequent acids or enzymes. However, the high cost associated with this procedure along with its inability to efficiently remove lignin and hemicellulose from the cell wall constituent, limits its suitability (Hendriks and Zeeman 2009; Hu et al. 2014; Jin et al. 2015; Nelson et al. 2013).

#### **3.2.1.2 Microwave Treatment**

Typically, the radiation of microwave is considered the most usual method for the treatment of plant biomass. In addition to ease of pretreatment, increasing the capacity of heating, reduced time processing, minimal generation of inhibitors, and lower energy consumption, this pretreatment method has various advantages. The microwave treatment enhances the adjustability of lignocellulosic raw material to enzymes, subsequently increasing the enzyme's activity effect (Chen et al. 2017a, b; Kumar et al. 2020).

### 3.2.1.3 Ultrasonication

In addition to opening crystalline cellulose, ultrasound can dissolve lignin molecules and markedly improve cellulose's accessibility and chemical reactivity. Nevertheless, it has only a minor impact on cellulose's fine structure. Hemicellulose can undergo disintegration when treated with ultrasounds. This results in a decreased fiber-to-surface area ratio, which in turn interferes with the enzymatic hydrolysis process. Cavitation effects, which trigger high enzymatic hydrolysis, are a result of using ultrasonic waves in enzyme processing (Chen et al. 2017a, b).

## 3.2.2 Chemical Treatments

Chemical hydrolysis procedures comprise acid/alkali treatments (Kiyoshi et al. 2015; Seifollahi and Amiri 2020).

### 3.2.2.1 Acid Pretreatment

Acid hydrolysis is a preferred and considered technique as it is relatively quick and inexpensive for hydrolyzing the cellulosic biomass generated as a part of agricultural waste (Palmqvist and Hagerdal 2000; Megawati et al. 2010; Bhardwaj et al. 2020). Temperature (120–180 °C), acid concentration (high or low strength), a total solid fraction (TS), and time duration (varying from minute to an hour) are the key parameters that affect the cellulosic and lignocellulosic biomass during acid hydrolysis (Grohmann et al. 1995; Talebnia et al. 2007). The glycosidic bonds are formed between hemicellulose and cellulose, and its susceptibility to acid forms the basis of acid pretreatment. Both inorganic acids such as sulfuric acid (Kärcher et al. 2015), phosphoric acid (Nair et al. 2015), nitric acid (Kim et al. 2015), and hydrochloric acid (Zu et al. 2014) and organic acids such as formic acid (Du et al. 2016), maleic acid (Jung et al. 2015), and oxalic acid (Jeong and Lee 2016) are used. Additionally, inhibition by compounds such as furfurals, 5-hydroxy methyl furfural, phenolic acids, and aldehydes formed as a result of undesired cellulose degradation during acid treatment makes it less attractive as a pretreatment option.

### 3.2.2.2 Alkali Treatment

The solubility of lignin in the alkali solution is crucial to the alkali pretreatment process. Alkaline pretreatment of lignocellulose can be done with NaOH, KOH, Ca (OH)<sub>2</sub>, and ammonium hydroxide. During the alkali pretreatment procedure, a saponification reaction occurs, causing the intermolecular ester bonds between hemicelluloses and lignin to be cleaved. This causes lignin and hemicellulose

particles to dissolve in the alkali solution, allowing enzymes to interact with the cellulose (Li et al. 2016). Furthermore, alkali pretreatment alters the lignocellulosic structure by causing cellulose swelling, which reduces crystallinity and degree of polymerization, resulting in an increase in internal surface area (Behera et al. 2014). In addition, alkali pretreatment enhances the accessibility of carbohydrates to enzymatic hydrolysis by removing acetyl groups and uronic acid substitutions in hemicelluloses (Maurya et al. 2015).

### 3.2.3 *Enzymatic Treatment*

The use of biocatalysts, such as enzymes like lipase and cellulase, plays a vital role in the hydrolysis and breakage of polymeric chains present in carbohydrate-rich feedstocks (Binhayeeding et al. 2020; Koti et al. 2016; Tavva et al. 2016).

## 3.3 Conventional Chemical Hydrolysis Methods for the Treatment of Agricultural Wastes

Crop and livestock farming generates a large volume of agricultural residues that pose a serious environmental concern when it is not treated or managed well. Crop residues are primarily generated from the cultivation of cereals, oil crops, pulses, roots and tubers, and fiber crops. These residues are rich in polysaccharides such as cellulose, hemicellulose, and pectin that can be converted into monomeric sugars such as glucose and xylose, and sugar acid (D-galacturonic acid) by the process of hydrolysis. However, a prior pretreatment step is necessary to remove the lignin and make cellulose more accessible to the hydrolytic enzymes. Conventionally, acid-alkali pretreatment followed by enzymatic hydrolysis has been used to treat a wide variety of agro-residues such as palm empty fruit branch, barley straw, sugarcane bagasse, and different grass types (Martínez et al. 2015). Alkali pretreatment has been reported to remove lignin extensively that resulted in more than 90% conversion of glucan into glucose by enzymes (Martínez et al. 2015). Of late, the efficiency of enzymatic hydrolysis has been further improved by combined pretreatment approaches. For example, in the case of rapeseed straw, delignification by hydrothermal dilute acid pretreatment followed by alkali posttreatment resulted in a significant increase in hydrolysis rate by 5.9 times (Chen et al. 2017a, b). Similarly, sequential dilute acid-alkali/ammonia treatment resulted in increased enzymatic hydrolysis of poplar biomass (Shi et al. 2020).

Although enzymatic saccharification is a widely used method for the conversion of structural carbohydrates present in the pretreated biomass into monomeric sugar, the high cost of the enzymes remains a major bottleneck. In this regard, the role of renewable heterogeneous catalysts in the breakdown and conversion of



**Table 3.1** Different chemical hydrolysis methods of wastes for the production of value-added products

Pretreated agro-residues	Hydrolysis method	Conversion/ saccharification efficiency (%)	Product	Reference
Barley straw	Commercial cellulases (Cellic <sup>®</sup> CTec2)	91.19 g/L (82% hydrolysis yield)	Fermentable sugars and ethanol	Paschos et al. (2020)
Rice straw, corncob, sugarcane bagasse, and banana stem	Hydrolytic enzymes from <i>Aspergillus tubingensis</i> are produced using black liquor	745.50 (86.02), 596 (74.5), 358.15 (42.98), 245.70 (33) mg/g of TRS, respectively	Reducing sugars	Narra et al. (2020)
Potato peel waste	Commercial enzymes (cellulase and amylase) or (alpha-amylase from <i>Bacillus</i> sp. Gb67) used either separately or in mixtures	72.38% (for commercial enzymes)	Fermentable sugars and ethanol	Atitallah et al. (2019)
Mixed food and beverage waste	Glucosylase and sucrase	Glucose (228.1 g L <sup>-1</sup> ) and fructose (55.7 g L <sup>-1</sup> ), 0.17 g sugar per g mixed waste	Sugar rich hydrolysate	Kwan et al. (2018)
Date palm cellulosic wastes	Cellulases from <i>Geobacillus stearothermophilus</i>	31.56 mg/mL of glucose	Fermentable sugars and lactic acid	Alrumman (2016)
Corn cob	Rice husk-based solid acid catalyst	TRS yield of 486.53 mg/g and xylose of 253.03 mg/g	Fermentable sugars (xylose, arabinose, glucose)	Chen et al. (2019a, b)
Mixed rice straw and de-oiled algal residue	Garlic peels derived solid acid catalyst	41.41%	Fermentable sugars, lipids, and carotenoids	Bardhan et al. (2022)
Rice straw (RS)	Glycerol-based solid carbon acid catalyst	262 mg/g TRS (from alkali pretreated RS) 147 mg/g TRS (from native RS)	Fermentable sugars and ethanol	Goswami et al. (2015)

lignocellulosic biomass is an emerging area of interest (Lin et al. 2021). Table 3.1 below depicts the saccharification of agro-residues using different chemical hydrolysis methods for the production of biofuels and other value-added products.

### 3.4 Conventional Hydrolysis Methods for Treatment of Poultry and Dairy Wastewater

Besides crop residues, the agro-industrial sector also generates a wide range of various waste streams such as poultry manure, animal wastes, and wastewater from the dairy processing industries. These wastes are rich in organic matter with a high carbon content, while the macronutrient (N, P, K) content varies considerably depending on the type of the feedstock (Markou and Monlau 2019). However, the wastes/wastewater have to be pretreated and hydrolyzed before the organic carbon is readily available for microalgal growth or anaerobic digestion for the production of suitable bioproducts. Usually, the wastewater from poultry slaughter-houses or dairy industries is rich in lipids and proteins. Enzymatic hydrolysis (commercial lipases) was used to convert the fats in the flotation froth (hydrophobic material phase-separated from wastewater by flotation) into long-chain free fatty acids during anaerobic digestion (Pascale et al. 2019). In another study, 10% garbage enzyme (obtained by the fermentation of fruit or vegetable peels, molasses, and water) was used to treat synthetic dairy wastewater and was found to reduce total soluble solids (TSS) by 26% at pH 6.5 after 5 days of treatment (Sambaraju and Lakshmi 2020). Researchers have also reported the application of whole-cell catalysts such as *Penicillium citrinum* whole cells in decreasing organic matter and lipid content in dairy wastewater. In the same study, it was reported that free whole cells achieved higher hydrolysis efficiency (92.5%) as compared to immobilized whole cells (Alves et al. 2019). Although enzymatic hydrolysis (using lipases, protease, keratinase) is conventionally used for the conversion of lipids and proteins into fatty acids and peptides/amino acids, respectively, certain new promising technologies have been developed in recent years for recovering value-added products from the food processing industry wastes. One such tool is the “sub-critical water hydrolysis” method finding wide application in the recovery of protein hydrolysates from animal and vegetable wastes (Marcet et al. 2016).

### 3.5 Conventional and Recent Hydrolysis Methods for the Treatment of Sewage and Sludge

Sewage from both domestic and municipal sources consists of organic and particulate matters, thus regarded as complex wastewaters. Organic polymers, viz., carbohydrates, proteins, and lipids constitute about 30–70% of particulate chemical oxygen demand (COD<sub>P</sub>) of domestic sewage. These organic particulate matters are reported to hinder or decrease the efficiency of wastewater treatment processes (Rajagopal et al. 2019). Wastewater treatments are high-energy driven and usually expensive processes. High-energy consumption and utilization of various resources are the main disadvantages of conventional wastewater treatment methods. It has been reported that about 3–4% of total U.S. electricity is utilized in the wastewater

treatment process and such is the case with other developed and developing nations. Additionally, high-energy consumption is associated with the production of a large amount of carbon into the atmosphere which could be responsible for enhanced global warming (U.S. Environmental Protection Agency 2006). The increase in population and the subsequent release of excessive wastewaters into the environment have put a burden on social sustainability and stability due to the water-energy inefficient wastewater treatment methods. The conventional active sludge process (CAS) for wastewater treatment requires extensive energy-driven aeration and thus is not recommended as an energy-efficient method. In a CAS process, it has been estimated that about 50% of the total energy consumption is utilized for supplying air to the aeration tanks only (Waqas et al. 2020). Therefore, energy-efficient wastewater treatment methods are required to decrease the burden on energy resources and maintain economic stability as well as social sustainability. In order to avoid the limitations, hydrolysis has been applied as an important part of anaerobic treatments. Hydrolysis (biological pretreatment) involves the breakdown of complex organic molecules into simpler ones by hydrolytic enzymes secreted by fermenting bacteria. The applications of hydrolysis include partial removal of COD by fermentation and an increase in biodegradability (Zhang et al. 2021). As hydrolysis is based on anaerobes and supply of aeration and external temperature is not required, therefore employed as energy and cost-efficient method for large scale wastewater treatment. The study carried out by Bian et al. (2018) demonstrated the effect of COD load on hydrolysis in a pilot-scale hydrolysis-aerobic system and found that 39–47% COD removal was achieved even at a COD load of  $1.10 \text{ kg/m}^3\text{-day}$  in municipal wastewater. It has been documented that 50% of the organic load (BOD/COD ( $\text{kg/m}^3\text{ day}$ )) entering the municipal wastewater treatment plant (WWTP) is comprised mainly of particulate organic matter (POM). Therefore, it is a prerequisite that POMs should be broken into smaller pieces through hydrolysis before their treatment and conversion to valuable by-products. Alvarado et al. (2021) studied the hydrolysis of particulate organic matter in municipal wastewaters under aerobic conditions. They found that during the first days, the high molecular weight of organic molecules increased and bacteria produced sufficient enzymes for their further degradation. On the other hand, they also found that oxygen utilization rate (OUR) developed continuously indicating the conversion of less-biodegradable organic matter to easily biodegradable organic matter.

It is evident that with improved wastewater treatment methods production of sludge has also increased tremendously throughout the world. The sludge is enriched in not only organic matter but also contains various toxic substances including heavy metals, persistent organic pollutants, and a wide variety of pathogens posing a threat to the environment. Therefore, emphasis is put on reusing valuable components of the sludge and energy recovery by different physicochemical methods particularly anaerobic digestion (Xu and Lancaster 2009). Organic matter is inaccessible to bacteria due to its complex nature; therefore, enzymatic hydrolysis is required to increase their bioavailability. It has been demonstrated that enzymatic hydrolysis improved sludge solubilization and acidification. Yu et al. (2013) studied the effect of endogenous amylase, protease, and combined amylase-protease treatment on

sludge anaerobic digestion. They found that combined amylase-protease treatment enhanced biodegradability along with the 23.1% increase in biogas production. It is important to discuss that hydrolysis also enhances the reduction of sludge production as well as the dryness and compactness of sludge cakes. Neyens et al. (2003) reported that hot acid hydrolysis reduced the sludge volume production by 70% more than the initial volume and the DS-solid content of the dewatered cake increased twice the initial untreated value. Hydrolysis treatment is significant for treating wastewaters from dairy industries with high protein and fat content. The study carried out by Mendes et al. (2006) reported that 12 h hydrolysis pretreatment of lipid-rich wastewater from dairy industries resulted in the enhanced levels of production of biogas ( $445 \pm 29$  mL) and organic matter (78.2%) as well as color removal. As discussed, wastewater sludge is a by-product of wastewater treatment processes and has become a major environmental problem for metropolitan cities and towns due to its huge production, high disposal cost, etc. The current approaches employed for sludge management and disposal include anaerobic digestion, landfill, and incineration (Zhang et al. 2017). Expensive sludge treatment and disposal, poor dewaterability, and inefficient utilization of wastewater sludge are the main challenges for wastewater sludge management (Chen et al. 2019a, b). The wastewater consists of about 40%, 14%, and 10%–25% proteins, carbohydrates, and lipids, respectively, but the conventional methods of wastewater sludge treatment could not recover an ample amount of organic and nutrient resources (Youssef et al. 2011). In this regard, thermal hydrolysis is gaining interest as an efficient method for wastewater sludge treatment due to its efficient sludge reduction as well as enhanced sludge dewaterability (Zhao et al. 2013). Liang et al. (2021) developed a three-phase sludge treatment and reduction method by incorporating thermal hydrolysis followed by fungal fermentation and subsequent anaerobic digestion. It was found that temperature treatment (140–180 °C) significantly reduced sludge volume while organic release efficiency was enhanced. The sludge liquor obtained at 160 °C consisting of the highest concentrations of carbohydrates and proteins was subjected to fungal fermentation by *Aspergillus niger* promoted the conversion of waste organics into valuable fiber materials. It was also demonstrated that the obtained fungal hyphae could be developed for making papers or some other value-added fibrous products. Therefore, the integration of thermal hydrolysis with fungal fermentation turned out to be an effective sludge reduction and waste organic valorization approach. As we know enzymatic hydrolysis enhances the biodegradability of sewage and sludge; therefore, its pretreatment with commercially available enzyme or inoculation of in situ enzyme-producing bacteria could promote biodegradation and production of by-products. The study carried out by Agabo-Garcia et al. (2019) demonstrated the application of commercially available proteases as well as the inoculation of *Bacillus licheniformis* as a pretreatment strategy to enhance the biodegradability and biogas production of raw sewage from aerobic digester. The investigators found that biochemical treatments enhanced the stabilization and biodegradability of sewage sludge since the experiments showed higher depuration efficiency in terms of CODs (73–85%), TVS (30–42%), and CODt (16–28%) in comparison with the control experiment with CODs (38%), TVS (28%), and CODt

(12%). Fish industry discharges are often rich in total suspended solids (TSS), oil, and grease, and have high levels of COD as a result their release into the environment is quite harmful in terms of sustainability and stability. The inefficient conventional aerobic treatment of fish industry effluent has shifted the paradigm towards anaerobic treatments. Due to the excessive presence of oil and grease, the anaerobic treatments are hampered as the agglomeration and pellet formation hinders sludge sedimentation, thereby reducing treatment efficiency (Chowdhury et al. 2010). The enzymatic pre-hydrolysis treatment provides an alternative to reduce the oil and grease contents and speed up the treatment for fat-rich fish industry effluents. In this context, Duarte et al. (2015) demonstrated the enzymatic hydrolysis by lipase produced by the fungus *Penicillium simplicissimum* in solid-state fermentation and anaerobic treatment of fish processing effluent at different temperatures. They found that enzymatic hydrolysis at 50 °C and anaerobic fermentation at 30 °C promoted removal of 97.5% of chemical oxygen demand and the production of 105.4 mL CH<sub>4</sub>/g COD<sub>removed</sub> was also achieved. It was suggested that thermophilic enzymatic hydrolysis reduced the overall amount of enzyme, hydrolysis time, and cost of anaerobic treatment, therefore could be applied on an industrial scale. In the pulp and paper (P&P) industry, the main area of interest is to reduce the biomass produced during wastewater treatment processes as sludge management accounts for 60% of total treatment cost (Mahmood and Elliott 2006). Due to the presence of various toxic substances and recalcitrance of P&P wastewater sludge as well as low production of methane, its anaerobic digestion is not as feasible as for domestic wastewater sludge. To achieve high feasibility of anaerobic digestion and enhance methane production during P&P wastewater sludge treatment, enzymatic pretreatment has been preferred as an important alternative. The enzymes decrease the complexity of biosludge, thereby enhancing anaerobic digestion with substantial enhancement in by-product production, methane yield, and/or COD solubilization (Yang et al. 2010). It has been reported that P&P sludge consists of 70% of proteins and carbohydrates; therefore, proteases, glycosidases, or combination are the desired candidates for pretreatment of P&P biosludge (Bayr et al. 2013). Bonilla et al. (2018) reported that proteases from *Bacillus licheniformis* enhanced the anaerobic digestibility of P&P biosludge and 26% increase in biogas production.

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# **Relevance of Gandhian Non-Violent Movement in Contemporary India**

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## **Abstract :**

Mahatma Gandhi is not only recognized for his instrumental leadership role in the Indian independence movement but prominently known as an emblem of the truth and nonviolence across the world also. The concept of Satyagraha expounded by him is the combined manifestation of truth and nonviolence. He was the preacher and practitioner of truth and nonviolence, and spent his entire life while conducting experiments with truth. As per his ideology, sustainable solution is feasible only through the practice of nonviolence as violence leads to hatred that further leads to hostility, which implies moving forward from bad to the worst situation. He strongly and effectively put forward the concept of Satyagraha against the society that enabled the weaker and vulnerable sections of the society to get their demands fulfilled from the authority peacefully and amicably. Gandhi laid down the foundation of nonviolent movement across the earth. Gandhian ideology still today exists in the form of diverse struggles against discriminations and exploitations. Therefore, Gandhi may not exist for a while in the current dialogues, discourses, discussions

# AGRICULTURAL FACTOR MARKETS AND INDIA'S SMALL FARMERS

**EDITED BY**  
**ANUP KUMAR DAS | BINOY GOSWAMI**  
**MADHURJYA PRASAD BEZBARUAH**



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# Chapter 1

## Introduction

**Binoy Goswami, Anup Kumar Das and  
Madhurjya Prasad Bezbaruah**

Agriculture in India, as in most developing countries, is organized with farm households as the basic production units. But farm households rarely possess different factors of production in the optimal proportions. While only a small proportion of rural households own large plots of farmland, landless, marginal and smallholders constitute the majority of the rural population. When it comes to labour, small and marginal farmers usually have more manpower in their possession relative to the land that they own. The pattern of transactions in the markets for leasing of land (land rental markets) and the rural labour markets has been traditionally playing the role of optimizing the land–labour ratios across larger and smaller farm households. As agriculture in the country has modernized with the adoption of newer technologies and progressive mechanization of farming operations, factor markets in agriculture have also expanded in numbers and transaction volumes.

Take the case of farm machineries and equipment, such as tractors, power tillers, irrigation pump sets and harvesters. As acquiring such machines requires lumpy investments, only farmers with access to the necessary financial resources, owned or borrowed, can afford to procure them. Small and marginal farmers rarely have access to enough

## Chapter 4

# Agricultural Labour Markets

## Structure and Functioning

Raju Mandal and Anup Kumar Das

### 4.1. INTRODUCTION

Unequal endowment of factors of production among the households is a common characteristic of an agrarian economy. More often, it is found that in relation to farmland, labour is abundantly available with smaller farmers, and it is scarce for larger farmers (Ray 2011, 409). As a result, cultivation is carried out with varying land-labour ratios, and usually, a small farm operates with excess labour, whereas labour power is deficient in large farms. Meanwhile, the average size of landholding is getting smaller due to an ever-increasing population pressure and division of land ownership with inheritance, which has resulted in an increase in the number of farmers with surplus labour. Under such circumstances, there is the emergence of the agricultural labour market and land-lease market to correct the unequal distribution of such factors of production. An agricultural labour market facilitates the transfer of the services of manpower from labour-surplus households to labour-deficient households. However, it is a stylized fact that as the economy matures, a segment of agricultural workers moves away to sectors with high productivity and better remuneration. India, an



## Chapter 6

# Rental Market of Farm Machineries and Equipment

Anup Kumar Das

### 6.1. INTRODUCTION

The scope of increasing agricultural production through the expansion of cultivable area is getting reduced due to increased population pressure on land, the supply of which is inelastic in nature. Consequently, intensive utilization of farmland becomes important to raise agricultural production. Farm mechanization that facilitates enhancement of agricultural production through intensive and productive utilization of farmland has therefore gained importance. The use of farm machineries such as tractors, power tillers and pump sets enhances cropping intensity (Agarwal 1984; Rao 1972; J. Singh 2006; Verma 2006) and productivity in agriculture significantly (Rao 1972; Roy and Blase 1978; Verma 2006). Farm mechanization helps in timely cultivation, maintaining the quality of operation, increasing the productivity of factors like land and labour, reducing the cost of cultivation and risks of weather and non-availability of labour, all of which raise agricultural output (G. Singh 2006, J. Singh 2006). However, farm mechanization is constrained by factors like small and fragmented landholdings and poor economic conditions of the farmers. For instance, the use of ploughing machinery in a farm requires the farmland to be of a viable minimum size.

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# **Review of Periyar's Contribution towards Social Justice and Rationality in Indian Landscape**

**Dr. Vinod Kumar Yadav**

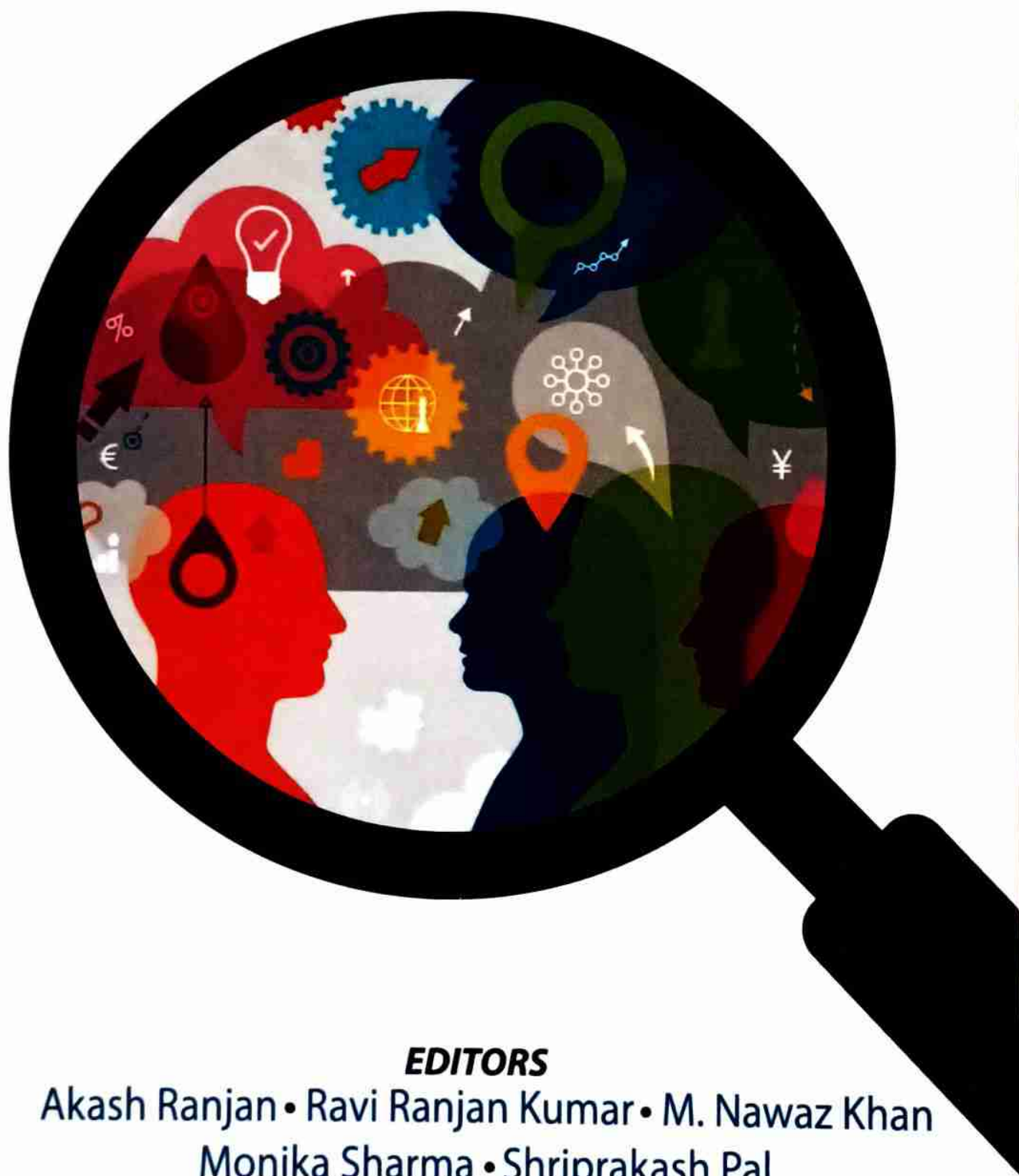
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## **Abstract**

Periyar is still relevant and contextual in the contemporary modern society for his lifelong struggles against casteism, social injustice, irrational thinking, superstition, blind adherence to religion, custom and tradition, exploitation of weaker and vulnerable sections of the society, etc. He was the champion of social justice and campaigner of marginalized society. He is recognized as the father of Dravidian Movement who struggled throughout his life for the rights and reverence of the oppressed and depressed class peoples. He was a strong opponent of Brahmanism as in his view, it was against the social justice, equity and equality in the society, and rational thinking that would paralyze the process of establishment of progressive society ahead. Rationalism and non-violence were the core elements of Periyar's philosophies and principles. The prominent mission of his life was to establish a progressive society through eradication of all the religions and annihilation of caste system. Periyarism is nothing but adherence to Periyar's ideology. He is an iconic figure of social justice and rationality across the globe.

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## Chapter - 8

# Role of Interpersonal Communication in Rejuvenating Universal Happiness in the Post-Truth Era

Oman Tayung\*  
Ravi Ranjan Kumar†

### *Abstract*

*In the 21st century of post-truth era, there has been a significant rise of individualism within most society around the world. Individualism is the moral stance, political philosophy, ideology and social outlook that emphasize the intrinsic worth of the individual. Individualists promote the realisation of one's goals and desires, valuing independence and self-reliance, and advocating that the interests of the individual should gain precedence over the state or a social group, while opposing external interference upon one's own interests by society or institution such as the government (Wood, 1972). This has resulted in the breakdown of traditional community or family foundation that was seen in most of human history. Today one of the reasons why people may feel more isolated may be their greater tendency to use social media. A study conducted by Coombs, 2020 it has been found that there is an increasing correlation between social media usage and feelings*

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# RURAL NON-FARM ENTERPRISES AND ASSAM ECONOMY

Prasenjit Bujar Baruah

## ABSTRACT:

The nonfarm sector is an integral part of the rural economy in the underdeveloped and developing countries, although the size and importance of this sector has been underestimated until a few decades ago. This sector in these countries absorbs a large part of the labour force and provides livelihood to a substantial segment of the population. Its contribution to gross domestic product (GDP), though less than proportionate to its share of employment, is by no means negligible. This paper based on secondary data compiled from different rounds of national sample survey reports tries to analyse the role of rural nonfarm sector enterprises in Assam economy where a relatively larger proportion of the population live in rural areas.

*Keywords: Nonfarm enterprises, Employment, Gross Value added.*

## Introduction:

Until recently, the rural economy in the underdeveloped and developing countries like India has been considered to be an

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## Chapter 15

# Soil Health Management in Arunachal Pradesh, India

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### INTRODUCTION

The states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura make up the North Eastern region of India, which is located between the latitudes of 22°05' and 29°30' N and the longitudes of 87°55' and 97°24' E. The area is distinguished by a variety of topographical and agro climatic conditions. A little more than 54.1% of the overall geographic area is covered by forests, 16.6% by crops, and the remainder is either uncultivated land or non-agricultural uses. A large portion of the land has a slope of more than 15%, an undulating topography, severely eroded and degraded soils, and difficult terrain, which naturally results in the low area under agricultural crops in the area. The area is endowed with a diverse range of physiography, climate, and biodiversity. By area, Arunachal Pradesh is the largest of Northeast India's seven sister states. The state is located between 26.28° N and 29.30° N latitude and 91.20° E and 97.30° E longitude and has an area of 83,743 km<sup>2</sup>. In spite of having the largest area, but the region only contributes a little percentage of the nation's total production of food grains (Baruah et al., 2014). One of the main causes of poorer production and productivity in this area is poor soil health status. "Soil quality" and "soil health" are frequently used interchangeably. However, soil health is viewed as the condition of a soil at a specific moment, which is analogous to the dynamic soil quality that varies quickly. Degradation of soil health has been a significant problem in the contemporary era, notably in the Arunachal Pradesh. The loss of a soil's innate ability to generate economic output and carry out

ecological tasks is referred to as soil health degradation. Arunachal Pradesh is the only state with a dense forest cover of 64.0% out of the seven states. Due to the continued practise of shifting agriculture in the area and the yearly conversion of thick forest into jhum fields, the amount of dense forest cover has drastically decreased. The region's ongoing depletion of forest cover as a result of shifting cropland, firewood and timber collection is posing the most crucial problem resulting in poor soil health and environmental degradation in the hills.

### **Soil deterioration causes**

The soils of North East India are currently susceptible to a number of degenerative processes, such as rapid erosion by water and wind, poor water transmission and retention capabilities, which contribute to the widespread drought-flood syndrome, soil compaction, nutrient imbalance, salinization, acidification, leaching losses, etc. Unsuitable agricultural methods, such as indiscriminate use of heavy equipment, inappropriate grazing, flood-based irrigation, uneven fertiliser use, and excessive pesticide use, are also to blame for soil deterioration. Major food crops like wheat, rice, sorghum, and millet have poor, stagnant national average yields that are characterised by a wide yield difference. The national average output of the world's primary food crops compared to India also differs significantly (Lal ., 2016). By 2050, it is predicted that there will be 8.9 billion people on the planet, which would drive demand for agricultural products (Lichtfouse et al., 2009).

In the Arunachal Pradesh, soil acidity is one of the primary causes of the poor chemical soil health. The high amount of exchangeable aluminum produced by the weathering of acidic parent materials and the significant loss of bases as a result of excessive rainfall are the natural causes of the strong acidity of the soils in the Arunachal Pradesh. As reported by Sharma et al (2006) that out of 21 mha area of acid soil of North –East India ,Arunachal Pradesh (6.8 million ha) has the most acid soils, followed by Assam (4.7 million ha), Meghalaya (2.2 million ha), Manipur (2.2 million ha), and Mizoram (2.2 million ha) (2.0 m ha). The deteriorated acid soils (pH 5.5) cover 11.2 million hectares (ha) in the NE Regions, with the majority being within Arunachal Pradesh (6.5 million hectares), Manipur (1.9 million hectares), and Nagaland (1.6 m ha).

Erosion accelerates the process of physical soil degradation, which leads to a decline in soil physical health. In particular in the North East, the traditional method of Jhumming or Slash and Burn (shifting) farming is said to be the main cause of soil erosion (Barthakur, 1976). According to estimates,

soil erosion from the Indian Himalaya occurs at a rate of around 28.2 t/ha annually, but soil erosion from the Lesser Himalaya and the Siwalik watershed occurs at a rate of 80 to 156 t/ha yearly (Singh and Gupta, 1982). Soil erosion from the hill slopes in Meghalaya state was calculated to be 14.46, 17.62, 30.2, 8.2, and 18.8 t/ha/year, respectively, under first year of jhum, second year of jhum, plentiful jhum, natural bamboo, and mixed forest areas (Singh et al. 1981). To prevent land deterioration that may otherwise have an influence on people's quality of life owing to landlessness, the notion of tolerance limit or permitted soil loss was developed. The soil loss tolerance level is exceeded in the states of Meghalaya (71.90% of TGA covering an area of 1747200 ha) and Arunachal Pradesh (67.6% of TGA covering an area of 5656739 ha) (Chattopadhyay et al., 2014; Dutta et al., 2014). This causes a significant amount of nutrient loss in the area each year. According to Shardha et al. (2013), assessment of soil erosion susceptibility involved prioritising crucial locations based on the maximum amount of soil that may be lost across all of the states in the nation. It was found that priority class II was assigned to 69% of the TGA in Nagaland, 43% in Arunachal Pradesh, 35% in Meghalaya, and 29% in Assam. Shardha et al (2010), calculated the annual production loss at the state level to be 41% of total agricultural production in the year 2005–2006. By diminishing soil fertility and production due to increased erosion, the removal of natural forests and their conversion to agriculture throughout the course of such traditional methods causes environmental degradation. In the NE Region, shifting cultivation is expected to result in annual losses of top soil, N, P, and K of 88346, 10669, and 6051 thousand tonnes, respectively (Sharma, 1998) . Saha et al. (2012) reported that shifting cultivation had the highest erosion ratio (12.46) and soil loss (30.2-170.2 t/ha/yr) under various land use systems in the Northeastern Hill (NEH) Region.

### **Approaches for sustaining soil health**

To mitigate the poor soil health of the state, there is an urgent need of management strategies for improvement of soil health. The approaches for sustaining the soils health are discussed as below:

#### **Organic Management**

The proper application of crop residues to the soil has significant impact on nutrient availability. Vermicomposting of rural wastes has a lot of potential for reducing the soil's lack of nutrients in NE India, especially given the availability of composting earthworms and need-based training in compost technique. In order to avoid unnecessary liming material waste, it is usually



preferable to apply liming materials in furrows rather than broadcast. Furrow limestone application has been shown to significantly boost maize output, using applications of only 250 kg/ha per year (Avasthe et al., 2014). paper mill waste products such as lime sludge, basic slag, paper mill sludge, etc can be used as an inexpensive liming materials (Sharma et al., 2006). Lastly, using watershed-based technologies along with appropriate soil and water conservation measures can be a great way to promote soil health for organic food production.

### **Intensive Integrated Farming System**

Integrated Farming System is designed to facilitate efficient resource utilisation and resource recycling within systems by directly using byproducts of one system as the input of another production system (Fig 1.1). The strategy is site-specific, technically skill-based, plays a multi-faceted role in meeting domestic needs, creates new employment opportunities, enables the wise and sustainable use of resources, promotes resource rejuvenation, and boosts farmer resilience. This strategy, specifically for hill agriculture, helps resource-poor farmers become self-sufficient and economically competitive by producing high-quality edible products from numerous enterprises that are integrated together and by making the best use of the resources that are available in a way that is extremely sustainable.



**Fig 1.1: Integrated Farming System**

### **Economical Polyhouse:**

Vegetable crop output and productivity in Arunachal Pradesh are extremely low as a result of a variety of environmental factors, including

excessive rainfall during the rainy season, frost during the winter, low soil nutrient content due to leaching losses, etc. The best option to change the impact of the mentioned conditions in order for crops to achieve their full potential is protected cultivation using inexpensive polyhouses. It makes it possible to produce high-value, low-volume vegetable crops all year long, including tomatoes, cucumbers, and capsicum. Bamboo and metallic wire that are readily available locally can be used to build a polyhouse for a reasonable price. Typically, IJV stabilized film of 200  $\mu$  (800 gauge) is used to cover the ceiling, and 75% shade net is utilized to cover the side walls. The size of the polyhouse determines the length of the UV-stabilized sheet and shade net. Turpentine oil is used to coat the bamboo posts to protect them from rotting and termite damage.

### **Soil Conservation Measures**

Depending on the soil the various mechanical methods may be used, such as contour bunding, bench terracing, channel terracing, narrow based terraces, broad based ridge terraces, etc. Depending on the soil depth and land use conditions, the bunds may be built using parabolic channels (0.3 m in height and 0.2 m in depth) on contours with vertical intervals of 0.5 m to 5.0 m. Constructing contour trenches (spaced at 10–30 m intervals) aids in lowering high surface runoff and also provides orchard crops with sufficient moisture conditions, such as banana, citrus, pineapple, etc.

### **Latest artificial intelligence based solutions**

The examination of soil health is crucial for Indian soil, yet technology has ignored it. Utilizing computers to automate the procedure enhances its objectivity. The application of artificial intelligence (AI) technologies (Fig 1.2) like machine learning and deep learning to agricultural operations can increase crop productivity and soil health maintenance (Patil, 2022). It has a number of precisely defined models, like as clustering, regression, support vector machine (SVM), and classification, which collect specific data and use specific techniques to get desired outcomes. A practical answer that can be found using a machine learning model is what the system aims to provide. To forecast soil health, the Support Vector Machine, Random Forest, and Linear Regression approaches are used. The longevity of agricultural land and good crop production are both gradually enhanced by scientific management of soil health. Machine learning offers useful and world-class algorithms for tracking soil health and classifying it into groups of healthy and unwell soil.



**Fig 1.2: Artificial intelligence based technologies**

## **CONCLUSION**

Soil health deterioration is a problem in the Arunachal Pradesh facilitated by significant soil erosion on hills by deforestation and shifting farming. Since the majority of the area is rain-fed and monocropped, the fertility of the soil has been steadily declining. The main issues with soil health are high levels of soil acidity with depletion of soil nutrient status. For the restoration of soil health, appropriate soil conservation measures with an integrated farming system approach would make logical sense. Latest scientific technologies and organic agricultural techniques may enhance the sustainability of the state.

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The book "Novel Technologies in Modern Agriculture" is designed to cover all topics of agriculture. Numerous chapters on entomology, agronomy, extension, biotechnology, and other topics are included in the book. The book focuses on the elements that will help students, researchers, and faculty members obtain various types of agricultural information. This book also covered topics that are crucial from the standpoint of the agricultural sector in exams. This book has been edited by the professionals of the S.V.P. University of Agriculture and Technology, Meerut.



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# Study of Sum-Rate Performance of Cooperative Cognitive Radio Networks Using MIMO



Champa Tanga, Joyatri Bora, Md. Anwar Hussain, and Karik Lego

**Abstract** As advancement in wireless communication became a new paradigm and challenges, this paper presents the advantages of multiple input multiple output (MIMO) in cooperative cognitive radio networks (CCRN), where primary users (PU) select some secondary users (SUs) with multiple antennas to transmit the PU data and simultaneously allowing the channel to transmit SU data. We have studied the average sum-rate performance of CCRN, which consists of MIMO secondary users (SU) network that operates in the range of multiple primary users (PUs). Next, the system average sum-rate performance of MIMO in CCRN with a highly scattering Rayleigh fading channel has been used in this study. This paper further analyzed the different linear precoding techniques such as SVD and ZF with varying the distance and signal to noise ratio power by keeping other parameters constant. It is found that SVD precoding techniques have given better sum-rate performance compared with the zero forcing beamforming precoding techniques.

**Keywords** Multiple inputs multiple output · Cooperative cognitive radio networks · Sum rate · SVD · ZF

## 1 Introduction

In recent wireless communication, the demand for the high-speed data is increasing very rapidly, and the capacity of the spectrum is becoming more deficits to fulfill the required demand of latest Internet of things [1, 2]. Furthermore, radio spectrum

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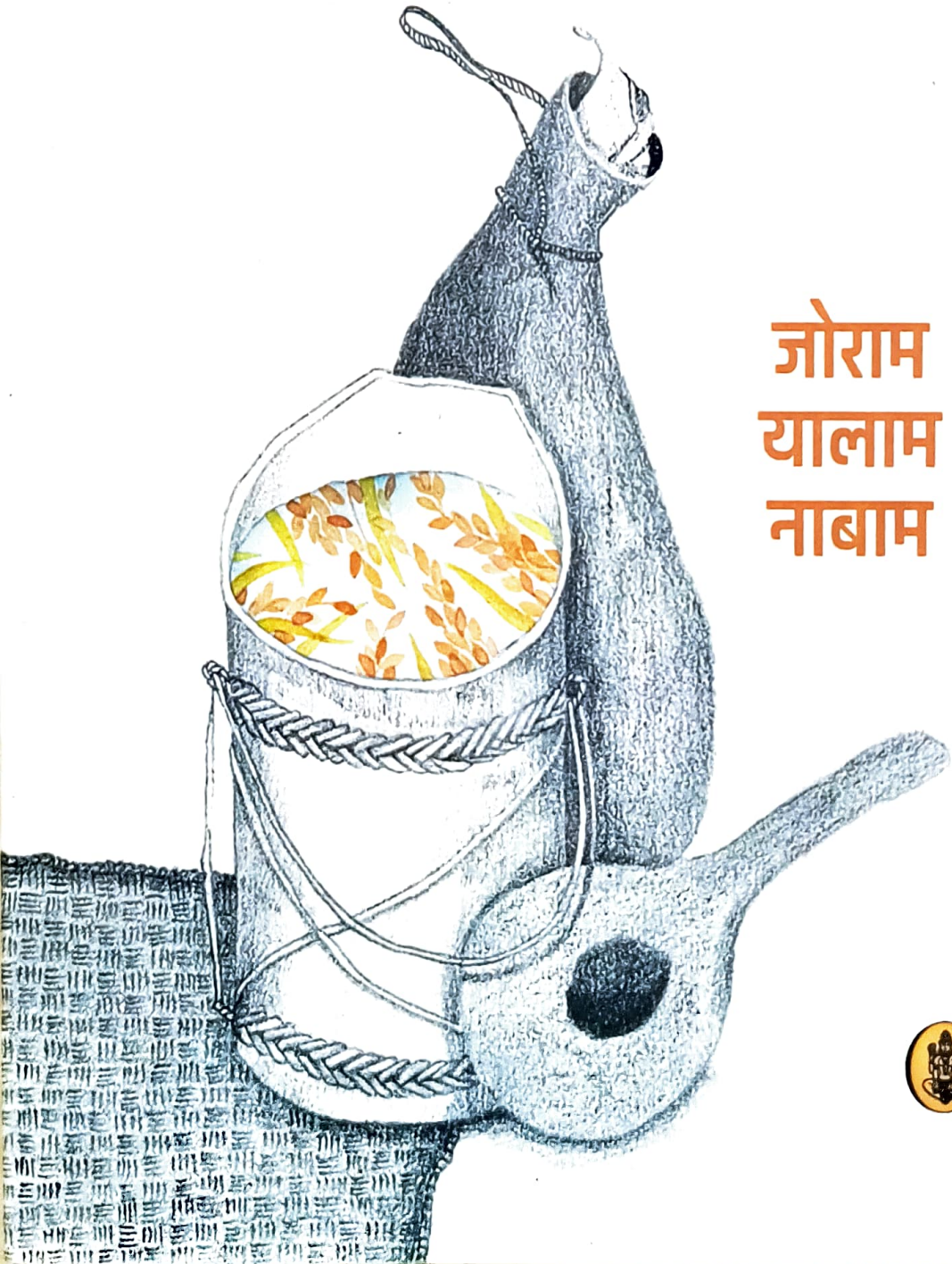
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## The Changing Context of Women's Work in Rural India: A Study on Arunachal Pradesh

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# Chapter - 3

## The Mind-Body Connection: Understanding the Psychological and Physical Demands of Badminton

Lakshyajit Gogoi, Dr. Anil Mili, Dr. Saon Sanyal Bhowmik, Dr. Poli Borah,  
Karuppasamy Govindasamy and Dr. Hemantajit Gogoi

### Abstract

The mind-body connection is a critical component of performance in badminton, as the interplay between psychological and physical factors can significantly impact a player's success on the court. This chapter provides a comprehensive overview of badminton players' physical and mental demands, highlighting the importance of developing a solid mind-body connection. The physical requirements of badminton, including aerobic and anaerobic fitness, agility, speed, and strength, are discussed, along with the importance of physical training and specific exercises and drills. The mental skills required for success in badminton, such as focus, concentration, resilience and motivation, are also explored, focusing on the benefits of mental training techniques such as visualization, positive self-talk, and goal setting. Finally, the relationship between psychological and physical factors in badminton performance is examined, along with practical tips for integrating mental and physical training, such as goal setting and mindfulness techniques. Additionally, guidance is provided on building a personalized training program that includes both physical and mental components. The benefits of working with a coach or mental skills trainer to enhance the mind-body connection are also discussed. The chapter also highlights the importance of the mind-body connection in badminton and how developing both physical and mental skills can lead to improved performance and greater enjoyment of the sport.

**Keywords:** Mind-body connection, psychological demands, physical demands, physical training, mental skills, mental training, visualization, positive self-talk, goal setting, stress management and mindfulness techniques

### 1. Introduction

The mind-body connection refers to the close relationship between mental and physical aspects of human performance. The mind-body connection is



critical for success in badminton since the sport requires physical as well as mental skills (Straw, 2021). On the physical side, badminton is a demanding sport that requires a combination of aerobic and anaerobic fitness, agility, speed, and strength. Players must move quickly and efficiently around the court, make explosive movements to hit the shuttlecock, and maintain their energy levels throughout a match. To achieve this level of physical ability, badminton players must engage in regular training and conditioning. On the mental side, badminton players must possess various psychological skills to perform at their best (Wilkie, 2016). These include focus, concentration, resilience, and motivation. A player must stay focused on the game, even when faced with distractions or setbacks. They must be able to bounce back from mistakes and setbacks quickly and maintain their motivation and confidence throughout the match.

The mental and physical aspects of sports performance are closely interrelated (Fossati *et al.*, 2021). For example, a player's level of physical fitness can influence their mental state and vice versa. A player may struggle to maintain their focus or motivation if they are physically tired or injured. Similarly, if a player feels anxious or stressed, this can affect their physical performance by increasing tension and reducing coordination. To perform at their best, badminton players must develop a strong mind-body connection that seamlessly integrates their physical and mental skills (Ma, 2022). This means engaging in regular physical and conditioning and mental training to develop skills like visualization, positive self-talk, and goal setting. By doing so, players can improve their performance, reduce the risk of injury, and enjoy greater success on the court.

The chapter is designed to provide a comprehensive overview of the physical and psychological demands of badminton sport and how these factors are interconnected. In addition, the chapter explores the importance of the mind-body connection in badminton performance and provides strategies for developing this connection to enhance both physical and mental skills.

## **2. The physical demands of badminton**

Badminton is a highly demanding sport that requires a combination of physical and mental skills. In order to perform at a high level, players must possess a range of physical attributes, including aerobic and anaerobic fitness, agility, speed, and strength (Charee *et al.*, 2022). Aerobic fitness is the ability to perform sustained physical activity over an extended period of time, such as during a long match. In badminton, players must be able to maintain a high level of activity throughout a match, including running, jumping and lunging.

This requires good cardiovascular fitness, which can be developed through activities such as running, cycling and swimming. On the other hand, anaerobic fitness refers to the ability to perform short bursts of intense physical activity. Badminton players must be able to move quickly and explosively in short bursts, such as when lunging for a shot or jumping to smash the shuttlecock. This requires good anaerobic fitness, which can be developed through activities such as sprinting, plyometric exercises, and high-intensity interval training. Agility refers to the ability to change direction quickly and effectively, which is essential for moving around the court and reaching for shots. Agility can be developed through exercises such as cone drills, ladder drills, and shuttle runs. Speed is another critical factor for successful badminton players, as players must be able to move quickly and cover the court effectively. This includes both straight-line speed and lateral speed, which are important for moving around the court and reaching for shots. Speed can be developed through exercises such as sprint training, plyometric exercises, and agility drills. While speed is a major critical factor, strength is another important physical requirement for successful badminton players. This includes both upper-body and lower-body strength, which are important for generating power in shots and movements. Strength can be developed through exercises such as weight training, bodyweight exercises, and plyometric exercises. Ultimately, the physical requirements of badminton are extensive and require a combination of aerobic and anaerobic fitness, agility, speed, and strength. By developing these physical attributes through training, badminton players can improve their performance on the court and reduce the risk of injury.

### **3. The psychological demands of badminton**

While physical training is essential for badminton performance, mental skills are equally important. Successful badminton players must possess a range of mental skills, including focus, concentration, resilience and motivation (Baştuğ *et al.*, 2017). Focus refers to the ability to direct one's attention and concentration towards the task at hand. In reference to badminton, this means being fully present on the court and focused on the game. Players must be able to block out distractions and maintain their focus throughout the match, especially during high-pressure situations. Concentration is similar to focus, but it involves the ability to sustain one's attention over an extended period of time. This means maintaining a high concentration level throughout the match, even during long rallies or difficult points. Resilience is the ability to bounce back from setbacks and overcome adversity. It indicates the ability to recover quickly from mistakes or losses

and maintain a positive attitude throughout the match. Motivation is also critical for badminton performance, as it provides the drive and determination necessary to succeed. Players must be motivated to work hard in training, push themselves to their limits and strive for improvement on the court. To develop these mental skills, badminton players can engage in a range of techniques and strategies, including visualization, goal-setting, mindfulness and positive self-talk. Visualization involves mentally rehearsing successful performances, while goal-setting helps players stay focused and motivated towards achieving specific objectives. Mindfulness involves being fully present at the moment and accepting one's thoughts and emotions without judgment. This can help players stay focused and centred on the court, even during high-pressure situations. Positive self-talk involves using positive affirmations and statements to maintain a positive mindset and boost confidence. The mental skills required for successful badminton performance are just as important as physical skills. By developing focus, concentration, resilience, and motivation, players can improve their mental toughness and perform at their best on the court.

#### **4. The mind-body connection in badminton**

The relationship between psychological and physical factors in badminton performance is complex and interdependent. While physical factors such as speed, strength and endurance are essential for success on the court, psychological factors such as focus, motivation, and resilience are equally important. Physical factors contribute to the overall fitness level of the player, which is important for sustaining performance throughout the game. Aerobic fitness is required for long rallies and extended games, while anaerobic fitness is essential for quick bursts of energy during rallies. Strength training helps players generate more power in their shots, while agility training helps improve footwork and quick movements on the court. However, physical factors alone do not guarantee success in badminton. The psychological factors of a player, such as their focus, motivation, and resilience, are also critical. Focus and concentration allow players to stay present at the moment and react quickly to shots. Motivation provides the drive and determination to train hard and strive for improvement, while resilience enables players to recover quickly from mistakes and setbacks. The interdependence between physical and psychological factors in badminton performance is also evident in the impact of fatigue and stress on both physical and psychological aspects of performance. Physical fatigue can lead to decreased speed, strength and endurance, while mental fatigue can lead to reduced focus, motivation and resilience. Stress can also have a negative

impact on both physical and psychological performance, leading to muscle tension, decreased reaction time, and increased anxiety. The relationship between psychological and physical factors in badminton performance is complex and interdependent. Both physical and psychological factors are essential for success on the court, and players must strive to develop and maintain both aspects of their performance in order to perform at their best.

Stress and anxiety are common experiences for badminton players and can significantly impact performance (Cabello-Manrique *et al.*, 2022). Stress and anxiety can affect physical and psychological performance aspects, including muscle tension, decreased reaction time and reduced focus and concentration. However, mental training can help manage these factors and improve performance. Mental skills and physical performance are interdependent and mutually reinforcing in badminton (Bebetsos & Antoniou, 2003). Mental skills such as visualization and positive self-talk can enhance physical performance. Players can improvise their technique and reduce errors by visualizing themselves executing shots with precision and accuracy. Positive self-talk can improve confidence and motivation, leading to improved physical performance. On the other hand, physical performance can enhance mental skills such as focus and concentration. When players are in good physical shape, they can stay focused and concentrate on the game, improving mental performance. Mental skills such as resilience and motivation can improve physical endurance. When players are mentally tough, they are better able to push through physical fatigue and maintain their performance level for longer periods of time. Physical performance can also improve mental resilience. When players push themselves physically, they develop mental toughness and the ability to overcome obstacles and setbacks on the court. Mental skills such as relaxation techniques can improve recovery after physical activity. By practising relaxation techniques such as deep breathing or meditation, players can reduce muscle tension and improve their ability to recover after matches. The relationship between mental skills and physical performance is complex and interdependent. The development of mental skills can enhance physical performance, and physical performance can improve mental skills. By focusing on both aspects of their performance, players can improve their overall performance and achieve greater success on the court.

## **5. Strategies for developing the mind-body connection in badminton**

Integrating mental and physical training in badminton can be challenging but essential for improving overall performance. It is necessary to set realistic and achievable goals for both physical and mental training. Players can use the SMART criteria (specific, measurable, achievable, relevant, and time-

bound) while setting their goals (Boogaard, 2021). For example, players can set a goal to improve agility by completing a certain number of ladder drills in a specific amount of time and keep track of their progress toward goals by self-monitoring. They can record physical and mental training sessions in a journal and note the accomplishments, challenges, and areas for improvement. Finally, use this information to adjust the training plan as needed. Incorporating mindfulness techniques into the training routine can help to manage stress and anxiety. Techniques such as deep breathing, visualization, and progressive muscle relaxation can help to stay calm and focused during matches. Mental rehearsal techniques to visualize game situations can help to build confidence and improve overall performance. It is necessary to replace negative thoughts with positive and empowering statements to help to stay motivated and focused. The importance of recovery strategies for physical and mental training should not be forgotten. Rest days should be incorporated into the training plan as relaxation techniques to help the body and mind recover.

Working with a coach or mental skills trainer can be incredibly beneficial for enhancing the mind-body connection in badminton. A coach or mental skills trainer has expertise in the physical and mental aspects of badminton. They can provide guidance on proper technique and form for physical training and offer strategies for improving mental skills such as focus, concentration, and resilience. In addition, a coach or mental skills trainer can provide individualized training tailored to the specific needs and goals. They can help to identify areas for improvement and develop a training plan that meets the unique needs according to the individual. Working with a coach or mental skills trainer can provide motivation and accountability. They can help to stay on track with the suitable training program and offer encouragement and support along the way. A coach or mental skills trainer can provide feedback and evaluation of the player's performance. They can help to identify strengths and areas for improvement and offer guidance on how to make adjustments to the training program. A mental skills trainer can provide support for managing stress, anxiety, and other mental health issues that may impact performance. They can offer techniques for managing emotions and building resilience to help to perform best under extreme pressure conditions. Working with a coach or mental skills trainer can give a competitive advantage to badminton players by improving their physical and mental skills and helping them to perform better and achieve their goals.

## **6. Conclusion**

The mind-body connection is a critical component of performance in badminton. The mind and body are interconnected, and the performance of

one can impact the other. This means that psychological factors such as focus, concentration, and motivation can affect physical performance and physical fitness can influence mental toughness and resilience. The importance of the mind-body connection in badminton is reflected in the nature of the sport itself. Badminton requires players to engage in fast-paced, high-intensity physical activity while maintaining mental focus and attention. Players need to be able to respond quickly to the movements of their opponents and make rapid decisions, all while remaining focused and alert. A strong mind-body connection can lead to improved performance in badminton. By developing the mental and physical skills necessary for success, players can enhance their overall performance on the court. For example, improving mental skills such as focus and concentration can help players make better decisions and react more quickly to their opponent's movements. Similarly, developing physical fitness and strength can improve endurance and reduce the risk of injury. In addition to improving performance, the mind-body connection can also lead to greater enjoyment of the sport. When players are able to achieve a state of flow, where they are fully engaged and immersed in the game, they are likely to experience greater enjoyment and satisfaction with their performance. It is essential to success in badminton, both in terms of physical performance and mental toughness. By recognizing the importance of this connection and working to develop both physical and mental skills, players can improve their performance and find greater enjoyment in the sport.

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# **Dynamism of Democratic Development**

*Contemporary Concerns and Gandhian Roadmap*

**EDITORS**

**Ravi Ranjan Kumar • Monika Sharma • Shriprakash Pal**





## CHAPTER - 3

# The Viewspaper: Gandhian Perspective on Indispensability of Dissent and Press Freedom

Shriprakash Pal\*  
Ravi Ranjan Kumar†  
Monika Sharma‡

### *Abstract*

*The sole aim of journalism should be service. The newspaper is a great power, but just as an unchained torrent of water submerges whole countryside and devastates crops, even so an uncontrolled pen serves but to destroy. "If the control is from without, it proves more poisonous than want of control. It can be profitable only when exercised from within." It is doubtful if this philosophy of journalism will be fully acceptable to press barons of today. The superficiality, the one-sidedness, the inaccuracy and often even dishonesty that have crept into modern journalism, continuously mislead honest men who want to see nothing but justice done. In principle, they may accept that freedom of the press is basically freedom of speech and expression for the citizens. In practice, they look upon freedom solely as their freedom to publish anything they want.*

**Keywords:** Gandhian Perspective on Indispensability, Press Freedom, Views paper.

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# Universal Happiness through Enabling Ecosystem

**Evidence Based Perspectives**

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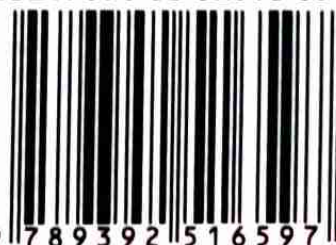


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# Apatani

CHANGE AND CONTINUITY



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# **APATANI**

## **Change and Continuity**

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# **Myoko: Embracing Social and Cultural Change in the Apatani Community**

**Dr. Padi Hana**

## **Introduction:**

The Apatani community is an indigenous community residing in the Ziro Valley of Arunachal Pradesh. The Myoko celebration holds great importance for the Apatani people. It is a vibrant festival that blends religious, cultural, and social elements, showcasing the community's unique traditions. The Apatani community of the Ziro in Arunachal Pradesh celebrates the lengthy festival known as Myoko. A community's identity and ideals are vividly reflected in its cultural festivities. They offer a venue for upholding customs, promoting social harmony, and appreciating the beauty of cultural diversity. One of the key components of the Apatani community's socioreligious festival is Myoko. The celebration is designed to strengthen the bond between humans and deities (Kaning, 2008, 169). Myoko is a holiday celebrated by the community, the village, and the clan. Three groups—Hari-Bulla, Niichi-Niit, and Hangu village—celebrate Myoko Day in a cyclical pattern each year.

Myoko is a social institution. The every aspects and parts of the Myoko ritual and ceremony has a procedures which is generally accepted and followed by the community. Myoko celebration is sanctified and sacred. Myoko festival has got several distinct components for socio-religious activities. The basic structure of Myoko celebration remains the same in today's time but there are few traditional practices that are modified by the community bodies and changes occur at the individual level. This paper shall be looking at the social and cultural changes taking place at the general and family level during the time of celebration.

There should be a proper distinction between cultural and social change to understand the changing aspects in the society. There is common understanding among the layman about the meaning of cultural and social change and they used it interchangeably in their social situation.

# What's in a name? Contextualising naming patterns amongst the Apatani

Nani Umie

## Introduction

It is widely accepted that, in all societies, personal naming practices and culture are intertwined. Given that culture is not static, but dynamic and ever-changing, personal names have undergone a major transformation due to socio-cultural and political factors. As societies diversify, the naming patterns can be examined in the context of cultural identifications and acculturation strategies used by individuals exposed to other cultures. Much as names are considered personal choices yet the names chosen are a reflection of the consequent cultural amalgamation. A review of the literature shows that researchers have tended to be more concerned with the outcomes of having particular names, rather than the process through which these names are chosen. Thus, the process through which these names are chosen is an important aspect to be examined especially in the light of society and culture that is in transition. It is in this light and context that the paper seeks to examine the predictors of baby-naming choices. After all, a name is not just a name, it is an expression of who we are and an important reflection of how we define ourselves. As such, it may be considered an extension of the individual and the society and culture to which one belongs.

## Context

The Apatani narratives begin north of the Himalayas and recount an ancient migration path defined by a series of locations. Migration is traced through a succession of halting locations, each of which symbolizes the occurrence of a significant event: the performance of an important rite, a natural calamity, or the surmounting of a challenge, according to Apatani traditions (Blackburn, 2003, p. 26-27-28). The tribe is predominantly divided into seven major villages. Further, these villages are categorized into three groups. Hong as constituting