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THE DECLINING FISH DIVERSITY IN URBAN MARKETS: A CASE STUDY OF WARD NO: 003, KOLKATA MUNICIPAL CORPORATION

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ABSTRACT

The study has been undertaken to determine the declining fish diversity in urban markets and the consumption pattern of available fishes in different markets of a selected area of Ward No.: 003 under Kolkata Municipal Corporation and its surrounding areas. In the present study attempt has been made to identify the controlling factors that influence the choice of consumers in purchasing fishes in the local fish markets under the studyarea. In this study a total of 36 types of fishspecies were found in different fish markets. The selected area was a place of livelihood of middle-income class people and they are inextricably bound up with a cultural and dietary preference for fish. It has been observed that the dominance of freshwater fishes on sale compared to other forms of high-quality foods (e.g. meat or chicken) is extreme in the markets of Kolkata under study. In this study, it was also observed through interviews among the seller and buyer of fishes that both consumption and availability of fishes had gone through various characteristic changes. Consumers are fond of fishes having moderate price and good quality but they were still in search of various fishes, which were not available in today's market. Various factors were identified for such declining nature of fish diversity. The major factor is selective aquaculture in fish farms situated in the East Kolkata Wetland area.

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Keywords: Urban fish market, fish diversity, freshwater, aquaculture, consumer preference, Indigenous species, Exotic species

Introduction

Biodiversity signifies to the variety of life on Earth at all its levels, from genes to ecosystems, and can encompass the evolutionary, ecological, and cultural processes that sustain life. Biodiversity, also called biological diversity, is the variety of life found in a place on Earth or, often, the total variety of life on Earth. Biodiversity is decreasing day by day. If it does not stop then our earth could no longer be a place to live in. Therefore, different measures help in increasing the biodiversity of the earth. A common measure of this variety, called species richness, is the count of species in an area. Biodiversity is the most complex feature of our planet and it is the most vital. It deals with nature's variety, the biosphere. It refers to variability among plants, animals and microorganism species. The term 'Biodiversity' includes the number of different organisms and their relative frequencies in an ecosystem. It also reflects the organization of organisms at different levels. Therefore, it is very important to have a good knowledge of biodiversity for a sustainable livelihood.

Biodiversity is extremely important to maintain the ecological system. Most Noteworthy many species of plants and animals are dependent on each other. There are the three different stages of biodiversity that we can identify viz. Species diversity refers to the variety of different types of species found in a particular area. It is the biodiversity at the most basic level. Genetic diversity refers to the variations among the genetic resources of the organisms. Every individual of a particular species differs from each other in their genetic constitution. Ecological diversity is an ecosystem is a collection of living and non-living organisms and their interaction with each other.

In-situ conservation is the methods of conserving all the living species, especially the wild and endangered species in their natural habitats and environment. In-situ conservation of Biodiversity includes biosphere reserves, national parks, wildlife sanctuaries, etc. On the other hand, ex-situ conservation is the methods of conserving all the living species in the artful habitats that reflect their natural living habitats. Examples of ex-situ conservation of biodiversity include aquariums, botanical gardens, cryopreservation, DNA banks, Zoos, etc.

India is considered a mega-diversity hotspot due to the great diversity of organisms found here, ranging from Eastern to Western Ghats

mountain areas and also from northern and southern India as well. India is known for its rich heritage of biological diversity, having already documented more than 91,000 species of animals and 45,500 species of plants in its 10 bio-geographical regions. To be a mega diverse country it needs to have 5000 vascular plants species as endemic to the country.

Fish diversity is an integral part of an aquatic ecosystem. Most of the higher vertebrates residing in an aquatic environment are dependent on fishes for their food. The fish diversity of any regime has great significance in assessment of that zone reference to environment and pollution, as well as it contributes to the necessary information for fisheries.

Fish species diversity is roughly divided equally between marine (oceanic) and freshwater ecosystems. Coral reefs in the Indo-Pacific constitute the centre of diversity for marine fishes, whereas continental freshwater fishes are most diverse in large river basins of tropical rainforests, especially the Amazon, Congo, and Mekong basins. More than 5,600 fish species inhabit Neotropical freshwaters alone, such that the Neotropical fishes represent about 10% of all vertebrate species on the Earth. Fish diversity is the measurement of different fish species inhabiting a certain spatial region, and represents a further important indicator in determining reef health. The greater is the fish diversity, the healthier and more resilient the reef.

India is an exceptional hotspot of freshwater fish diversity with a high degree of endemism contributing to the World's biological resources. Fish known from the fresh and marine waters of India comprise 3231 valid species constituting 9.7 percent of the total number of about 33,059 species of fish known from the world, of which the marine fish diversity alone accounts for 7.4 percent.

There are 2546 species so far listed 273 (3.32%) belong to the cold freshwater regime, 544 (24.73%) to the warm fresh waters domain, 143 (6.50%) to the brackish waters and 1440 (65.45%) to the marine ecosystem. The endemic fish families form 2.21 per cent of the total bony fish families of the Indian region. 223 endemic fish species are found in

India, representing 8.75 per cent of the total fish species known from the Indian region.

All over India, freshwater fish diversity is on a decline. Many of them have been lost forever Few studies have been carried out so far regarding this aspect. They mainly identified three major forces driving extinction which are; over –harvesting, competition by newly introduced exotic fishes and pollution.

West Bengal is the only state of India that extends from the Himalaya to the Bay of Bengal. A large portion of the state occupies the transitional zones between the Himalayas in the north and the Chhotanagpur plateau in the west to the plains of the Ganga-Brahmaputra delta in the southern and eastern sections. West Bengal is enriched with 6.08 lakh hector of freshwater fisheries resources in the form of Ponds and Tanks (2.88 lakh hector), Beels and Boar (0.41 lakh hactor), Reservoirs (0.27 lakh hector), 22 river drainage basins (1.72 lakh hector) and Canals (0.80 lakh hector). Basins of river Ganga (81% of area), river Brahmaputra (12%), river Subarnarekha (4%) and two small coastal rivers (3%) provide an important domain for freshwater fish biodiversity in West Bengal. Various studies on fish diversities in West Bengal revealed 267 species of freshwater fishes (including 186 primary freshwater species, 70 species were freshwater cum brackish water and 11 species were freshwater cum brackish water cum marine habitats).

India is the third largest fish producing country and the second largest aquaculture fish producer in the world. India contributes about 7% to the global fish production. India has more than 10% of the global fish biodiversity and is one of the 17-mega biodiversity rich countries. Around 14 million people are engaged in fisheries and its allied activities. Andhra Pradesh is the largest fish producer in the country followed by West Bengal and Gujarat. The total fish production during 2017-18 is estimated to be 12.60 million metric tons, of which nearly 70% is from inland sector and about 50% of the total production is from culture fisheries. More than 50 different types of fish and shellfish products are being exported to 75 countries around the world. Fish and fish products have presently emerged as the largest group in agricultural exports from

India, with 13.77 lakh tons in terms of quantity and Rs. 45,106.89 crore in value.

In India, two types of aquaculture are practiced, viz. fresh water aquaculture and brackish water aquaculture. Freshwater aquaculture involves the breeding of freshwater fish like carp, Catla, Rohu, Magur, freshwater prawn etc. However, Rohu, Catla and Mrigal, which are called Indian major carps, make up nearly 90% of India's freshwater aquaculture, according to one estimate. Shrimp, especially white leg shrimp, is popular in brackish-water aquaculture, which forms just 5% of aquaculture in the country.

Although, the state has registered a high growth in fish production, the supply in countryside is shrinking due to deceleration in area arising out of situations like rural rivalry, litigation, theft, breaking of joint family etc. The traditional system of fish production has failed to meet the growing demand, resulting excessive dependence on commercially managed, organized fish production units, locally known as 'bheries' and on the supply from other fish producing States. The production as well demand for fish in West Bengal is the highest in the country. The domestic demand for fish in West Bengal is high because almost all the people of West Bengal consume fishes.

Various wetlands, river Ganges and local fish ponds etc located on the periurban interface of Kolkata City have been under continuous pressures of conversion for settlements and agriculture. These wetlands, which are famous for fishery activities, receive pollutants like heavy metal, oil, grease etc. through effluent of different industries like tannery, electroplating, plastic, dye industries of surroundings, and alter the ecosystem. The rich fish germplasm resources of East Kolkata wetlands have been suffering from various potential anthropogenic stress leading to not only reduced abundance but even touching the genetic threshold. Awareness campaign amongst the fishers, strict ban on illegal monsoon fishing, uncontrolled introduction of exotic fishes, repeated drying of maturation pond and usage of proper mesh size nets should be involved. Besides, the protection of breeding grounds from agricultural run-offs and indiscriminate fishing of commercially important fish species should

be established which would ultimately protect and conserve the endangered species.

Literature Review

India is the second largest in aqua-cultural production in the world. Fish production has increased from 41.57 lakh in 1991-92 to 82.90 lakh tons in 2010-11. As per the website of Department of Fisheries, Government of India, this country is the 2nd largest aquaculture nation in the world after China. The study of Sarkar, Pathak, Sinha, Sivakukar et al, (2012) describes the river Ganges as the major contributor of current distribution and abundance of freshwater fishes as assessed from April 2007 to February 2009. It was documented and described 143 freshwater fish species in the all stretches of the river which is higher than what was reported earlier.Bhakta, J. N., and Bandyopadhyay, P. K (2008) showed that about 10 fish species were ornamental, whereas left over 35 species were food fish and both groups of fishes have potent commercial value. Of the 45 recorded fish species, 7 were belonging to exotic fish and remaining fish species were indigenous group. They concluded with the lack of policies of the Government, such as, identification and listing of threatened and endangered fish species of freshwater body, determination of population size and distribution, find out the breeding behavior of threatened fish species which is essential for conservation of the species.Dudgeon et al. 2005; Arthington and Welcomme 1995; Arthington et al. 2004; De Silva and Abery 2007 conducted survey on riverine ecosystem of India which has suffered from intense human intervention resulting in habitat loss and degradation and as a consequence many fresh water fish species have become heavily endangered, particular in Ganges basin where heavy demand is placed on fresh water. S Bhattacharya, 2019 has been observed that the freshwater fisheries based on their Seasonality of breeding, migration, etc for breeding species including pattern of livelihoods by people based on fishing and various factors responsible for negative impacts on the fish populations, like pollutions, overcrowding by fast moving boats, use of harmful fishing techniques (e.g. use of gill nets, use of fine mesh sieve for catching prawn

seeds, etc.). Kiran, Vasantha and Vijaylakshmi (2015) pointed out that the life styles of people have undergone drastic changes which have brought about major impact on dietary pattern of people. They also highlighted that life style changes and taste buds backed by the urban culture have a strong impact on the consumption pattern.T P Bhutia, N W Qureshi and V K Yadav (2019) have studied that most of the fish tend to be sold whole, live or iced. Retailers may specialize in one specific type of aquatic product or sell a variety and the consumption habits of the buyers are very much dependent of the taste, quality, freshness, availability of varieties, age, income capacity etc. Kundu, Mukherjee et al.,(2002) found that customers in Kolkata markets tended to consume fish on a daily basis, whereas meat of all types is much less frequently consumed; fish were eaten on more than 5 occasions a week compared to less than once for all meat. Consumers tended to consume fish more frequently than poorer people, although even the poorest group consumed fish more than 4 times per week on average.

Objectives

1. To determine the current pattern of abundance of freshwater fish in local market based on the total sales;
2. To find out factors controlling the habits of fish consumption by the consumers in local market based on the availability of fishes ;
3. To find out the declining trend of various types of freshwater fishes since last 5 years;

Methodology

The Study area was the local markets of Ward no. 003 of Kolkata Municipal Corporation (KMC) and its adjacent markets.

The primary data was collected through face-to-faceinterviews and direct conversations amongst a total of 109 fish consumers and fish sellers who have been randomly selected andhave been willing to participate in the study. The secondary data from different publications and the data sources have also been used to understand the change in distribution, availability pattern of fishes, sales volume etc. in the surrounding freshwater lakes and Ganges. Dataand information collected

from secondary sources had been used to find out the following results:

a. Total sales of available fishes for the period of Dec 21-Jan 22.
b. Declining fish availability during last five years
c. Factors controlling the consumption and as well as purchase habits of fishes available for the period of Dec 21-Feb 22 as noted below:

- Quality of fish and reason for its changes, improving or deteriorating
- Variety of fish and variation in prices of fish
- Taste of fish and Hygiene of the fish market
- Convenience to visit market and Freshness of fish as available
- Good relationship with retailers
- Probable reasons for changes in fish variety such as market oriented aquaculture, awareness of fisheries on fish diversity etc.

The average monthly sales of the available types of 36 numbers of fishes have been calculated using the arithmetical average formula.

The data on the amount of available 36 types of fishes, both 5 years back and in recent times, have been collected through the interview from both the buyers and sellers and comparison has been done to show the decline availabilities since last five years.

Out of the primary data received from 109 buyers and consumers, the percentage calculation of factors of consumer habits including price of fish, taste and variety of fish, hygienic condition of the fish market, lack of fish variety of types of fishes and lack of well-maintained market place etc. has been derived.

Results And Discussions:

1. The study has been done during the 'third-wave' of COVID outbreak in Kolkata and its surroundings. The urban markets selected for the study were not operational and buyers have not visited markets frequently.
2. The primary data collected from both the buyers and sellers of those markets under study on face-to-face interviews, the

following list of average sales of common fishes in 36 numbers found in the markets available under study during Dec 21-Feb 22:

Sl No	Local Names of Fish species Available	Average Sales During Dec 21- Feb 22 in Kg
1.	Catla	50.29
2.	Rui	49.63
3.	Bhola Bhetki	48.97
4.	Mrigel	47.64
5.	Pomphret	47.64
6.	Bata	46.98
7.	Khoira	46.98
8.	Kalbose	46.32
9.	Tilapia	46.32
10.	Parshe	46.32
11.	Aar	46.32
12.	Boal	46.32
13.	Bele	46.32
14.	Bhangan	45.66
15.	Bhetki	45.53
16.	Lotey	43.01
17.	Kajoli	43.01
18.	Pholui	43.01
19.	Topshe	41.69
20.	Gurjali	40.36
21.	Tangra	39.70
22.	Mourola	39.70
23.	Punti	38.38
24.	Sol	38.38
25.	Sarpunti	37.06
26.	Chandana Ilish	37.06
27.	Silver Carp	36.39
28.	Magur	36.39
29.	Phesa	36.39
30.	Pabda	35.73
31.	Chital	33.09
32.	Desi Koi	32.42
33.	Bhola	29.78
34.	Ilish	29.78
35.	Singi	23.16
36.	Desi Magur	19.85

Table -1: Sales data of available freshwater fishes (in Kg)

From Table-1 above, it has been found that the major portion of total sales is occupied by the "Catla" fish and the overall sales of available fishes are as graphed below:
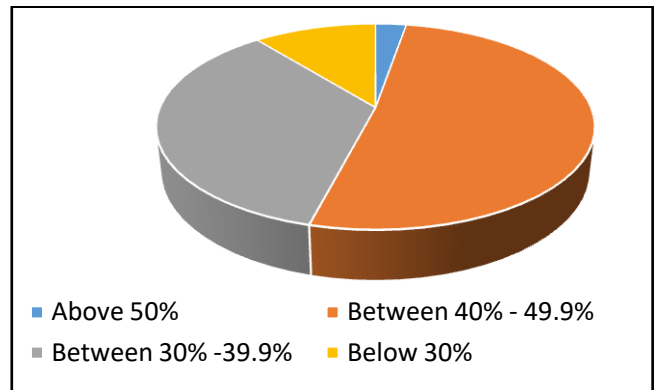
Figure-1: Percentage of sales during Dec 21-Feb22

3. The following secondary data (Table-2) has been collected from "HANDBOOK ON FISHERIES STATISTICS 2020; Department of Fisheries, Ministry of Fisheries, Animal Husbandry & Dairying Government of India, New Delhi", which shows a progressive growth in freshwater fish production in West Bengal during 2015-2020

2015-16	2016-17	2017-18	2018-19	2019-20
14.93	15.25	15.57	16.19	16.79

Table-2: Sales decline of fish availability between 2016 to 2021

4. The primary data as per the list below shows that few types of freshwater fishes as identified viz. Singi, Chital, Sarpunti, Desi Magur, Mourola, Punti, Desi Koi are declining with their abundance in local market since last 5 years.

Name of Fish	Average sales (in Kg) for 2016	Average sales (in Kg) for 2021
Singi	27	23
Mourola	37	35
Chital	35	33
Punti	34	32
Sarpunti	39	37
Desi Koi	39	32
Desi Magur	24	20

Table-3: Average Sales of available fishes between 2016 and 2021

5. Present market survey including the interview and interaction with fish sellers had strongly supported the above facts given in Table-2 above. Out of these fish

species the local fishes such as Singi,Desi magur, Desi Koi and Punti have been notified with nearly 15% decline during 2016 and 2021.

6. Primary data was collected based on the interviews and direct interactions with both the buyers and sellers in those markets under study to find the fish consumption habits and their inclination towards purchase of fishes based on the availability of fishes (Table-4).

Sr. No	Factors to determine fish consumption habits	Total responded out of 109 interviewers
1.	Improvement of Quality of fish	49
2.	Deterioration of Quality of fish	44
3.	Variety of fish	86
4.	Price of fish	85
5.	Taste of fish	83
6.	Hygiene of the fish market	104
7.	Convenience to visit market	77
8.	Freshness of fish	107
9.	Good relationship with retailers	75
10.	Aquaculture practice as one of the reasons for changes in fish variety	52
11.	Awareness of fisheries on changes in fish variety	41

Table-4: Factors on fish consumption habits of buyer during Dec-21 to Feb -22

7. The results showed that a part of buyers have found improvement of Fish Quality (45%) whereas another part of survey population have observed deterioration of Fish Quality (40%). Beside this, both the seller and consumer are found not aware of the change in aquaculture practice as a factor responsible for declining fish diversity and this group of respondents constitutes 48% of the total survey population. It is to note that38% of the interviewees have knowledge that awareness of fisheries is an important factor for change in fish variety.

Conclusions

It may be concluded from the present study that the declining fish variety in the local fish market is mainly due to the monopolistic aquaculture in wetlands and local fishponds. As a result, the local fish species are being gradually disappeared from the wetlands, which is very much detrimental to the stability of the aquatic ecosystem. It may happen that local fish species may be phased out due to the selective aquaculture in fisheries leading to loss of biodiversity. Moreover, the preference for fishes by consumers is reduced day by day because of low availability of different fishes in market. A significant outcome of the study is that the fish consumption habit of the buyer is altered by such variability in aquaculture as well as availability of fishes. Therefore, it is strongly suggested that the farming of exotic fish species should be controlled in the local fishponds and wetlands to protect indigenous fish diversity.

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IMPACT OF EASY-EFFECTIVE GREEN TECHNOLOGY COMPONENTS FOR SOCIO-ECONOMIC DEVELOPMENT OF RURAL COMMUNITY: A CASE STUDY OF A BIO-VILLAGE IN TRIPURA

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ABSTRACT

*The State Government of Tripura had taken up a scheme on Establishment of Bio-village in various rural & semi urban areas of Tripura for addressing the growing concern about the adverse effects of application of chemicals in the agriculture practices and to restore the environment for sustainable production that encourages the introduction of organic inputs in a comprehensive but sustainable way. The state Govt. with appropriate technique and capacity building program had distributed various Green Technology supportive components viz. Solar water pump, Bio-gas unit, Biomass cook stove, Solar RO water purifier, Energy saving electrical gadget kit (ceiling fan, tube lights & LED bulbs) as **Renewable energy & energy saving components** and Biotech kit (Knapsack sprayer, bio-fertilizer-fungicide-pesticide etc.), Mushroom cultivation unit (spawn, pp-nylon bag etc.), Bee keeping unit (including bee colony), Fruit plants, Fish fingerlings & fish feed, Chicks/ducklings with feed & essential medicine and Goatlings /piglets with feed & medicine as **Environment friendly livelihood security components** for addressing restoration of the environment & socio-economic development of that particular community. A case study was done to understand the impact of the concept & the components distributed among the beneficiaries of Bio-village in terms of environmental benefit & socio-economic development with a comprehensive survey.*

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Keywords: Bio-village, Tripura, Green technology, socio-economic development

Introduction

The concept of 'Bio-village, is an easy but effective technology has been framed out by the Govt. of Tripura with comprehensive pre project survey, accordingly distribution of two categories of components viz. **Renewable energy & energy saving components** and **Environment friendly livelihood security components** and followed by regular extensive field monitoring visits. Bio-village by its' origin does not mean organic village but it has an essence of step forward towards encouraging the organic practice in long run along with other many sustainable features. Bio-village concept has gained popularity in faster pace due to its practical utility in addressing the issues faced by the rural farmers across thenation. The concept has been implemented in the state for the first time with number of tangible and intangible challenges. However, it has learnt that the takeoff and landing of the concept was possible due to the adoption of eco-friendly technologies and enterprise development mostly based on biological resources by the Govt. of Tripura.

Bio-village is human-centered sustainable rural development that, on the one hand, harnesses the elements of evergreen revolution to achieve agricultural productivity in perpetuity without accompanying ecological and social harm, and eco-technologies driven eco-enterprises to create rural livelihoods, on the other. Eco-technologies are resultant of combining the best of the frontier technologies with the traditional technologies and ecological prudence. Hence, they have pro-nature, pro-poor, pro-women, and pro-employment orientation. Bio-villages adopt the principle of "do ecology," which involves conservation and enhancement of bio resources and creation of on-farm, off-farm, and nonfarm livelihoods for income generation to enhance access to food and nutrition security. Skill and knowledge empowerment are integral to bio-village paradigm for human resource development. By integrating ecology, equity, and bio economy, bio-villages lay the foundation for sustainable rural development. Thus, the bio-village paradigm has the potential to ensure bio happiness through bio economy in all the hamlets/villages of Tripura.

The State (Tripura) is predominantly Agriculture based with 70% of its population dependent upon agriculture. The average land holding is 0.47 ha and 90% of its farming community is small and marginal farmers. Considering the small land holding of the state

(0.47 ha.) the agricultural based as well as eco-friendly non-agricultural based approaches by different enterprises are required for sustainable development of rural communities. However, the compatibility of each enterprise with the other is required to be judged. The previous project experiences and outcome of the existing Bio-village projects shows a positive shift towards the sustainable development of rural communities.

The Govt. of Tripura through its' line departments has distributed various Green Technology supportive components during August, 2018 to July, 2020 viz. Solar water pump, Bio-gas unit, Biomass cook stove, Energy saving electrical gadget kit (5 star ceiling fan, tube lights & LED bulbs) as **Renewable energy & Energy Saving Components** and Biotech kit (Knapsack sprayer, bio-fertilizer, bio-pesticide, bio-fungicide & yellow sticky traps), Mushroom cultivation unit (spawn, pp-nylon bag, hand pump sprayer), Bee keeping unit (including bee colony) Various fruit plants, Fish fingerlings & fish feed, Chicks/ducklings with feed & essential medicine and Goatlings/Piglets with feed & essential medicines as **Environment Friendly Livelihood Security Components** for maintaining the ecological balance & Socio-economic development of that particular community. There are total 40 nos. of households in Brajendranagar hamlet and all those households were brought under the project in discussion with the prospective beneficiaries and local public representatives. Pre-project meeting with all beneficiaries were

held and the vision of the project was thoroughly discussed with them. After surveying land & credentials of the beneficiaries as per scope of that project the main 40 beneficiary list was finalized. A master plan and programme for capacity building were also designed before commencement of the project to keep the beneficiaries well informed & equipped with the use & outcome of the components of the project. A comprehensive survey work has been carried out within time frame of February, 2022 to April, 2022 at Brajendranagar Bio-Village under Pandavpur GP of Dukli RD Block, West Tripura District, Tripura to study development in terms of restoration of ecology & socio-economic betterment with the implementation of Bio-village.

Brajendranagar is a big hamlet in Sepahijala District. One part of Brajendranagar lies under Dukli Block (Pandavpur GP) and the rest part lies under Bishalgarh Block (Madhupur GP). The hamlet is mainly agrarian in nature & most of the inhabitants of the village are dependent on Agriculture and allied activities for their livelihood. Total 190 families are residing in the hamlet. The project was implemented at the part of Brajendranagar hamlet which comes under the Dukli RD Block.

The details baseline information of agriculture related aspect of **Brajendranagar** is mention below in the table-1 (Collected from local agricultural office and panchayat) followed by map of Dukli and Bishalgarh Block and baseline information of Pandabpur and Madhupur GP.

Table- 1: The details baseline information of agriculture related aspect of Brajendranagar

Sl. No.	Parameter	Part of Brajendranagar under Pandabpur GP	Part of Brajendranagar under Madhupur GP	Total of Brajendranagar
1	No. of house hold	80	110	190
2	Total Farmer	70	90	160
	Male	55	70	125
	Female	15	20	35
3	Land for Vegetable cultivation (in Kani)	10	50	60
4	Vegetable cultivator	50	50	100
5	Land for paddy cultivation (in hectare)	24	32	56
6	Paddy cultivator	70	80	150
7	Schedule Caste	15	10	25
8	Schedule Tribal	Nil	Nil	Nil

Table- 2: Geographical information of the study area

Study Area	Brajendranagar Bio-village (Brajendranagar hamlet), Pandavpur GP, Dukli RD Block, Sepahijala District, Tripura
Average Temperature during Day:	38°C (Summer) 21°C (Winter)
Average Temperature during Night:	31°C (Summer) 18°C (Winter)
Humidity:	Max 91% Min 57%
Rainfall:	High (Monsoon)
Latitude:	23°40'00''N
Longitude:	91°10'00''E
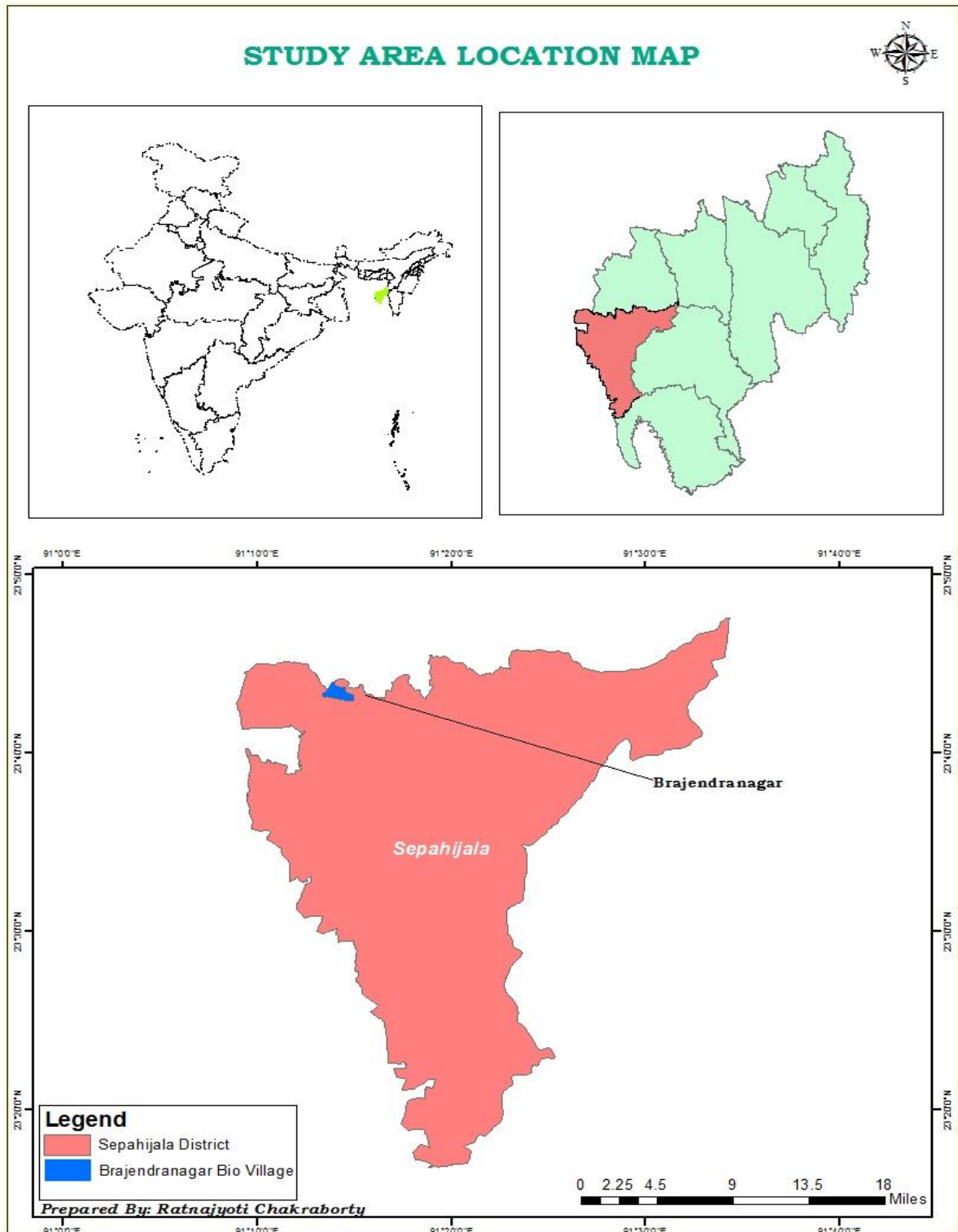
LOCATION MAP OF THE STUDY AREA

Literature Review

The concept of bio-village is not new now-a-days. It is in fact based on sustainable models mainly accepting the principle of mutual co-operation and participation aiming at welfare of the community. The farmer needs are diverse as it is involved with sustaining his livelihood security which may be a crop, animal enterprise or both. On a particular commodity level, it includes the system in totality right from initiation (of a particular enterprise) to final disposal/marketing of the same. Many of the concepts on sustainable models are in vogue in villages and in fact based on welfare or holistic development of a farmer or a farming community. And the farmers' active participation is a must (Mishra et al. 2012). The sustainable models again satisfy both the state/country's mandate and UN's 17-points Sustainability Development Goals (SDG).

Various activities orienting towards welfare of farming community are in force. Out of this sustainability of the bio-village is very important because it assists the farming community directly through raising their farm income/ employment and maintaining livelihood security for them. However, evaluation of sustainability of bio-village through farmers' participation in crops including pulse sis necessary to assess their progress so far and the objective to be realized (Ali and Gupta 2012). These programmes have already been carried out across the country as a whole and Uttar Pradesh in Particular (Singh etal. 2009-10).

Thus, these studies aiming at evaluation of sustainability of bio- village through farmers' participation are important because it helps to have appraisal for mid-term correction/ improvement required, if any besides plugging the loop holes to realize the objectives set forth (Ali and Kumar 2006). Keeping in view of its importance, this project was implemented at Brajendranagar Bio village, Sepahijala District of the Tripura State especially to find the impact of easy-effective green technology components for socio-economic development of rural community in Tripura.

Bio-village is human-centered sustainable rural development that, on the one hand, harnesses the elements of evergreen revolution to achieve agricultural productivity in perpetuity without accompanying ecological and social harm, and creates rural livelihood with the help of eco-enterprises utilising eco-friendly technologies, on the other. Eco- friendly technologies are resultant of combining the best of the frontier technologies with the traditional knowledge as well as techniques and ecological prudence. Hence, they have pro-nature, pro-poor, pro-women, and pro-employment orientation to achieve rural development. Biovillages adopt the principle of "do ecology," which involves conservation and enhancement of bioresources and creation of on-farm, off-farm, and nonfarm livelihoods for income generation to enhance access to food and nutrition security. Skill and knowledge empowerment are integral to biovillage paradigm for human resource development(P.C Kesavasan et al. Jan 2020).

No detail bio village related study has been carried out for the State of Tripura. However, few of the news channels reported that the bio-village projects aim to make a holistic development of socio-economy for a rural community with the application of eco-friendly technologies. The components included in the bio-village project are, distribution of energy-saving electronic gadget (LED bulb & fan), biotech kit, mushroom, beekeeping and biogas unit. The same has been implemented at Amtali village under Amtali RD Block. (Source: https://nenow.in/north-east-news/bio-village-projects-cards-tripura-government-signs-pact ongc.html.)

Objective of The Study

The main objectives of the study are as follows:

➢   To study the promotion of green technology for sustainable production of agricultural and allied sector

➢   To study the socio-economic condition of small and marginal farmers post application of simple biotechnological intervention and adding livelihood generation component.

➢   To study the strengthening of human resource development through skill and knowledge development.

➢   To understand the development of Entrepreneurship mindset & approach towards it amongst the beneficiaries

Methodology

- The present case study has been taken up to understand the impact of easy-effective Green Technology component for socio-economic development of Brajendranagar Bio-village.
- In discussion with the implementing department and followed by interaction with the beneficiaries, names of distributed components were identified
- To understand the aim & objectives of distributed components a sample questionnaire with prospective options have been prepared and approaches made to find out the answer
- Data recorded based on interaction with the: (i) Implementing Govt. department Officials (ii) Beneficiaries of Brajendranagar Bio-village
- Photographs were taken of components, beneficiaries & outcome results of Biovillage

Various Research Methodology used in the Project are:

(i)   Methods for Primary Data collection: Questionnaire/Personal Interview.

(ii)   Sources of Secondary Data: Internet/Journals.

Sample Design: Classified Data Sampling Method

1. Data Interpretations And Findings:

Table-3 and Figure-2 shows the Types of Farmers in the village under study.

Particulars	No. of Respondents	Percentage (%) of Respondents
Vegetable & Rice grower	24	60
Livestock farmer	10	25
Both	06	15
Total	*40*	*100*

Table-3: shows that among 40 nos. of beneficiaries (farmers) 24 nos. farmers are vegetable & rice grower, 10 nos. are livestock farmer and 6 nos. depend on both.
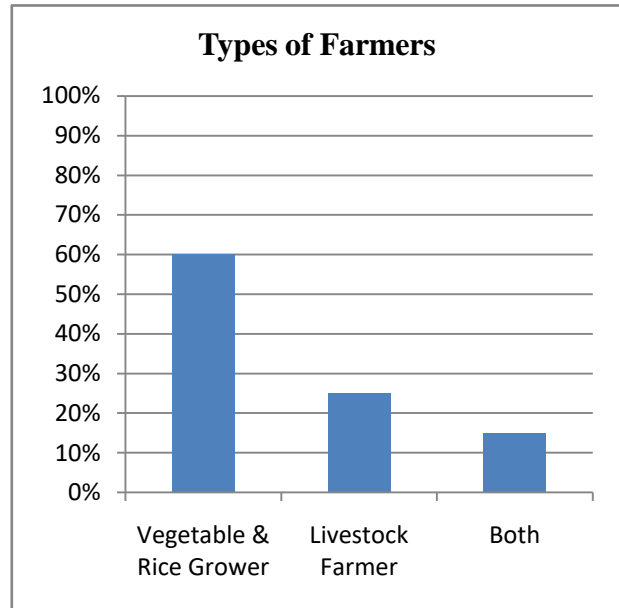
Figure-2: shows the percentage of classification of farmers based on their different livelihood choice. It is seen that 60% farmers are vegetable & rice grower, 25% are livestock farmer and 15% are depends on both.

Table-4 and Figure-3 shows the response of the farmers on question 'Do you have reduced using Chemical inputs on field with the introduction of Biotech Kit under Bio-village project?'

Particulars	No. of Respondents	Percentage (%) of Respondents
Yes	34	85
No	02	5
Preferred not to say	04	10
Total	*40*	*100*

Table-4: shows that among 40 nos. of beneficiaries (farmers) 34 nos. farmers had reduced using chemical inputs with the introduction of Biotech Kit. 2 of them did not reduce and 4 nos. farmers preferred not to disclose their opinion.

Response of the farmers on reducing chemical inputs

**Opinion about Yield status with introduction of Biotech kit**
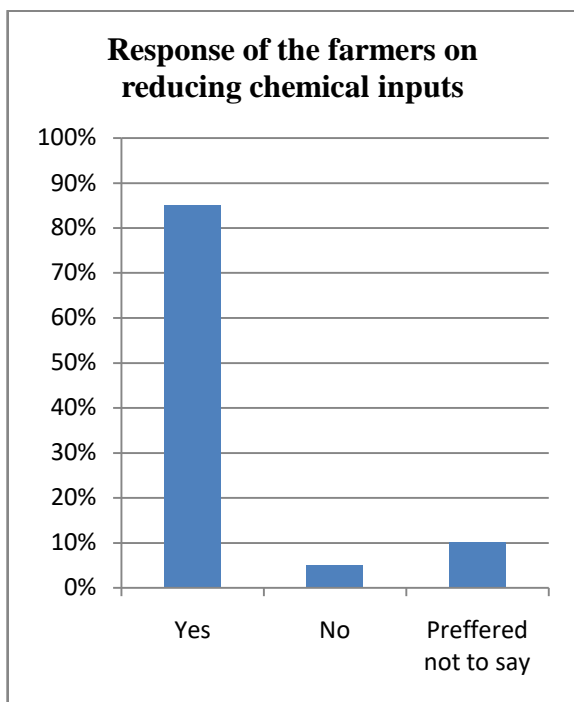
Figure-3: indicates that 85% of farmers had reduced using chemical inputs with the introduction of Biotech Kit. 5% of them did not reduce and 10% of the farmers preferred not to disclose their opinion.

Table-5 and Figure-4 shows the response of the farmers on question 'With the introduction of organic inputs in your agricultural land what are changes have you experienced?'

Particulars	No. of Respondents	Percentage (%) of Respondents
Yield increased	18	45
Yield decreased	18	45
Do not know	04	10
Total	*40*	*100*

Table-5: shows that among 40 nos. of beneficiaries (farmers) 18 nos. farmers expressed their opinion as 'yield increased'. Also the same nos. of farmers said their 'yield decreased' and 4 nos. of farmers answered 'Do not know' as they were not farm sure about the fact.
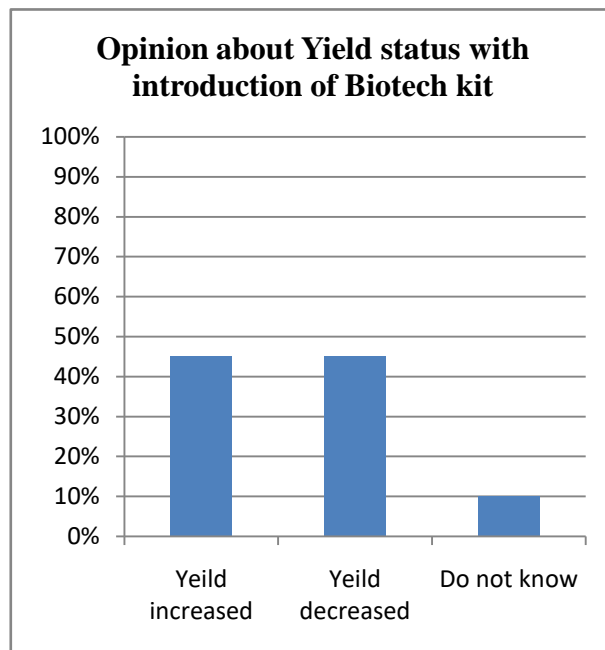
Figure-4: indicates that 45% of the beneficiaries (farmers) of Biotech kit believed that their yield increased with the introduction of Biotech kit and the same % of farmers believed that decreased. 10% of the farmers were not farm sure about the yield status

Table-6 and Figure-5 shows the response of the farmers on question 'Do you think pollination is increased with the cultivation of Bee by you and your co-villagers?'

Particulars	No. of Respondents	Percentage (%) of Respondents
Yes	26	65
No	06	15
Do not know	08	20
Total	*40*	*100*

Table-6: shows that among 40 nos. of beneficiaries (farmers) 26 nos. farmers of Bee keeping believe that their pollination has increased, 06 nos. do not agreed and 08 of them were not sure about the fact.

Opinion on Pollination Status

Opinion on Financial benefit
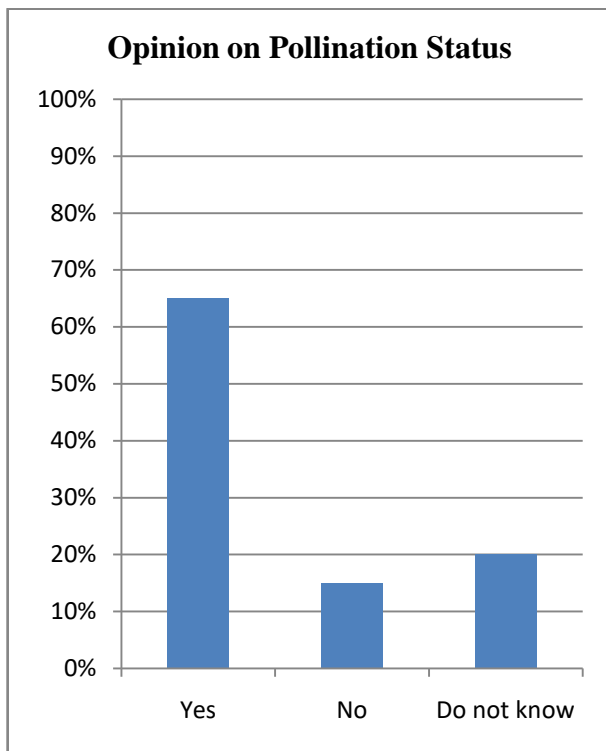
Figure-5: indicates that 65% of the beneficiaries (farmers) of Bee keeping believe that the pollination has increased, 15% do not agree with the fact and 20% of them were not sure about the pollination status.

Table-7 and Figure-6 shows the response of the farmers on question 'Have you been financially benefitted with the cultivation of Bee directly?'

Particulars	No. of Respondents	Percentage (%) of Respondents
Yes	38	95
No	02	5
Do not know	00	0
Total	*40*	*100*

Table-7: shows that among 40 nos. of beneficiaries (farmers) of Bee keeping 38 nos. farmers agreed that they have benefitted directly in terms of economy by selling raw honey and 02 of them did not agree.

Figure-6: indicates that 95% of the beneficiaries (farmers) of Bee keeping directly benefitted by Bee keeping unit by selling raw honey and 5% of them did not benefitted.

Table-8 and Figure-7 shows the response of the farmers on question 'Do you think the economic condition of your household will be better in future with the plantation of fruit plants?'

Particulars	No. of Respondents	Percentage (%) of Respondents
Yes	24	60
No	08	20
Do not know	08	20
Total	*40*	*100*

Table-8: shows that among 40 nos. of beneficiaries (farmers) 24 of them believe that their household economy would be better in future with the plantation of various fruit plants, 08 nos. each of them do not think so and 08 nos. replied as 'Do not know'.

Opinion on future economy condition with fruit plant plantation

Opinion on role of plantation on eceology restoration
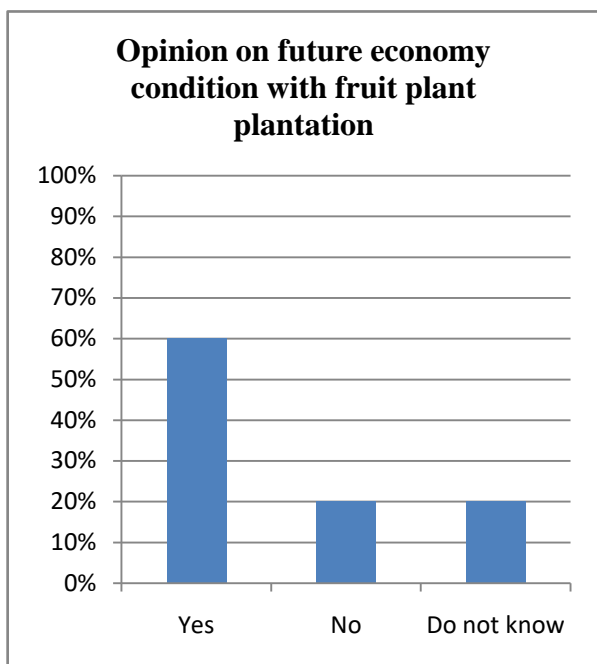
Figure-7: indicates that 60% of the beneficiaries (farmers) believe that their economic condition will be better in future with the plantation of various fruit plants. 20% of them do not believe it and rest 20% were not sure about the fact.

Table-9 and Figure-8 shows the response of the farmers on question 'Do you think plantation shall play a role in environmental ecology restoration?'

Particulars	No. of Respondents	Percentage (%) of Respondents
Yes	30	75
No	04	10
Do not know	06	15
Total	*40*	*100*

Table-9: shows that among 40 nos. of beneficiaries (farmers) 30 of them believe that plantation shall play a role in environmental ecology restoration, 04 nos. of them do not think so and 06 nos. replied as 'Do not know'.

Figure-8: indicates that 75% of the beneficiaries (farmers) believe that plantation shall play a role in environmental ecology restoration. 10% of them do not believe it and rest 15% responded as not sure.

Table-10 and Figure-9 shows the response of the farmers on question 'Have you been benefitted with Mushroom Cultivation?'

Particulars	No. of Respondents	Percentage (%) of Respondents
Yes	40	100
No	00	0
Do not know	00	0
Total	*40*	*100*

Table-10: shows that among 40 nos. of beneficiaries (farmers), all of them got benefitted with Mushroom cultivation in some way.

Response on mushroom cultivation benefit
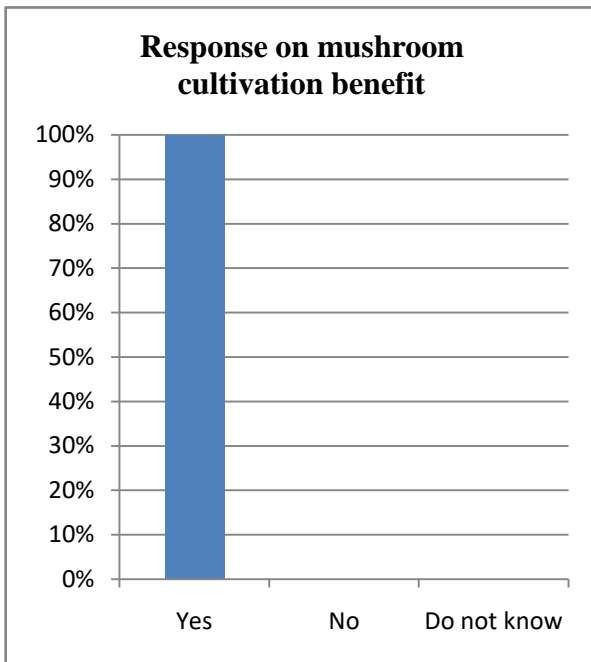
Figure-9: indicates that 100% of the beneficiaries (farmers) agree that they got benefitted with the cultivation of Mushroom.

Table-11 and Figure-10 shows the response of the farmers on question 'How have you benefitted with cultivation of Mushroom?'

Particulars	No. of Respondents	Percentage (%) of Respondents
Economically	06	15
Nutritional demand fulfilled	04	10
Both	30	75
Total	*40*	*100*

Table-11: shows that among 40 nos. of beneficiaries (farmers) 06 of them informed that they got benefitted only economically with the selling of Mushroom in the market. 04 beneficiaries believed that their health got better with the intake of cultivated Mushroom as it is a good source of protein and 30 beneficiaries agreed that they got benefitted in both way i.e.; economically & nutritionally.

Beneficial way with Mushroom cultivation

Figure-10: indicates that 15% of the beneficiaries (farmers) believed that they got benefitted only economically, 10% believed that the benefit in terms of nutritional benefit and 75% of the beneficiaries agreed that Mushroom became beneficial in both ways for them.

Table-12 and Figure-11 shows the response of the farmers on question 'Have you been benefitted with the raring of livestock components (chicks/ducklings, goatlings/piglets?'

Particulars	No. of Respondents	Percentage (%) of Respondents
Yes	26	65
No	09	22.5
Don't know	05	12.5
Total	*40*	*100*

Table-12: shows that among 40 nos. of beneficiaries (farmers) 26 of them agreed that they got benefitted with raring of distributed livestock components. 09 of them did not agree as some of the components died and 05 of them replied as 'Do not know'.
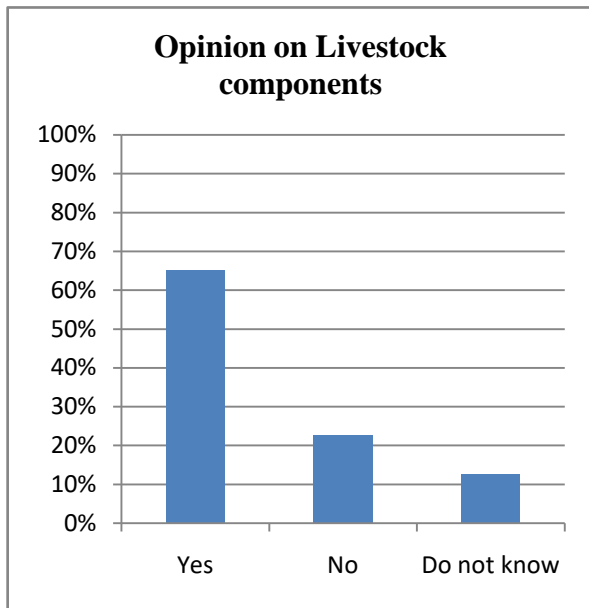
Figure-11: indicates that 65% of the beneficiaries (farmers) agreed that they got benefitted with raring of livestock components. 22.5% of them confessed that they did not benefitted due to death of some of the components and 12.5% replied as 'do not know' as they could not calculate the ratio of investment in feed materials, medicines, accessories etc. with output from the components

Table-13 and Figure-12 shows the response of the farmers on question 'Whether Energy saving electrical gadget kit became beneficial?'

Particulars	No. of Respondents	Percentage (%) of Respondents
Yes	40	100
No	00	0
Don't know	00	0
Total	*40*	*100*

Table-13: shows that out of 40 beneficiaries, all of them confessed that they got benefitted with the distributed component- energy saving electrical gadget kit which includes star rated ceiling fan (2 nos.), LED tube light (2 nos.) & LED bulbs (6 nos.). The component served in terms of comfort & savings both ways.

Figure-12: indicates that 100% of the beneficiaries agreed that they became benefitted by using energy saving electrical gadget in terms of comfort & savings both ways.

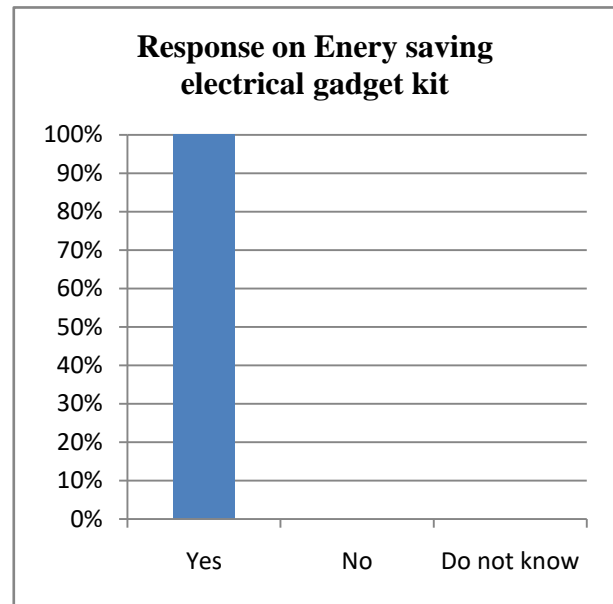**Table-14 and Figure-13** shows the response of the farmers on question 'How much money have you been saving per month on average by using energy saving electrical gadget kit?'

Particulars	No. of Respondents	Percentage (%) of Respondents
Less than Rs. 50/-	12	30
Rs. 50/- to Rs. 100/-	28	70
Above Rs. 100/-	00	0
Total	*40*	*100*

Table-14: shows that out of 40 beneficiaries, 12 nos. of them saved > Rs. 50/- per month on electricity on average basis. 28 of them saved Rs. 50/- to Rs. 100/- per month.

Response on avg. savings on electricity bill per month
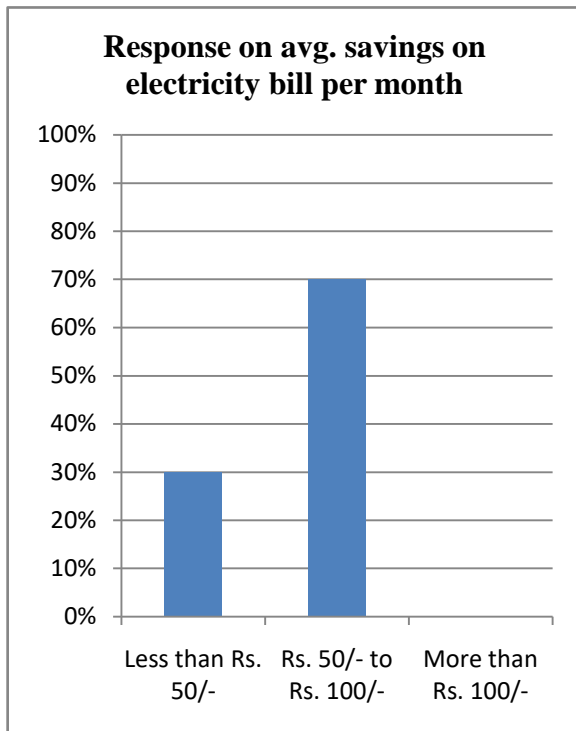
Figure-13: indicates that 30% of the beneficiaries saved > Rs. 50/- per month on electricity on average basis and rest 70% saved Rs. 50/- to Rs. 100/- per month on avg.

Table-15 and Figure-14 shows the response of the farmers on question 'How Solar water pump seemed more beneficial?'

Particulars	No. of Respondents	Percentage (%) of Respondents
Cropping cycle increased	12	30
Quality of crops improved	06	15
Both (i) & (ii)	22	55
Preferred not to answer	00	0
Total	*40*	*100*

Table-15: shows that out of 40 beneficiaries, 12 nos. confessed that their cropping cycle increased as earlier in the dry season it was difficult for farming as they had to rely on rain only in the remote agricultural field. 06 beneficiaries agreed that their quality of crops improved with the sufficient water in dry seasons. 22 farmers agreed with both the aforesaid options.

Response on utility of solar water pump

Figure-14: indicates that 30% of the beneficiaries agreed that their cropping cycle increased, 15% agreed with quality of crops improved, 55 % believed in the both statements.

Table-16 and Figure-15 shows the response of the farmers on question 'Whether Bio-gas is unit is a useful component of the project?'

Particulars	No. of Respondents	Percentage (%) of Respondents
Yes	30	75
No	04	10
Preferred not to answer	06	15
Total	*40*	*100*

Table-16: shows that out of 40 beneficiaries, 30 beneficiaries agreed that Biogas unit is really useful. 04 of them answered no and 06 out of them preferred not to answer.

Response on usefulness of Bio-gas unit
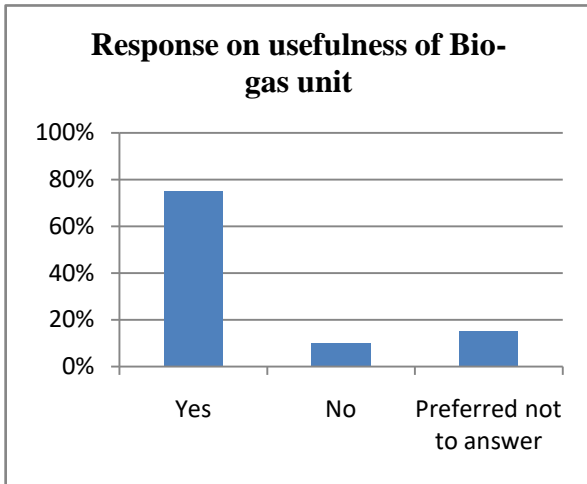
Figure-15: indicates that 75% of survey population agreed that Biogas unit is really useful. 10% of them answered no and 15% out of them preferred not to answer.

Table-17 and Figure-16 shows the response of the farmers on question 'Is Biomass cook stove is beneficial for you?'

Particulars	No. of Respondents	Percentage (%) of Respondents
Yes	36	90
No	02	5
Preferred not to answer	02	5
Total	*40*	*100*

Table-17: shows that out of 40 beneficiaries, 36 beneficiaries agreed that Biomass cook stove is really beneficial. 02 of them answered no and rest 02 preferred not to answer.

Response on usefulness of Bio-gas unit

Figure-16: indicates that 90% agreed that Biomass cook stove is really beneficial. 5% of them answered no and rest 5% preferred not to answer.

Table-18 and Figure-17 shows the response of the farmers on question 'Which category of component of Bio village project played more important role according to you?'

Particulars	No. of Respondents	Percentage (%) of Respondents
Environment friendly livelihood security components	08	20
Renewable energy & Energy saving components	10	25
Both	20	50
Do not know	02	5
Total	*40*	*100*

Table-18: shows that out of 40 beneficiaries, 08 of them believed that Environment friendly livelihood security components played more important role in the Bio-village project. 10 nos. beneficiaries believed Renewable energy & Energy saving components were more important, 20 nos. confessed both category of components played equal role and 02 out of them answered 'do not know'.
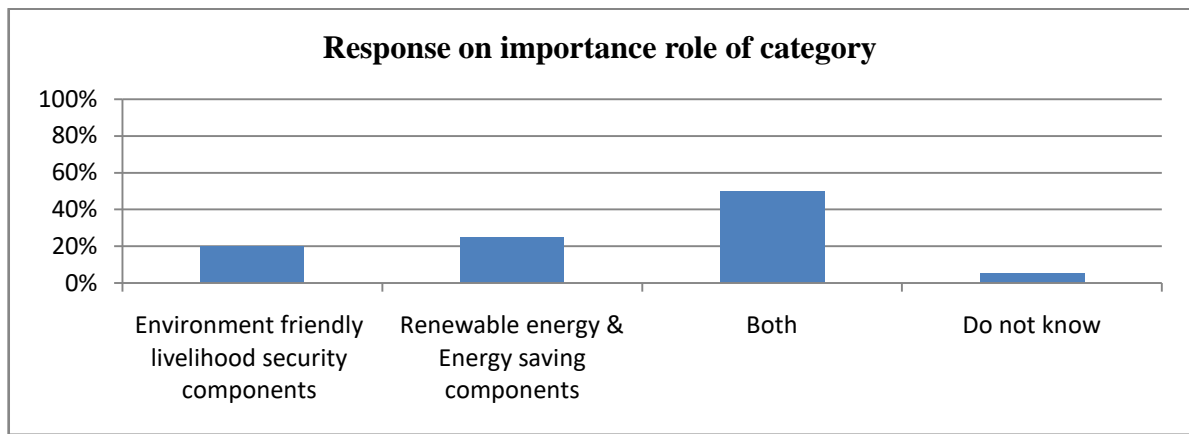
Figure-17: indicates that 20% & 25% of total beneficiaries believed that Environment friendly livelihood security components & Renewable energy & Energy saving components played more important role respectively. 50% believed both & 5% gave opinion as not aware of that.

Table-19 and Figure-18 shows the response of the farmers on question 'How would you rate the Bio-village concept over all?'

Particulars	No. of Respondents	Percentage (%) of Respondents
Excellent	26	65
Good	12	30
Average	02	5
Poor	00	0
Total	*40*	*100*

Table-19: shows that out of 40 beneficiaries, 26 beneficiaries rated Bio-village concept as 'Excellent'. 12 rated as 'Good' and 02 beneficiaries rated as 'Average'.
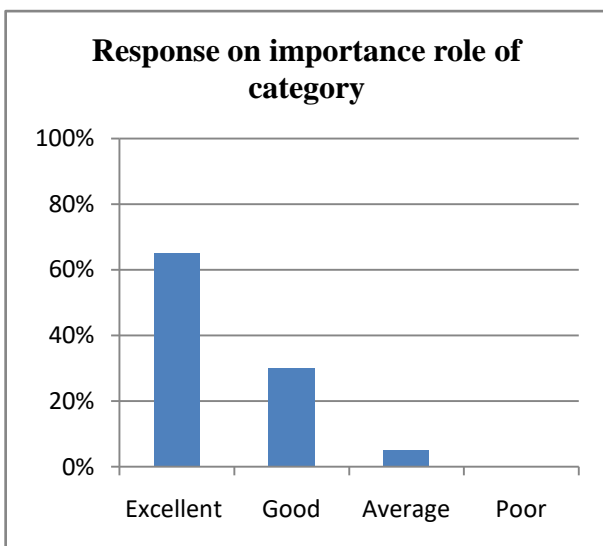
Figure-18: indicates that 65% beneficiaries rated Bio-village concept as 'Excellent'. 30% rated as 'Good' and 5% beneficiaries rated as 'Average'.

Table-20 and Figure-19 shows the response of the farmers on question 'Would you recommend Bio-village concept to be implemented in other villages of the state?'

Particulars	No. of Respondents	Percentage (%) of Respondents
Yes	36	90
No	00	0
Preferred not to answer	04	10
Total	*40*	*100*

Table-20: shows that out of 40 beneficiaries, 36 beneficiaries responded that they would recommend Bio-village concept to be implemented in other villages of the state and 04 beneficiaries preferred not to answer on that.
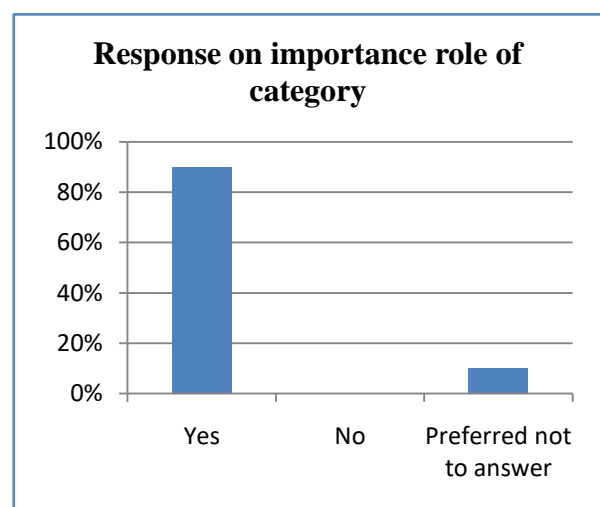
Figure-19: indicates that 90% beneficiaries responded that they would recommend Bio-village concept to be implemented in other villages of the state and 10% of them preferred not to answer on that.

Discussion

The concept of 'Bio-village' is henceforth come out as a multi dimensional project which has been accepted by the marginal farmers and rural people where socio-economic development and precious use of bio-resources have aimed at. The successful implementation of the concept was possible due to the adoption of eco-friendly technologies and enterprise development mostly based on biological resources. The outcome of the project has yielded with increased income/per month of the beneficiaries of the project and sustainable development of ecological status of the village during the project period. The inherent character of the project is to provide sustainable livelihood and food security. It further extended the opportunity to the rural community to access multiple sources of livelihood through adoption of number of components at a time with skill up gradation and technological empowerment. This pilot project tries to highlight some of the sustainable technologies which is compatible to one another and can be undertaken in other villages of the State, subject to consideration of inherent strength of the village like rich biodiversity, nutritional requirement of the family, availability of the resources interest of the people with positive mind set. An integrated drive by different stakeholder may change the socio-economic condition of a rural village and thus the people can realize that there is a visible impact of sustainable development through the integrated eco-friendly approach.

Therefore it is worthy to state that Bio-village concept has showed the use of easy effective green technology supportive components to uplift the socio economic standard of village community.

Conclusion

The project concept is well accepted by the farmers in terms of livelihood & ease of daily life, therefore it can be multiplied in number of villages in the state. There are few cases of mortality in livestock components, so efforts can be taken to address the issue in future projects. For small landholding farmers proper management of all these components seemed tough in some odd cases. Since the beneficiaries were selected based on their resource available & interest, to multiply the project or bring more farmers under the project the farmers may be given a option for choosing their desired components rather than opting all. The benefit of applying bio-inputs in agri land may be advertised more aggressively if the quantity of NPK present in their soil is tested pre & post project and through open sharing. It has learnt from the beneficiaries that during the summer & rainy season the quality of produced Mushroom remained not so good, thus the beneficiaries may be encouraged to cultivate Mushroom during winter season to reduce the loss. Further to popularize & spread the concept throughout the state huge fund is required and accordingly initiative may be taken to arrange funds from CSR or Govt. of India agencies.

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AN EXPERIMENTAL STUDY OF HARDNESS AND pH FOR UNDERGROUND AND SURFACE WATER OF NORTH DUMDUM MUNICIPALITY AREA, KOLKATA, INDIA

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ABSTRACT

In recent time, water contamination has become a important issue. Environmentally, hard water is considered inappropriate for drinking, domestic, industrial and agricultural purpose. Our bodies are regularly working to attain a balanced pH level. The foods we eat and the liquids we drink are all contributing to our pH level. Either too alkaline or too acidic can be detrimental to our health. The significance of water pH is to keep our body in balance and to regulate metabolic processes. Present studies were performed to explore the degree of hardness and pH in underground and surface water of the North Dumdum Municipality (NDDM) area, Kolkata. To serve the purpose, water samples of different wards were collected and analyzed. This work involves present practices and easy approaches to evaluate the quality of water. The hardness of tested water samples were found in the range of 157 ppm (parts per million) to 243.3 ppm for surface water and for ground water 339.6 ppm to 459.3 ppm by titration method. The tested samples have shown pH range 7.01-8.25 for underground water and7.39 -8.40 for surface water. The obtained results were compared with the national and international standards worldwide.

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Keywords: Water quality; Hardness; pH, Soap solution, Complex metric.

1. Introduction

Water is significant for day to day life and plays the key role for continued existence. Water is use through our cells, organs and tissues for smooth body performance like creating saliva, regulating body temperature, cognitive functioning, boosting our energy levels, excreting the waste from our bodies. Water is also used for drinking, preparing food, bathing, washing clothes and dishes, brushing your teeth, watering the garden, farming and fisheries purpose. In case of industries water is termed as "Blood of industry". Moreover the use of hard water in industries may result in increased consumption of fuel in boiler which in turn enhances atmospheric pollution and depletion of natural resources. There are two main sources of water: surface water and groundwater. Surface Water is found in lakes, rivers, and reservoirs. Groundwater lies under the surface of the land, where it travels through and fills openings in the rocks. The principal chemical parameters can include pH, acidity, alkalinity, chlorine, hardness, Dissolved Oxygen (D.O), Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD). At the time of measuring the quality of water, pH is one of the first measurements that we have considered. Pure water has a neutral pH. However, rainfall is somewhat more acidic

and typically has a lowest pH recorded 5.6. The lowering of pH value in surface water bodies indicates environmental problems like acid rain, industrial wastewater discharge into water bodies etc. Therefore, pH is considered to be one of the primary indicators of water quality. Water is considered to be safe to drink if it has a pH of 6.5-8.5. On the other hand Hardness occurs when water contains high mineral levels. Hard water is formed when water percolates through deposits of limestone, chalk or gypsum which are largely made up of calcium and magneium carbonates, bicarbonates and sulphates. In most cases, groundwater has more hardness than surface water. The hardness of water is due to the presence of soluble bicarbonates, chlorides and sulphates of calcium and magnesium. Water which does not give lather with soap is hard water. Soft water lathers with soap. Water which is obtained from the rains is soft water. This water is suitable for household purposes for example laundry and cleaning. The hardness of water can be classified into two types: Temporary Hardness and Permanent Hardness. The presence of magnesium and calcium carbonates in water makes it temporarily hard. In this case, the hardness in water can be removed by boiling the water. When the soluble salts

of magnesium and calcium are present in the form of chlorides and sulphides in water, we call it permanent hardness because this hardness cannot be removed by boiling. Hardness must also be removed before certain industries can use the water. For this reason, the hardness test is one of the most frequent analyses done by facilities that use water. In the present study, we have concentrated our work to measure the hardness and pH of underground and surface water of different wards under North Dumdum Municipality of North 24 Parganas district of West Bengal which is located at 22.6520800°N 88.4190700°E. After examine the water sample we have compared the pH and hardness between ground water and surface water, identified the cause of variation and disseminate the process of water softening.

2. Literature Survey

Water is a precious commodity[1] and the most vital resource of life. Last few decades, there has been a gigantic increase in the fresh water due demand to quick increase in population and industries[2]. For harmless life, drinking water must be safe and prevented from germs, inorganic and organic contaminants[3]. Polluted water is not suitable for human fitness and causes a lot of diseases[4]. In the year 1970s, only 38% people had access to safe drinking water in developing countries[5] and one billon human beings still lack approach to clean drinking water[6]. Hard water contains the higher concentration of magnesium (Mg^{+2}) and calcium (Ca^{+2}) ions [7]. Hard water can be classified into two groups: (a) Carbonates based hardness which is caused by calcium bicarbonate, magnesium bicarbonate, magnesium bicarbonate, calcium bicarbonate.(b) Non-Carbonates based hardness which is caused by calcium sulphate, magnesium sulphate, calcium chloride, magnesium chloride[8]. In drinking water, degree of hardness is generally evaluated in terms of its calcium carbonate content[9]. Hard water creates serious problems for domestic life, agriculture and industry[10]. The regular intake of hard water may increase the risk of cancer[11], reproductive system failure, cardiovascular diseases, high blood pressure and many heart diseases. A few investigations have shown a connection between water hardness (especially calcium and magnesium) and cardiovascular ailments, Alzheimer's infection and atopic skin inflammation[10]. Hard water minerals bring about scaling issues in pipelines of boilers[12].

Hardness, a physico chemical property of water, is generally a measure of calcium and magnesium ions with very low concentration of Zinc, iron, strontium, aluminum, and manganese[13]. Common calcium containing minerals are limestone (calcium carbonate) and chalk (calcium sulphate) and magnesium mineral is dolomite, which also contains calcium[14]. Initially, water hardness was understood to be a measure of the capacity of water to precipitate soap, later it has been generally accepted that hardness is defined as the sum of the Ca and Mg concentrations, determined by the EDTA (Ethylenediamine tetraacetic acid) titrimetric method, and expressed in mmol/l (Millimoles per litre)[15] or as $CaCO_3$ equivalent in mg/l(milligrams per liter)[16]. Multiple different scales of water hardness were suggested (e.g. very soft – soft – medium hard – hard – very hard)[17]. The relationship between water hardness and the incidence of vascular diseases was first described by a Japanese chemist Kobayashi[18].The World Health Organization says that "there does not appear to be any convincing evidence that water hardness causes adverse health effects in humans"[19] . Wherever water hardness is a concern; water softening is commonly used to decrease hard water's adverse effects[20].

3. Experimental Methodology
3.1. Materials

Thirty two (32) water samples were collected from different wards of NDDM area. All the water samples were collected aseptically in to sterilized screw capped glass bottles and brought to the laboratory, .EDTA (ethylene diamine tetra acetic acid), $Zn(CH_3COO)_2,2HO$ (zinc acetate), NH_4OH (ammonium hydroxide), NH_4Cl (ammonium chloride), EBT (Eriochrome-Black-T) were obtained from Loba Chemicals, Bombay, India. All other chemicals and solvents were reagent grade as received.

3.2. Preparation Of Solution Required

3.2.1. 0.01m Edta solution: Near about 0.9306 g of EDTA is weighed out into a 250 ml volumetric flask and dissolved with deionised water, volume is made up to the mark and made uniform by shaking.

3.2.2. 0.01 M Zinc acetate solution: Near about 0.5475g of A R(Analytical reagent) Zinc acetate is correctly weighed out into a 250 ml volumetric flask containing 2 g of NH_4Cl (ammonium chloride) dissolved in 10 ml deionised water, the solid is dissolved same water, the volume is made up to the mark and made uniform by shaking.

3.2.3. NH_4OH-NH_4Cl buffer (pH-10) solution: Nearly 17.5 g of NH_4Cl (ammonium chloride) is mixed with 142 ml of concentrated NH_4OH (ammonium hydroxide) and the mixture is made up to 250 ml with deionised water and kept it with covering the mouth of the container properly.

3.2.4. EBT-indicator: 40 mg solid mixture of EBT (Eriochrome-Black-T) with AR KNO_3 (potassium nitrate) which contains about 1% indicator. 0.05 g of the indicator and about 4.9g of KNO_3 are to be mixed by grinding .

3.3. Standardisation Of Edta Solution

In a 250 ml conical flask, 25 ml of the standard zinc acetate solution is taken with pipette and 5 ml of NH_4OH-NH_4Cl buffer solution is added to it. The whole solution is diluted to 100 ml with deionised water and warm to about $40°C$. 20 mg of EBT indicator is added and the mixture is shaken and resultant a wine-red colour. Then titrated with standard EDTA solution until the colour changes to blue. Calculations are completed using standard equation ($V_1S_1=V_2S_2$)[22].

3.4. Determination Of Hardness

Exactly 50 ml of water is pipette out into a 250 ml flask which is diluted to 100 ml with deionised water. 5 ml of NH_4OH-NH_4Cl buffer and 20 mg of EBT indicator indicator is added to the water, The mixture is shaken and wine-red colouration is observed and then the mixture is titrated with the standard EDTA solution until the wine-red colour changes to bule colouration. Calculations are made following standard method[21].

3.5. Determination Of pH Of Water

The pH of a water solution can be calculated using glass- calomel electrode system in which following electrochemical cell is formed:

(-)   Salt bridge   (+)

Pt/Hg(l)/Hg_2Cl_2(s)/KCl (aq).saturated//agar-KCl (satd.)/glass electrode
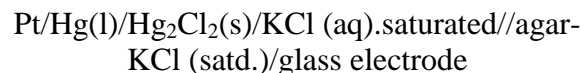
Left-hand electrode is the saturated calomel electrode (SCE) and the right hand electrode is the glass electrode. The structure of the glass electrode is based on the study that the electric potential difference in between a glass surface and an aqueous solution varies regularly with pH of the aqueous solution except those which are very strongly acidic or very strongly alkaline. The electrode is prepared of a thin walled bulb of low melting glass of high electric conductivity. Inside the bulb is placed a solution of constant pH (a buffer solution,or,1(N) HCl solution) together with a little quinhydrone and a platinum wire for electric contact. The potential (Eg) of the glass electrode at 25°C may be expressed according to,

$$Eg = Eg° +0.059 \log a_{H+} = Eg° +0.059 \; pH$$
.... (1)

For actual pH measurement, the glass electrode is standardised in buffer solutions of known pH values. Usually potassium hydrogen phthalate (pH of 4), phosphate (pH of 7) and borax (pH of 9.2) buffer solutions are used for calibration of pH meter. The pH value can be read off directly from the digital pH-meter calibrated with standard buffer solutions.[22]

4. Results and Discussion

For groundwater analysis, majority of the total sample size showed hard character of water and out of them four samples marked with 5,7,12 and 14 showed very hard character of water . If we compare the hardness of all the samples, it is seen that sample no.14 showed the highest hard character (459.3 ppm) and sample no.11 showed lowest hard character (339.6 ppm). On the other hand we consider the reference normal range for pH in groundwater systems as 6.0 to 8.5. It is also supported by our experimental values of pH. Here, the value of pH samples of the study area

ranges between 7.01 to 8.25 i.e. general trend towards weakly alkaline in nature. In case of sample no.11 it is lowest (7.01) and for sample no.2 it is highest (8.25).

Table 1.pH and Hardness of Under- ground water of different positions under NDDM, Kolkata-51.

Sample No.	Description	pH	Hardness (ppm)	Remarks(*)
1	Ward No.-01	8.01	359.2	Hard
2	Ward No.-03	8.25	392.5	Hard
3	Ward No.-04	7.60	374.5	Hard
4	Ward No.-09	7.86	400.5	Hard
5	Ward No.-10	8.21	455.4	Very hard
6	Ward No.-11	7.95	343.5	Hard
7	Ward No.-12	7.87	451.5	Very hard
8	Ward No.-13	8.03	386.7	Hard
9	Ward No.-14	7.43	373.3	Hard
10	Ward No.-18	7.14	344.5	Hard
11	Ward No.-20	7.01	339.6	Hard
12	Ward No.-23	7.83	451.5	Very hard
13	Ward No.-24	7.55	424.6	Hard
14	Ward No.-25	7.56	459.3	Very hard
15	Ward No.-33	7.79	353.3	Hard
16	Ward No.-34	8.10	356.1	Hard

* [23]

In the case of surface water (mainly pond water in the study water) all the samples tested showed moderately hard character with ranging from 157 ppm to 243.3 ppm. From experiment it is clear that among all the samples sample no.14 shows lowest hardness (157 ppm) and sample no.4 show highest hardness which is 243.3 ppm. We know the safe range for pH in surface water systems is 6.5 to 8.5 (according to Bureau of Indian Standard (BIS)). All the pH results under the present study falls within the safe range. The value of pH samples of the study area ranges between7.39 to 8.40. With careful observation it is seen that sample no.11 shows lowest pH (7.39) and sample no.14 shows the highest pH (8.40). It may be concluded from the above results that the surface water in the study area is safe for human health and also suitable for the propagation of the aquatic life in terms of pH.
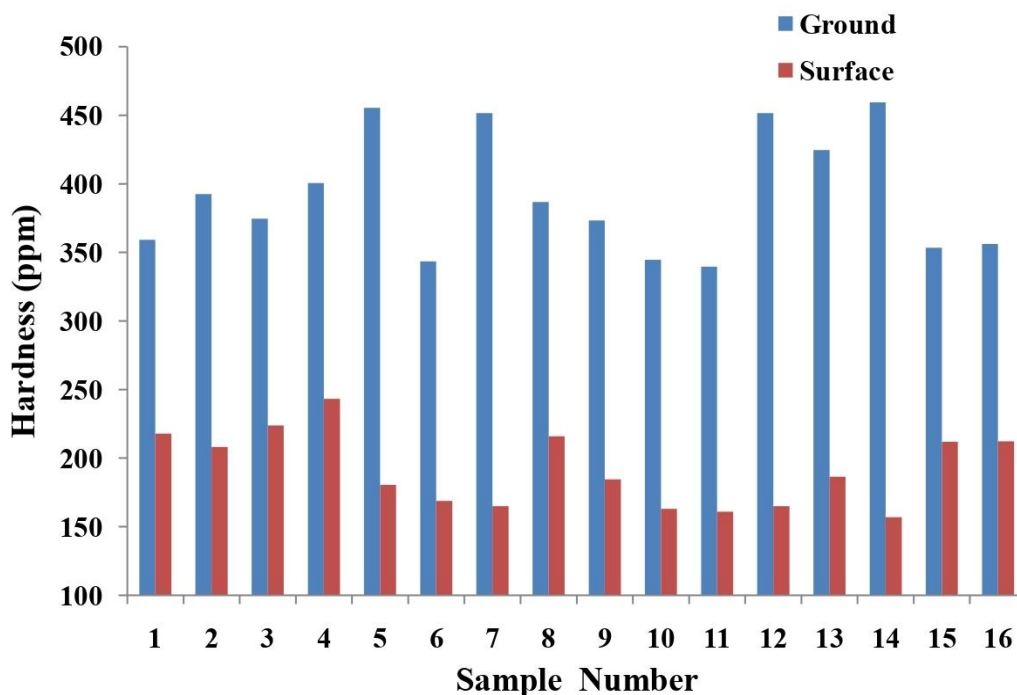

Figure: 1. Comparison in Hardness of surface water (maroon colour) and ground water(blue colour).

Table 2. pH and Hardness of Pond water of different positions under NDDM, Kolkata-51.

Sample No.	Description	pH	Hardness (ppm)	Remarks(*)
1	Ward No-01	8.35	217.9	Moderately Hard
2	Ward No-03	8.39	208.1	Moderately Hard
3	Ward No-04	8.04	223.8	Moderately Hard
4	Ward No-09	8.05	243.3	Moderately Hard
5	Ward No-10	8.31	180.6	Moderately Hard
6	Ward No-11	8.08	168.8	Moderately Hard
7	Ward No-12	8.03	164.9	Moderately Hard
8	Ward No-13	8.16	216.0	Moderately Hard
9	Ward No-14	8.06	184.5	Moderately Hard
10	Ward No-18	7.60	163.0	Moderately Hard
11	Ward No-20	7.39	161.0	Moderately Hard
12	Ward No-23	8.09	164.9	Moderately Hard
13	Ward No-24	8.09	186.5	Moderately Hard
14	Ward No-25	8.05	157.0	Moderately Hard
15	Ward No-33	7.99	212.0	Moderately Hard
16	Ward No-34	8.40	212.2	Moderately Hard

*[23]

If we compare the hardness of groundwater and surface water it is very clear that hardness of ground water is very high compare to surface water (Table:1 and 2, Figure:1). The most probable reason is that the groundwater is contained in or by a subsurface layer of soil or rock and also very low chance of contamination with groundwater than surface water. The rock tends to act as a filter to remove some contaminants and it is hard water due the presence of high mineral content. On the other hand Surface water which is found on the surface of the earth such as in a river, lake or other surface cavities is not rich in very high mineral content and due to this it remains soft water with very less mineral concentration.
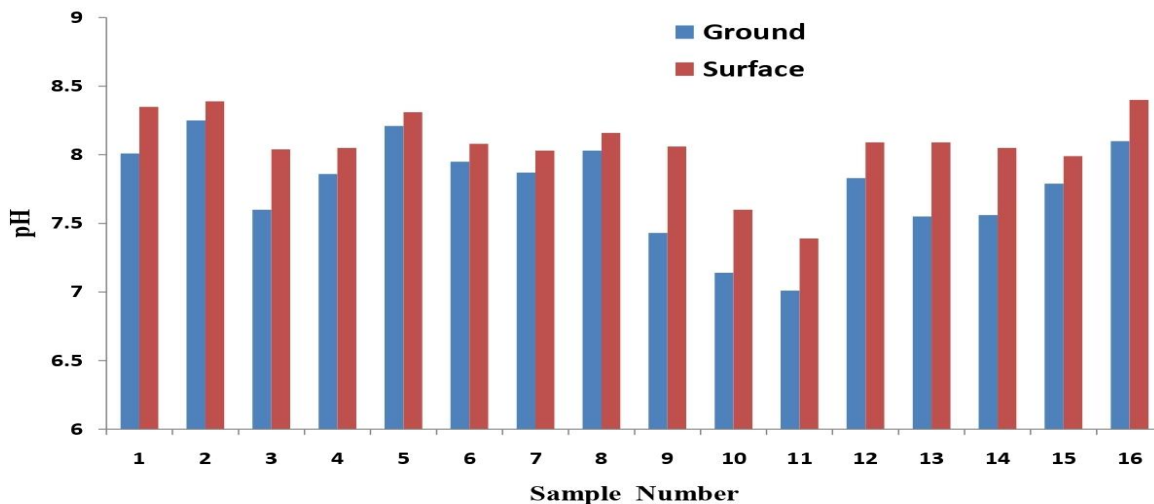
Figure: 2. Comparison in pH of surface water (maroon colour) and ground water(blue colour)

For pH comparison, from value of pH samples of the study area it is clearly observed that the pH (Table:1 and 2, Figure:2) of surface water is high with respect to ground water. It may be due to various reasons like contamination from cement products, algal bloom etc. The most probable cause for elevated pH values is the contamination with cement products. Since cement is used in several contexts in connection with various constructional work the dumping and discharge of construction wastes and wash water respectively flows to the pond water. An algae bloom is a common cause for high pH during the day as algae consumes carbon dioxide and other inorganic compounds for photosynthesis. It is supported by the observation that pond looks very green in colour with an increase in pH during day time due to growth of biomass. On the other hand, low pH is usually caused by the

metabolic process like respiration by organic life present in the pond.

5. Conclusion

The present study had revealed that under the study area, the hardness character of surface water is moderately hard and for underground water it is hard in most cases but for four samples it showed very hard character in nature. For pH measurement, in both case, i.e. for underground (7.01 to 8.25) and surface water (7.39 to 8.40) the values are within the permissible limit of pH range and it is also showed that the pH of surface water is higher than the pH of groundwater. The significant outcome of the present study is that the surface and groundwater are safe for human consumption in terms of pH and hardness. Moreover the surface water quality strongly supports the growth of aquatic life in the water bodies of study area.

6. Acknowledgements

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HUMAN BEHAVIOR AND ENVIRONMENT: A TANGLE

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ABSTRACT

Behaviourism is the theory of knowledge based on the idea that all behaviours are acquired through governance, and this governance occurs through communion with the environment. In simple words, behaviorism is referred to the way humans behave under a certain condition. Human behavior is directly related to the condition they are in. Human behavior can create or rupture, guard, or wipe out his environment. The present environmental challenges like climate change, pollution, loss of biodiversity, water scarcity, etc are due to the human behavior of over-exploitation of natural resources. Human destroys the environment either due to a lack of knowledge and awareness or due to ignorance. Environmentalism promotes the restoration, preservation, and improvement of the natural environment and the critical earth systems. It focuses on the protection of climate, controlling pollution, and protecting plant and animal diversity. Environmentalism also focuses on maintaining the balance between the relationship between humans and the natural environment in a manner so that all the components are under a proper degree of sustainability. Although the measure and outcome of the balance are controversial and there are many other ways to express environmental concern. Environmental concerns are dependent on environmental awareness and the practice of environmental concerns is related to human behavior. The way humans behave reflects the degree of their consciousness about the environmental concern.

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*Keywords***:** Behaviour, environment, sustainability, environmentalism, behaviorism

1. Introduction

Environment and human behavior are correlated and have immense influences on each other. While some schools of thought claim that the surrounding environment shapes human psychology and behavior to some extent. On the other hand, the environment is highly being altered, polluted, degraded, or even conserved by a human. Here we've attempted to re-evaluate the connections between these. There are handful numbers of research on environmental psychology and vice-versa, and here we will be discussing a few.

As a few psychologists opined, the environment has ever been regarded as a platform that could be used for free. In any psychological investigation, the environment has been spotted as a disturbance or interference that people receive from outside. In certain cases, these noises have been reduced to the highest to perceive a good result. Though in real-time studies, it is indeed accepted that environment is not to be ignored; rather it should be considered an indispensable and critical factor that has an impact on human psychology and behavior. Hence, the ecosystem or environment isn't a valueless stage on which humans can perform as per their wish; rather the stage may shape the performance as required. Although psychology, as a discipline asserts that only the human being should be in focus. Environmental values are being carried by humans as the investigations portray.

Besides, there's a huge difference between human attitude and behavior, whatever people claim regarding their consciousness towards the environment, is not always the same as they act in reality. Sometimes, we regard the environment simply as an illusion, but numerous records are there to prove that environment has got an enormous ability to come up with feedback on human activities directly. Environment shapes psychology, hence human psychology is highly dependent upon the surrounding environment of an individual, be it social, cultural, economic, or educational.

In a few earlier studies, dissimilarities have been identified between the behavior of the city dwellers and that of the rural people. The keenness for helping others, i.e., interpersonal relations have been studied to drop as urbanization took place (Krupat, 1985). Aggressiveness is found to be common with the so-called improvement of civilization. Individualism, self-centeredness, social withdrawal, detachment, and egoistic behavior are common among the men in the cities

(Korte and Grand, 1980; Moser and Uzzell, 2003; Steg, Norlund, 2018).

2. Environment shapes human behavior

2.1. Environmental Determinism, Possibilism, and Neo- determinism

Environmental Determinism

In the late 19th century, German geographer Friedrich Ratzel proposed the theory of Environmental Determinism that was influenced by the "Origin of Species"- by Charles Darwin. This was followed by the introduction of the determinism theory in the early 20th century by Ellen Churchill Semple, a student of Retzel. As per the philosophy, human psychology is entirely influenced by their environment and climate. This eventually influences the societal culture, work culture, and habits. The attainments of civilization in a particular continent depend upon its geographical location, and climatic conditions (Ratzel, F., 1896).

Environmental Possibilism

A French geographer, V. De La Blanche opined that the environment doesn't control the entire societal and cultural behavior of humans, rather it offers possibilities or options that man could opt for. By 1950, environmental determinism had almost been replaced by the concept of environmental possibilism. The crux of the theory is, that the environment is there with several possibilities, it is the human who has to select the proper one for living, human is not only the product of nature, they're the administrator to decide from the options given by the nature, nature is only the adviser for human, man can sometimes manipulate the possibilities by his intellectual supremacy and grow crops or fruits in the adverse climatic conditions. The thought has been greatly criticized in several ways, most importantly, that humans can never control the physical power of nature despite having presumed possibilities.

Neo- determinism

In 1920, the Australian geographer Griffith Taylor proposed a new concept stating that environmental condition determines a country's economic foundation. Humans can speed up, slow down, start or stop the developments but be off from the geophysical (elevation, soil, slopes, landforms, and so on) and climatic (temperature, precipitation, humidity, and so on) conditions (if wise) that nature has provided. Man can control the "stop and go" mechanism with the options. Neo-determinism says, every choice made by a human, be it for the environment or against it, is sure to get paid off by the ecosystem.

2.2. Human behavior and built environment

Now, coming to the modern scenario of living and mindset of humans and its relation to the surrounding environment. People's frame of mind is dependent upon the surrounding built environment *viz*., indoor air quality, availability of light and air, ambient temperature, weather conditions, access to greeneries, noise, and so on. Several studies show detrimental impacts of continuous exposure to darkness on the mental health of man whereas, daylight offers positivity amongst them. Even few health-care institutions reveal that the speed of recovery is correlated to the cabins allowing daylights. Besides, a prolonged sight of the greeneries impacts better analytical ability, control of emotions, and self disciplines in social and personal life. On the other hand, a person having lesser access to nature might be suffering from dejection, fretfulness, mindlessness, and so on.

Apart from the surrounding natural environment, the immediate built environment in which humans live is greatly responsible for human psychology-led behaviors. For instance, the gathering of humans, living in a congested locality; or even a household having a bigger number of family members might direct the behavior of the inhabitant in either way; being annoyed or being happy for the gathering. Thus, privacy is vital for the mental health of a good number of individuals. A few other factors that might influence the health of the human mind are the color of the walls, images, and vibes of the home, or the workspace as the researchers suggest. In the case of the workspace, another driving force is the ambient noise; it even can hamper the professional abilities of the employees. A healthy ambiance (or environment) is essential for healthy minds and bodies, and only a healthy and sensible

human can perceive the significance of a healthy environment.

3. Human behavior and environment

The studies on the confluence of the human psyche and environmental health are the newest thoroughfare of recent day research. Several dynamic models are being designed based on the variability of one against the other factor. This particular school of study is the need of the hour to approximate how far we are from sustainable earth. Researchers are aiming to anticipate the target behaviors which are outright pernicious for the ecosystem. This would bring out the possible way-outs which might be effective to drive the behaviors to be in favor of environmental protection.

The global thinkers are almost sanguine that it is human activity that contributes the most to the global climatic changes. The variations in weather, landforms, etc. make the inhabitants relocate which has substantial aftermath, especially on the psychological health of the man. We might not claim that only ecological security is at risk where the psyche of humans is in insecurity too. Civilization has shaped the physical environment in different ways. The concern was raised during the mid-twentieth century and since then people are busy in the study regarding this particular interface. Apart from climate change, loss of biodiversity, air, water, soil, and noise pollution are also crucial (Swim, Clayton, and Howard, 2011; Miles-Novelo and Anderson, 2022).

3.1. Pro-Environmental Behaviour (PEB)

Pro-environmental behavior is such behaviors that drive the human being to act environment friendly. Several facets effectively block the pro-environmental behaviors of the individuals. Psychological disengage might be the vital one all. Social, economic, and cultural hindrances are external whereas, behavioral is an entirely internal aspect that can be believed to be the function of emotions, thoughts, reliance, knowledge, confidence, and so on (Krajhanzl, 2010).

3.1.1. PEB and Human Psychology

Let's have look at the "Dragon of Inaction.." as proposed by Robert Gifford in 2011 (Gifford, 2011); here, he categorizes all these barriers into seven major categories, *viz.,* Limited Cognition (less or no awareness), Ideologies (the worldwide belief that clashes with environmental management strategies), Social Comparison (routine comparison with the activities of the surrounding people), Sunk Costs (investments nullifying alternative prospects), Discredence (incredulity in environmental problems and the policymakers as well), Perceived Risks (worried about whether the investments for the environmental benefits would pay off or not), and Limited Behaviour (tendency to opt for the easier alternatives than that of the eco-friendly ones) which are liable for eco-friendly inaction of man (Kollmuss and Agyeman, 2002; Gifford, 2011).

4. Conclusions

Environmental problems are burning issues of this era and several environmental policies and environmental protection acts are being taken for the improvement of the health of the environment. But how does environmental condition have reached such a sensitive state? The relationship between humans and the environment is a complex yet interesting concept to discuss. From the beginning of time human has developed a complex relationship with the environment around them. The interaction between the primitive human society and strong forces of nature has developed and established certain human practices and behaviors according to the physical environmental conditions. Human behavior depends upon numerous factors, and the relation between the psyche and ecosystem is complex indeed. Environmental awareness, education, and training amongst the population might influence the brains of all age groups and frequent and effective sessions along with monitoring of the day-to-day behavior could make a big difference by escorting society to a sustainable one.

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INDIGENOUS KNOWLEDGE IN DISASTER RISK REDUCTION: A CASE STUDY AT RANGABELIA, SUNDARBAN, INDIA

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ABSTRACT

Due to climate change the frequency of natural disaster is increasing. In the disaster prone areas people are in vulnerable situation. Landfalls, flood, cyclone, heat wave and avalanche are common in now days. People throughout the globe are helpless as nature has started to react upon the economy centered human civilization. The era of science could successfully predict a few disasters but wouldn't have enough power to stop them. Only they are able to minimize the loss. Needless to mention, the civilized human are actually afraid of the natural disasters whereas, a part of the human race, which are called tribes, are apparently not at all like the so called "civilized" and sometimes deprived from formal educations and health facilities are actually not afraid of those natural disasters. Those people having indigenous knowledge which they acquire either from the nature or from their community and culture can fight back and survive. These indigenous people are spread worldwide and they're the parts of the nature. With economic and societal developments, these human beings have turned into the minority in numbers and being dominated by the civic society. This could be the highest time to get in touch with these natural storages of wisdoms and preserve them and their valuable knowledge as well. A remarkable application of indigenous knowledge by the people living in Rangabelia, Adibashi Para, Gosaba, Sundarban, and West Bengal, India to survive in cyclone and flood prone coastal area has been unfolded in the current work.

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Keywords: Indigenous, knowledge, tribal, coastal, cyclone, flood

1. Introduction

Natural disaster is a major natural phenomenon which creates adverse effect in environment, human life, economy etc. Major types of natural disasters are floods, tsunami, cyclone, drought, earth quakes. Sometimes human are also indirectly responsible for this catastrophe. As we know the natural disaster ratio are increasing it also causing hazard in environment, loss in infrastructure and increasing the rate of climate refugees. According to the IDMC (The Internal Displacement Monitoring Center) India, Philippines, Bangladesh, and China this are the effected natural disaster countries which cause high number of climate refugees in 2019.

Indigenous knowledge is the old traditional process which the tribal people use in their daily life. This is not a bookish knowledge or there is no written form tribal people adopt from nature to cop up and practice those generation to generation. According to United Nations Environmental Program (UNEP) traditional communities depend on indigenous knowledge to conserve the environment and deal with natural disaster.Hyogo Framework for Action (HFA) which held in Japan on 2005 and plan for 10 years (2005-2015) focused on Tribal knowledge regarding disaster related

issue. The communities which are in disaster prone have produced huge amount of indigenous knowledge in prevention and mitigation. One of the most important aspects of this indigenous knowledge it is sustainable and long term. Many of them apply as early warning systems minimize the disaster risk. The sea level is increasing lands are getting submerge under the water.

The frequency of cyclone in Bay of Bengal is high as recorded in last few years. Gosaba, Sunndarban located in the coast and works as belt of West Bengal for the presence of mangrove forest which minimize the speed of cyclones and make the cyclone less vulnerable .The people in Gosaba are affect economically, psychologically, physically [1]. The study focused on the tribal people and their indigenous knowledge that can nullify the detrimental impacts of natural disaster. Tribal people are very close to nature. By observing the color of sky, behavior of animal they predict the nature. Government built shelter give food and protects them. 'Duwar e sarkar', disaster relief fund other government facilities help affected people. They protect themselves from nature by using natural products e.g. bamboo, wood etc. This create less hazard and sustainable. Indigenous knowledge passed by

generation after generation as per their need. There are several disaster management process, team with modern technology still at some point of time we should learn and practice those traditional tribal knowledge because those are sustain for environment. The societal aspects show that, male and female both work hard each day to earn money and they don't want their children to suffer. They pray to 'Banadevi or Banabibi' (Goddess/Guardian of Forest) as if they are worshiping nature. Post disaster recovery processes have been studied. Planting mangrove actively and constructing strong dams are the major solution for flood; these are being executed by the governmental bodies. The vulnerability is directly dependent upon the efficient management and rapid recovery. The cyclone cause huge impact on wild animals too. The indigenous knowledge could be the only sustainable way-out to minimize the disaster. Strong mental health, hearty connection with the nature makes the tribal even more powerful to combat the deadly disasters. It is our responsibility to protect the indigenous people and nature. Tribes from Odisha tribe, Karnataka tribe, Sundarban delta region tribe, North East tribe etc face many natural disasters like Cyclone, Drought, Flood, Land slide etc they recover all this by their knowledge [2, 3].

2. Methodology
2.1. Study Area

The entire study has been completed in Gosaba (22.1652° N, 88.8079° E), Adibashi Para in Rangabelia Village, a landscape inhabited by the indigenous people. Fig. 2.1 shows the geographical location of the study area.

Fig. 2.1. Study area (not to scale)

2.2 Survey

- Face to face interview with the Honorable Jt. BDO has been conducted to understand the overall socio-cultural and economic scenario along with the records of the occurrences of a few of the past incidences of natural disasters, disaster responses and relief organized by government and private sectors.
- A door to door survey has been done within the *Adibashi Para* to understand the outlooks of the villagers to the frequently occurring devastating natural disasters.

2.3. Other studies

- The modes of communications, availability of vehicles, socio-economic structure, educational infrastructure, disaster management and support systems, accessibility to health facilities have been studied and recorded for further evaluation.

3. Results

The village is inhabited by 53% of tribal population followed by 43% scheduled castes and 4% general castes by count. Sir Daniel Mackinnon Hamilton brought tribes from Chota-Nagpur and Odisha in 1903. The life style, social customs and cultures, economic structure, educations and health of the 53% population have been investigated thoroughly.
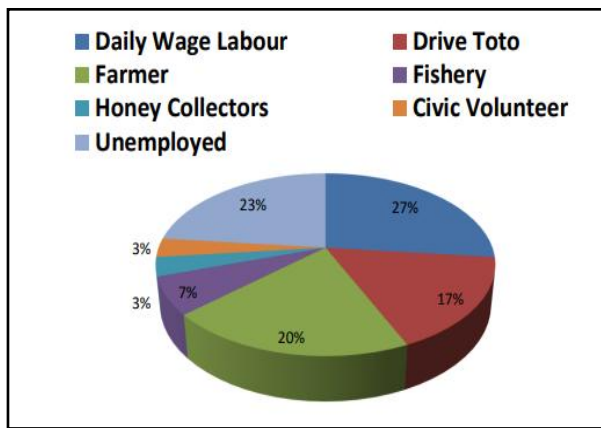
Fig. 3.1. Economy of tribal communities at *Adibashi Para*

The above picture (fig. 3.1) clearly depicts that the major proportion of the economy comes from the daily earners, and a considerable part (i.e. 23%) of the community studied are unemployed.

Only 7% have passed high school and mostly the population is devoid of higher educations. Cyclones and severe floods are the major natural disaster and have repeated occurrences over the area. The records have been noted down a few months after the Cyclone Yaas, a very severe cyclone which made it landfall on Odhisa and subsequently damaged the coasts of West Bengal too.

The central objective of the study is how the tribal people manage to fight these destructive forms of nature and survive for long. The reports reveal a few facts that are noteworthy. People having indigenous knowledge shelter themselves from storms and floods by building stilt houses or bamboo and mud houses which are exclusively designed and built with natural products available in the surroundings. Moreover, most of the houses have a canal passing along the entrance of their specially designed houses to flow off the flood water away from the constructions. Figure- 3.2 shows that all of the villagers from the community are using these indigenous ideas to pull through. Although a good number of population withstand the calamities in their naturally built shelters, another portion of the population move to the local cyclone relief centre allotted by the government or to the school building. As we've already noticed that the economy partially depends upon agriculture and cattle, huge losses are evident after any of the disaster. Health issues have been reported to be

another mentionable long term impacts of floods. Thus, the rhythm of daily tribal lives get hampered a lot and it takes almost half a year to get back the normalcy.
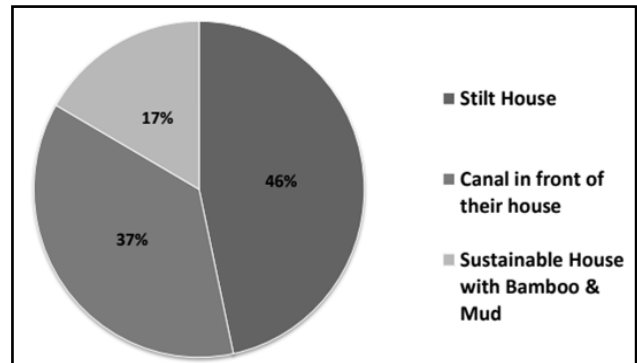
Fig. 3.2. Indigenous constructions to survive in disaster prone area

Even, in few cases, the losses are permanent. The most astonishing observation is, mostly these people don't leave their village and won't be ever leaving as they have accepted that calamities are the part of the nature and hence the part of their lives too. While asked about the increased incidences of disasters, they suggested reclaiming the mangrove forests, constructing dams in proper way may eradicate the issue.

Three major aspects have been identified that has saved these people of the nature from calamities are natural houses, temporary bridges and most importantly, their strong psychological strength, their oneness with the nature (Fig. 3.3).

4. Conclusions

The tribes living in Rangabalia (Adibashi Para), Gosaba highly vulnerable to cyclone, flooding and many more. Since we studied the situation economical, educational, demographic and overall situation of tribal community we can understand that their traditional knowledge makes a huge difference in the impacts of the mentioned disaster. Their traditional knowledge makes them strong to counter adversity due to the disaster [4, 5]. If we look back last few years we can well identify a number of cyclone and super cyclone consistently affected Sundarban area of West Bengal; thousand inhabitants, huge economic and other losses like agricultural loss, fishery loss and loss of household utensils, property loss.
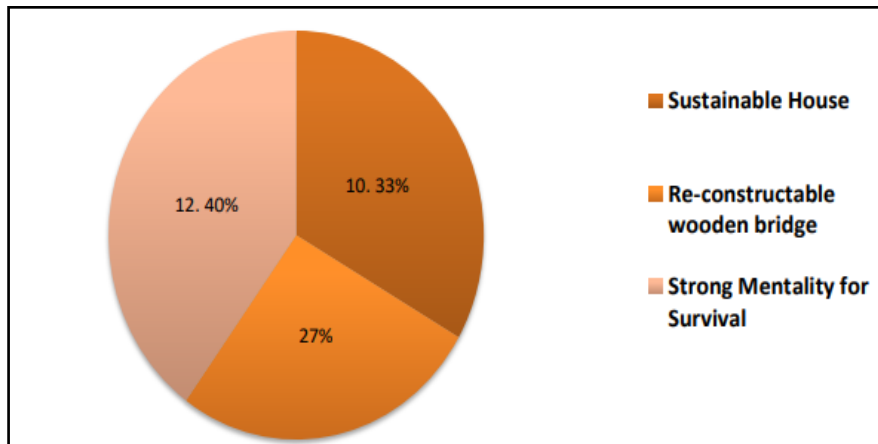
Fig. 3.3. Lifelines to survive

But we can see that after interacting with all these disaster affected tribes are confident enough with traditional and indigenous knowledge they perceived from their father forefathers. Government sector, NGO are also playing important roles. There are permanent shelters for vulnerable population, government monitor the processes over there. Government distributes PHE packet drinking water; food for people stuck in flood Local authority receives the news of low pressure formation or any cyclone prediction 4 days earlier from central meteorological department. There are active volunteers, block disaster management team, civic volunteer and NDRF team who work continuously to control the situation, well planned fight against any disaster helps to minimize the loss as much as possible. From the result we can easily find that the place is the inhabitation of the tribes as one of the leading population and they are practicing traditional knowledge which is very important. This knowledge is being shared from tribes other people all over follow the traditional method and knowledge to save themselves. From the discussion with common people we can understand the active group 31 to 50 years old people of age group they are honestly utilizing indigenous knowledge where elderly people source of knowledge they are physically unable in practice only they share it advice it to the younger generation. Good number of people generally stays in their house and never leaves their home ground and fight for their existence. Recently they are able to receive the broadcasts, predictions in televisions and radios. But they still believe in the old methods such as, the colour of clouds, behavior of animals and temperature of sea [6, 7]. The most effective tribal knowledge for saving themselves from the disaster impacts is building wooden bridge. Plantation of mangroves will help to protect from disaster and it the mangrove forests, once reforested, can work as shields and stop the soil erosions too. It will be sustainable and create fewer hazards if we can adopt from their knowledge. We can help them by constructing concrete dam, protect environment and aware them regarding the importance of proper education. A prevalence of unavailability of proper medical facilities has been noticed especially during and after disasters. Proper health facilities must be there for the overall betterment. Apart from their traditional knowledge, the strong mental health to fight with the disaster and post disaster situations is one of the most important things. Because they know natural calamity will come every year and destroy them in every aspect but their indigenous knowledge and strong mentality help them to stay in their ancestral land and fight in every situation. From this study we can understand that no book, library, course can provide us such mental strength to stand against super cyclones and combat adversities. Winning over the natural calamities using nature itself is only possible using the tribal knowledge. Worshiping nature by loving nature by being part of nature they can control, fight, and survive in nature.

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APPLICATION OF GEOSPATIAL TECHNOLOGY IN STUDYING WETLAND LANDSCAPE CHANGE – A CASE STUDY OF BARITI BEEL, A WETLAND AREA IN NORTH TWENTYFOUR PARGANAS, WEST BENGAL

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ABSTRACT

Wetlands are known to be extremely productive land that maintained all the ecosystem services through ages, preserving the ecological balance. They are defined as transitional lands between terrestrial and aquatic ecosystems, especially where shallow water covers the land, or the water table is generally at or near the land surface. Land cover and land use are two different things; while the initial term refers to the natural landscape as it exists covering the earth's surface, the second term refers to the various uses that a land is put to use for deriving economic returns. However, both globally and locally wetlands are found to be disappearing at a rate three times faster than forests and the land is being either reclaimed or transformed since 1970 keeping pace with economic development and urbanization. The spatio-temporal variations in the wetland coverage of West Bengal also indicate the land use transformation and wetland degradation. The primary objective of the study is to identify the causes responsible for the changing land use pattern of the wetland area leading to wetland area loss and degradation. Secondarily the objective is to prepare a digital wetland's database of the study area at 1:50,000 scale using LANDSAT 5 TM (Thematic Mapper) and LANDSAT-8 OLI-TIRS (Operational Land Imager and Thermal Infrared Sensor) data from the time frame 1972-2017 and prepare a Change Detection Analysis of Wetlands from 1972-2017. A scientific methodology with ground level survey was conducted to quantify the drivers of land use change and assess the overall status of the wetland under consideration. For this image pre-processing, processing and post-processing were done in three steps using RS and GIS techniques with QGIS (Quantum GIS) software and ERDAS (Earth Resources Data Analysis System) Imagine haze reduction tool, to get the accurate output for the present study. Bariti beel is a vast water body, famous for its presence in Barrackpore subdivision of West Bengal, positioned on 22° 49' 17" N and 88° 26' 30" E. The study indicates a massive loss of wetland area by 33%,along with 13% decline in agricultural activity and an increase in human habitation by 13% in 2017.Thus this quantification of the rate and volume of change in a wetland area with the help of geospatial technology and ground level survey was necessary to identify all the ecological, climatic as well as economic implications and think of ways to control further degradation on one hand and on the other , for achieving the future sustainable goal in regard to wetland land use management.

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Keywords: Land Use, Land cover, Geospatial Technology, Economic Returns, Change Detection, Wetland

Introduction

Wetlands are known to be extremely productive land that maintained all the ecosystem services through ages and preserve the ecological balance. However, these ecosystems have been suffering the losses worldwide due to large scale land use changes. The last century has witnessed worldwide transformations in land use attributed to large scale economic development. Wetlands are defined as transitional lands between terrestrial and aquatic ecosystems, especially where shallow water covers the land, or the water table is generally at or near the land surface. Wetlands are classified into seven landscape units, namely, estuarine, open coast, floodplains, freshwater marshes, lakes, peatlands and swamp forest (Cowardin and Golet 1995; Dugan 1990).

As per the Ramsar Convention on Wetlands, Global Wetland Outlook, special edition for marking the Conventions 50th Anniversary, it is reported that since 1970,around 35% of wetlands were lost globally and was marked as the most threatened ecosystem, disappearing at a rate three times faster than forests. Land use transformation has been regarded as the main driver for degradation and losses of wetlands since 1970. As per the report agriculture has been the widest form of land use change that has been responsible for the damage of half of the internationally famous wetlands.

According to NWIA (*National Wetland Inventory and Assessment*), 2011, the total area under wetland in the country is estimated

as 15.260 MHa, which accounts for 4.63% of the total geographical area of the country. West Bengal ranks second, (12.48%)in the country for being a wetland rich state after Puducherry and West Bengal is considered to have the highest number of small wetlands (138707) followed by, Uttar Pradesh, Orissa, Madhya Pradesh, and Rajasthan. The water bodies are locally called ponds, beels, baors char, dighi, bheri, sarobar, bandh, haor, sayar, nayanjali etc. In West Bengal they are mostly known as beels and baors.

The spatio-temporal variations in the wetland coverage of West Bengal indicate the interaction of possible human interventions along with many other natural changes. In case of North Twenty-Four Parganas, the increasing population (11,060,148) as per the 2021 census coupled with increasing number of infiltrations from Bangladesh was found to be a difficult task to accommodate them in the 4094 sq km of the area. The high density of population, 1,157 inhabitants per square kilometer, has been responsible for exploiting the natural wetlands for not only human habitation but for the purpose of gaining socio economic returns as well. Assessing LULC (Land use and Land cover) changes across the wetland ecosystem area indicates that both spatially and temporally the landuse patterns reflect an alarming transformation with initial signs of land degradation, thereby jeopardizing the ecology of the region. The land use change study helps to make future projection of changes depending upon the present scale operations of various variables which are likely to occur. The land use change data can be obtained more reliably through the uses of geospatial technology. RS and GIS techniques helps to develop land use and land cover mapping and obtain spatial analysis to provide precise information associated with land use changes. The continuous assessment of land use and land cover changes in wetland areas using RS (Remote Sensing) and GIS (Geographic Information System) helps to detect various environmental threats and helps to take steps for future conservation of natural habitats of wetlands. The aim of this study is to detect spatio-temporal LULC changes between 1989 and 2017 in Bariti beel area and assess the nature, rate and magnitude of changes in

this wetland area using satellite imageries of LANDSAT TM (Thematic Mapper) and LANDSAT OLI (Operational Land Imager)-TIRS (Thermal Infrared Sensor) through RS and GIS techniques. The present study examines an unexplored wetland area in the state. The findings of this study will help to identify the past and present land scenarios in this wetland area, assess the present environmental threats and draw the attention of the policy makers and environmentalists for providing an improved wetland management plan for a sustainable future.

Objectives

The primary objective of the study is to identify the causes responsible for the changing land use pattern of the wetland area leading to wetland area loss and its subsequent degradation. Secondarily the objective is to prepare a digital wetland database of the study area at 1:50,000 scale using LANDSAT 5 TM and LANDSAT-8 OLI-TIRS data from the time frame 1972-2017 and prepare a Change Detection Analysis of Wetlands from 1972-2017. Also, it is necessary to look for ways to combat any negative change that may provoke any further environmental disturbance in the near future.

Significance of the Study

Wetlands are extremely productive lands that not only provide us with innumerable services like food storage, water quality maintenance and livelihood in terms of fisheries and recreation but are also a home to many flora and fauna thereby maintaining the biological diversity of the region and maintaining its ecological balance. So it is necessary to make an inventory of all existing wetlands in an area, which would enable us to monitor the changes that are occurring over a period of time. The use of remote sensing techniques for deriving information on the quantitative and qualitative status of wetlands have gained immense significance in the recent times as collecting inaccessible data has become quite easy with it. In this study delineation of wetlands is carried out for a large area which was a very productive land once and a lifeline of the local people. This study would help to identify the causes of degradation and loss of a once

productive wetland into a fragmented and degraded land and this study could be further used for implementing various conservation and management techniques of the wetland present in this study area.

Data Source and Methodology

This study has been done using sensors of LANDSAT Level-1 satellite products and LANDSAT-5 TM satellite imageries of 1972, 1989 and 2006 and LANDSAT-8 OLI-TIRS satellite image of 2017, obtained from the USGS (United States Geological Survey) official website. LANDSAT-5 TM imageries comprise seven spectral bands of which the spatial resolution for bands 1–5 and 7 is 30 m and band 6 comes with 120 m spatial resolution (re-sampled to 30 m pixels). LANDSAT 8 OLI-TIRS include eleven spectral bands and 30 m spatial resolution for bands 1–8. Spatial resolution for bands 10 and 11 is 100 m each (re-sampled to 30 m). LANDSAT 8 has 16-bit radiometric resolution while LANDSAT 5 has 8-bit radiometric resolution. LANDSAT 8 has a greater spectral resolution (more spectral bands) than LANDSAT 5.

All of these satellite images were collected from the same period of pre-monsoon time of the various years which is basically dry time in January to reduce the influence of cloud coverage and seasonal changes for the classification procedure. In the beel area, pre monsoon phase is the main season for paddy sowing apart from growing some winter crops. Four satellite images were selected with approximately 16 years of time interval starting from 1972 to 2017 to analyze LULC changes for s period of 45 years within the wetland area. Image pre-processing, processing and post-processing were the three steps of the present study, using RS and GIS techniques with QGIS (Quantum GIS) software and ERDAS (Earth Resources Data Analysis System) Imagine haze reduction tool, applied to get the accurate output for the present study. All satellite images were geo-rectified during analysis and projected to GCS(Geographic Coordinate System) WGS (World Geodetic System) 1984 UTM (Universal Transverse Mercator) Zone 45 N (datum) to confirm uniformity between datasets.

Table 1 List of LANDSAT Images used in the study

Landsat Series	Sensor	Spatial Resolution (m)	Wavelength μm	Selected Bands	Path Row	Acquisition date	Percentage of Scene Cloud Coverage
Landsat 1	MSS	60	0.5-1.1	1-4	148/44	1972-12-11	0.00
Landsat 4	MSS	60	0.5-1.1	1-4	138/44	1989-04-25	0.00
Landsat 5	TM	30	0.45-0.90	1-4	138/44	2006-01-26	0.00
Landsat 8	OLI_TIRS	30	0.45-0.88	2-5	138/44	2017-04-14	0.96

Land cover and land use are two different things; while the initial term refers to the natural landscape as it exists covering the earth's surface and the second term refers to the various uses that a land is put to use for deriving economic returns. Change detection refers to the procedure of determining transformations of a phenomenon or condition by examining it at different periods (Singh. A.1989). In the present study the post-classification comparison technique was applied to evaluate the three changed scenarios for the years 1972, 1989 and 2006 dependent on 2017 the present-day situation. This post classification technique is the most commonly used technique used for studying land use change over the years.

Location of the Study Area

Bariti beel is a vast water body, famous for its presence in Barrackpore subdivision of West Bengal, positioned on 22° 49' 17" N and 88° 26' 30" E. Ichapur canal originates from river Ganga and gradually flows down into Bariti beel. The Bariti beel runs into the Vidyadhari River via Noai Khal. The Bariti beel is located at a distance around 35 km from Kolkata and is a part of Barrackpore I and II blocks, Barasat I and II Blocks and Amdanga Block of North Twenty-Four Parganas. It occupies an area of about 800 acres (according to Zoological Survey Records of India,1993, Occasional Paper no 150) or 3.23sq km in pre and post monsoon months. It is a temporary cyclical floodplain wetland situated in the Ganga River

basin and is a part of the moribund delta of the Ganges. It is formed due to the shifting of river Ganga over the years forming a cut off meander in its lower course where water is collected in the depression surrounded by high embankments. It is bounded by river Hoogly in the west, Bagher khal and Nadia district in the north, Noai khal and Barasat sub-division in the east and municipality of Cossipore and Chitpur in the south. The beel is the lifeline of the locals providing water for irrigation and practicing multi-cropping and pisiculture.
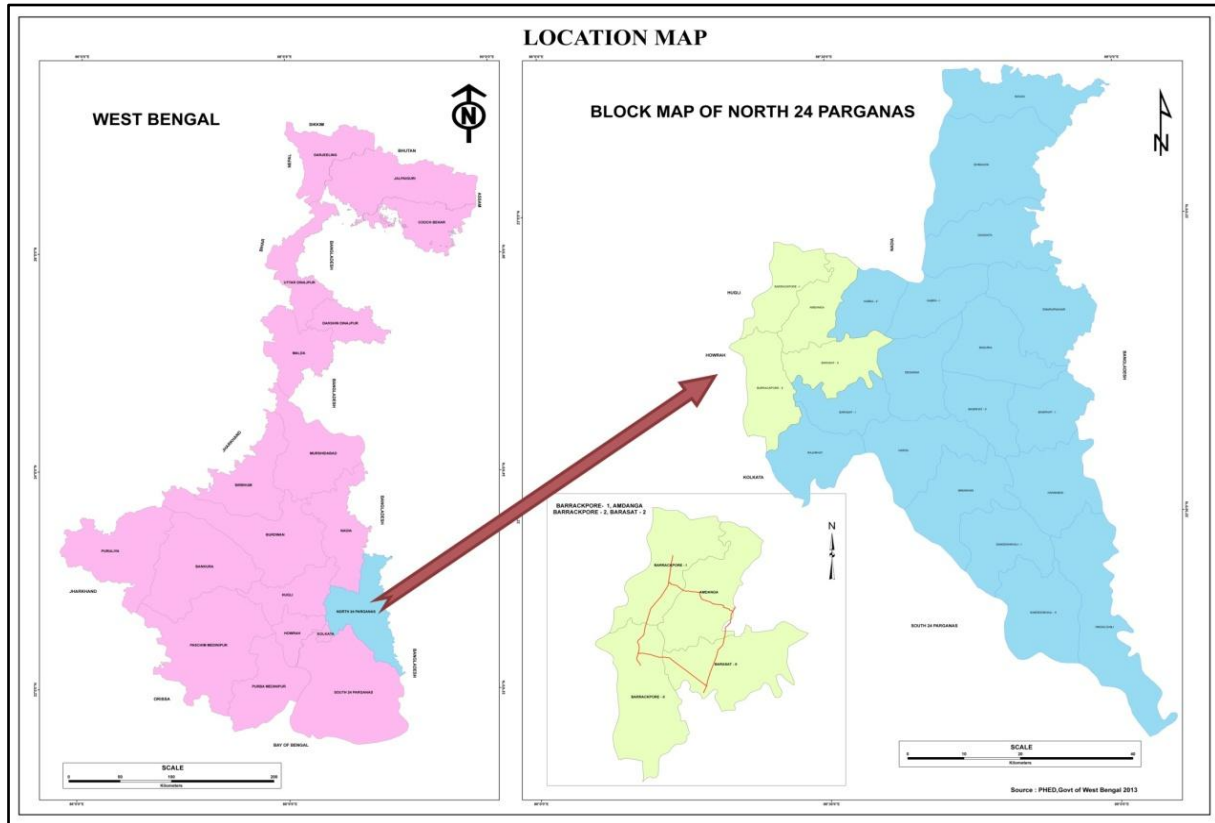
Fig. 1: Location Map

Discussion

Wetlands are areas where shallow water meets the land. They are mostly found in the transition zone from a terrestrial ecosystem to a deep-water ecosystem. Wetland landscape is therefore composed of a wide variety of typical native vegetation and fauna that are found only in such a transition zone. These natural areas of freshwater zones can be of only a few square feet of area or a large area of a few thousands of square km. The present wetland under consideration is a floodplain natural cyclic wetland found along left bank of Hooghly River. The Bariti beel is a unique wetland that is seasonally flooded with a fairly leveled terrain with areas of depressions that provide places for temporary storage of flood waters.

Fig No. 2: Schematic drawing showing the structure of the wetland
Source: Adopted and modified by author from Mitsch and Gosselink, 1993

Wetland landscape patterns are the result of various ecological, hydrological and economical processes. The natural flood plain wetland was once occupying large areas around 30,000 bighas (40 sq. km) of area and was its fringes were being utilized as a fertile productive land for growing huge quantities of paddy that coul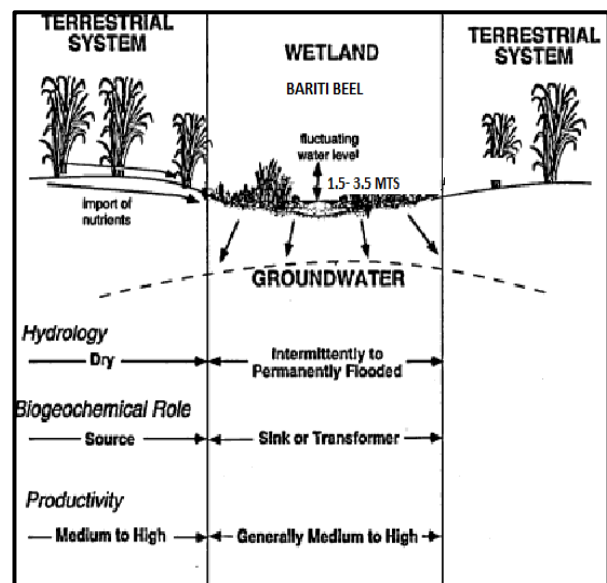d feed the rising population of the state. The wetland area with 1.5 m of permanently wet soil was ideal for paddy cultivation. Only depressions more than 3 m of depth could hold water throughout the year. The wetland formed at the source of the Noai Canal, which was once a mighty river called Labanyabati flowed across the floodplain region connecting with the Hoogly river in its right bank and Bidyadhadhari in its left bank. However gradually over the years with large amounts of effluents from nearby tyre factories, the water of Noai slowly started getting polluted over the years. Lack of regular monitoring and dredging in the canal, slowly got it silted thereby blocking the regular inflow of water from the Hoogly. With this the infrastructural development like construction of the Kalyani Expressway connecting with NH35 and the influx of refugees from nearby Bangladesh completely changed the entire land landscape of Bariti beel area. Slowly with rising rate of water pollution coupled with lack of water entering the canal from Hoogly River largely due to chocking of few of its connecting canals, the wetland got transformed mostly into settlement areas and welcomed other infrastructural developments. Thus, today what remains is only a fragmented wetland area with seasonal flooding, not encouraging any kind of cultivation due to lack of fertility of land. Once a home to several migratory birds, it is no more a breeding ground for them. The ecological balance of the region has been severely disturbed.

The area under consideration has been under study for the past few years and with the help of geospatial technology it has been easier to first delineate the wetland area and then with interpretation of satellite data with Ground Truthing it was easy to detect the land use change and prepare a change detection map for further analysis.

Analysis of Wetland Landscape Change

From the 1972 to 2017, the wetland landscape has changed greatly in the Bariti beel area (Fig.no.3). In the figure below (Fig.no.4) the trend of changes in land utilization over the past 45 years have been shown. From the year 1972 to 1989, around 4.48 km^2 of wetland area was lost due to significant rise in agricultural practice and human habitation. During this period, the percentage of area under the dry fallow land increased and moist fallow land decreased indicating the initiation of degradation. The period in between 1989 to 2006, around 13.2 sq km of wetland area was found, with only a marginal increase in agricultural area but a marked decline in human settlement area. However agricultural practice continued to show negligible importance. But the period in between 2006 to 2017 shows a drastic change in the entire land use structure of the wetland area reporting around only 4.4 sq km of water in the wetland area denoting about 33% loss of the wetland area only in the last decade. Wetland area had the largest reduction during this time, and this period is marked as the degradation stage. Additionally, the development of the land occupied by settlement increased continuously. Between 1972 and 2006, the wetland area was in the recovering stage and the wetland area increased by 11.47 km^2. In the last 15 years, built-up land increased continuously, mainly in the area occupied by cropland land, as well as in some land areas occupied by wetlands. The cropland transition was variable, changing from either cropland or built-up lands over a span of time. The trend of land use change in the last 30 years shows a drastic transformation of the land use pattern of the wetland area into a degraded land with only human habitation and infrastructural developments. The quality of the soil declined so rapidly that the land could not be used for proper agricultural practices. The wetland water also gets frequently polluted from the effluents discharged by the nearby tyre factories. As a result, the water that exists now is not suitable for even continuing with pisciculture practices. Around 28.03 sq meters of the wetland area got lost in the past span of 30 years for reasons like increasing number of human habitations, infrastructural development as a result of boom

in the realtor business , coupled with declining soil fertility and water pollution of the wetland from various point sources, not ignoring the problem of silting and choking of many canals connecting the wetlands with the river Hoogly for not taking proper conservational works, thus barring regular inflow of water in the wetland. The wetland area comprises of both rural and urban administrative units. Thus, the changing land use landscape became quite evident with the growth of transport networks and increasing accessibility. The Kalyani-Barrackpore Expressway originally built in 1980's runs almost alongside the wetland area and may be considered as a reason for wetland fragmentation and area shrinkage as this new communication route welcomed development, human settlement, urbanization along with traditional agricultural practices. The land use change in the past detected through the use of geospatial technology and the field visits in recent times at regular intervals have been analyzed to draw the present situation of the area under consideration.
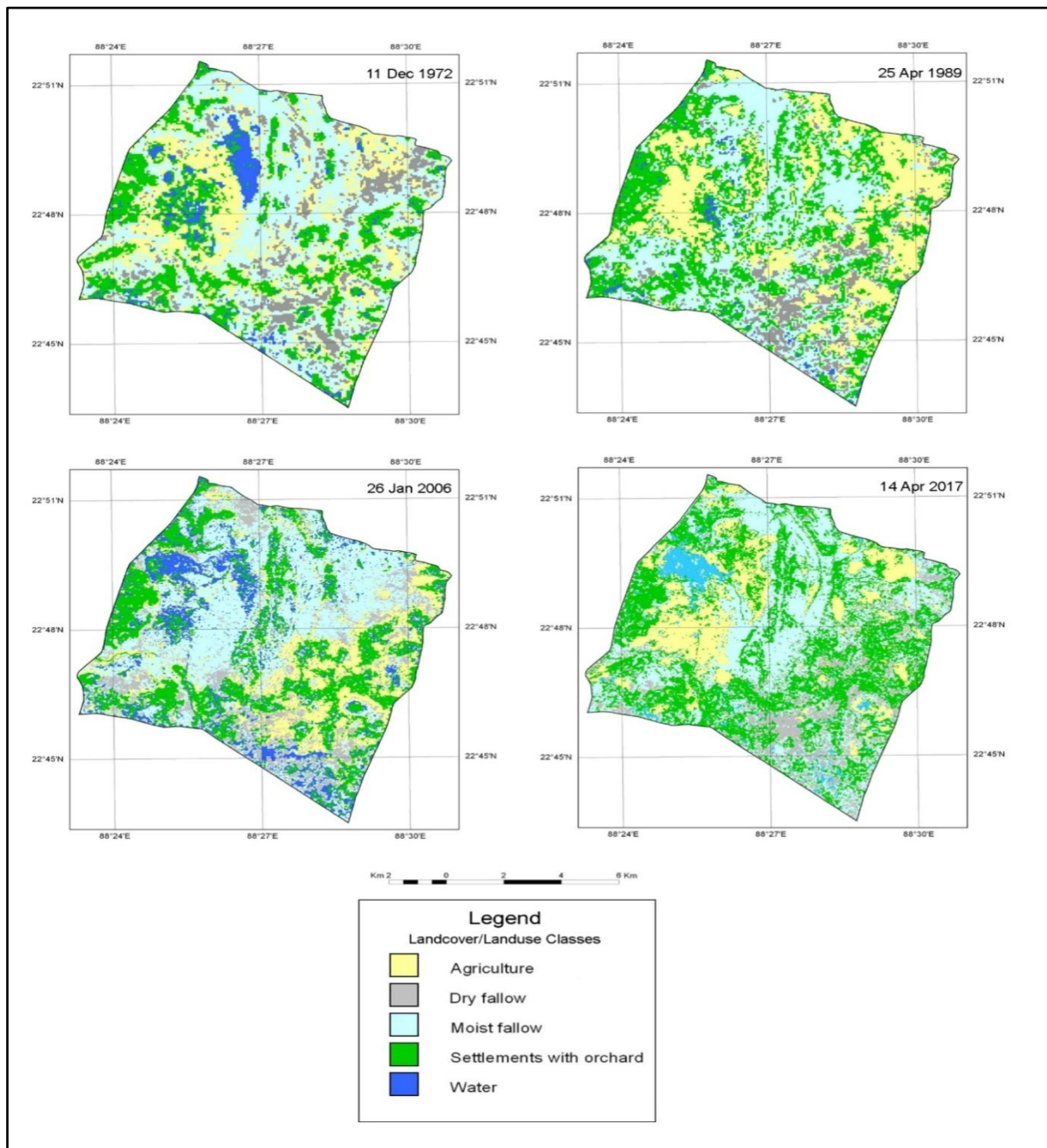
Fig No.3. Land Use and Land Cover map of Bariti Beel area for the years 1972, 1989.2006 and 2017
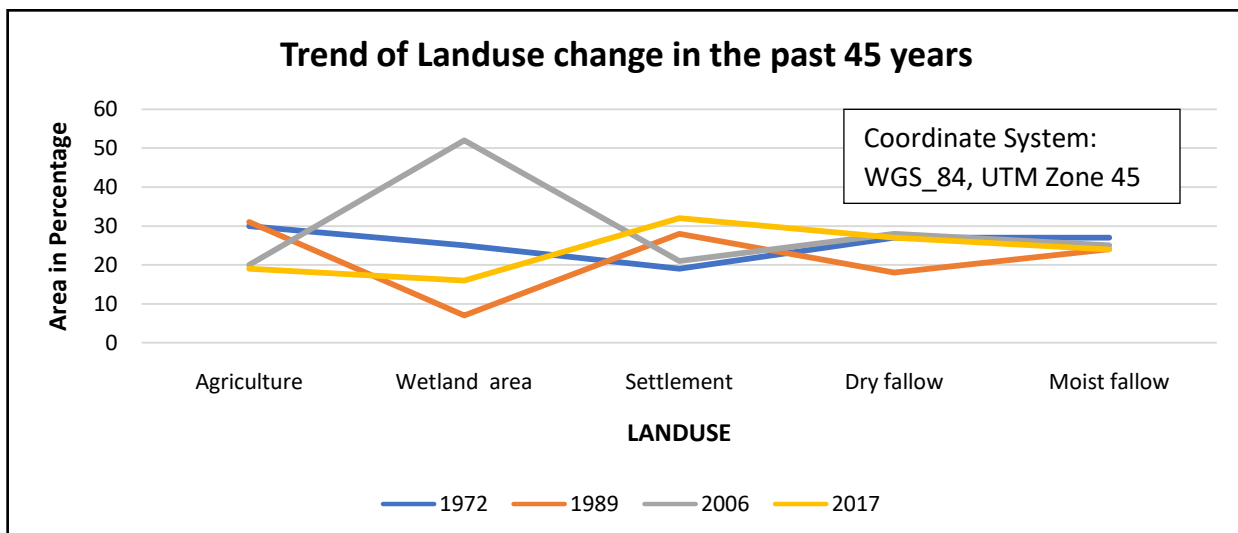
Fig. No.4 Trend of change in Land Use classes over a span of 45 years from data extracted and computed by the author

The data extracted from the land use and land cover study indicates the area under consideration have undergone a massive change in the past 45 years. From the trend line in (Fig No.4) it is observed that in the year 1972, the area was mostly covered by a significantly big seasonal wetland area that supported good yield of paddy production with only marginal area under human settlement. The wetland retained water consistently for a long period of time with hardly much fluctuation between the dry fallow and moist fallow seasons. The wetland area was in its pristine state with not much encroachment and degradation.

In the year 1989 the area is interpreted as the land being mostly utilized for agricultural purposes. The data being extracted from the pre monsoon period indicates that the area being a temporary cyclic wetland area it did not hold much water in the pre-monsoon season but the land was quite fertile from the new alluvium being deposited every year brought down by river Hooghly. Settlement of the human population was however commensurate with the agricultural production. The dry fallow and moist fallow land however showed marginal fluctuation in the pre monsoon time.

In the year 2006, the graph interpretation (Fig 4) suggests that the area was mostly under wetland area with not much agricultural activity. The cause behind the increase in the wetland area may be attributed to the fact that in the beginning of August 2000 there was a severe flood in West Bengal that affected many people mostly in the North Bengal. However, by the end of September there was heavy rain leading to rising levels of water in the numerous streams that run through the state. Situation worsened with simultaneous release of large amounts of water from many dams leading to flooding in the North Twenty-Four Parganas and adjoining districts. The geological structure of wetland area being like a shallow depression thus absorbed the excess water. This may be a reason for the spreading of the wetland area as from the graph below (Fig 5) it is noticed that the ground water table fluctuation in the four selected districts comprising the study area, during that particular period of time indicated a rising trend in Barrackpore I region only during the pre-monsoon season letting the soil remain wet. This trend line drawn, shown in the graph below indicates how the ground water level kept persistently hovering high in case of Barrackpore especially against all the other blocks of Barasat 1,II and Amdanga.

The year 2017 (Fig 4) shows a drastic change in the landscape with a steady decline in both wetland area and agricultural activity indicating wetland loss and fragmentation with decline in soil fertility leading to decrease in agricultural activity. Corresponding to this there is a marked increase in settlement area indicating infrastructural development in the area.
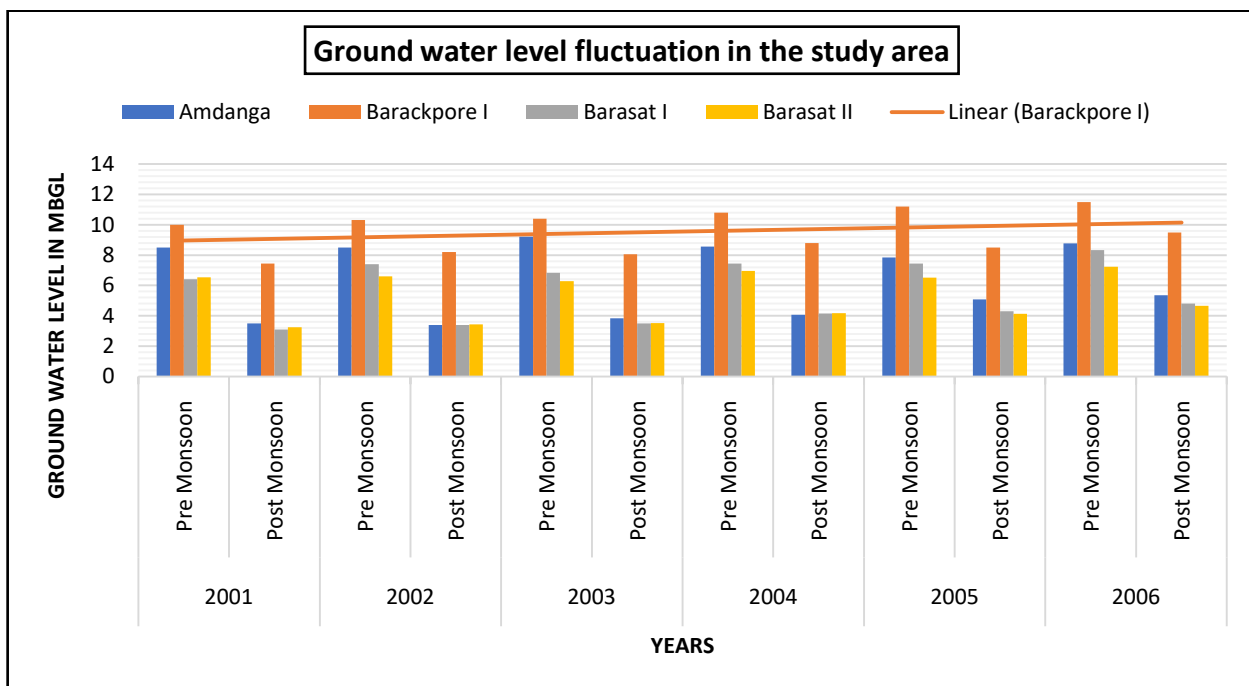
Fig No. 5. Ground water level fluctuation
Source: Ministry of Environment, Forest and Climate Change Notification S. O. 3611 (E),
Dated 25th July 2018

In the figure below (Fig no.6) the stack bars shows at a glance, the change in percentage share of the land cover and land use changes in the region under study. The land use and land Cover changes that took place in the study area over these years may be divided into three phases for a better understanding. In the initial phase from 1972 to 1989, (Fig 7) a period of 17 years shows a positive rise with respect to agriculture(+1) and settlement (+9) practices in percentage and a negative share in wetland area (-18), dry fallow (-9) and moist fallow (-3) areas in percentage. The scenario slightly changed during the second phase in between 1989-2006 (Fig 8) in the next 17 years. This was the ideal phase when the wetland area coverage again showed a marked increase by (+ 45) percent during this time along with dry (+10) percentage and moist fallow (+1) percentage of lands. However, agriculture (-11) and settlement (-7) percentage kept diminishing. The next phase is of 2006 to 2017, (Fig 9), again a period of 11 years shows a completely dismal picture of the study area. This period marked the growth of human settlement keeping in tune with the increasing population of the district. The initiation of the degradation of the wetland area may be ascribed to this phase when the graph of human settlement started to take off. Except human settlement accounting for (+11) percentage of increase, all the other land use classes show a steady decline with (-36) percent decline in wetland area followed by a minor (-1) percent decline in agriculture, dry and moist fallow respectively.

Corresponding to the changes in the five selected landuse classes it was also observed that the although changes occurred in cases of land used for settlement purpose or land put to use for cultivation purpose, there was no marked change in case of moist fallow land that may be defined after Sander et.al. as a transition period between rice crops when the soil undergoes various tillage regimes depending on the farmer's choice of management strategy. In some cases, the field remains flooded especially when water scarcity is not a problem. In case of dry fallow period, the field is left dry until land is prepared for the next crop, or it can undergo some tillage while under fallow. Also, the field goes through drying and wetting conditions when rains occur during the fallow period. There is also no marked change noticed in case of dry fallow land.
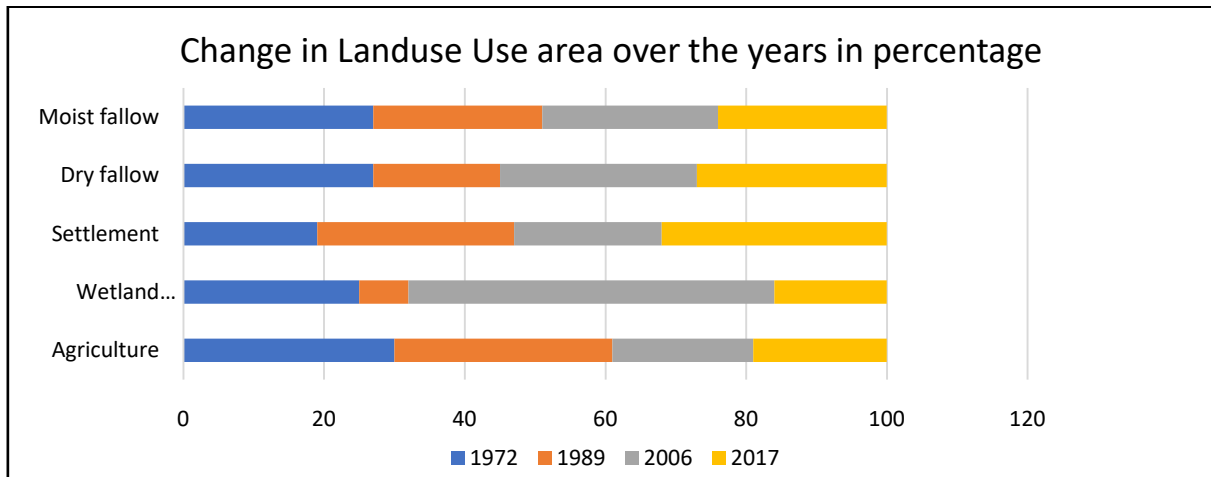
Fig.No. 6
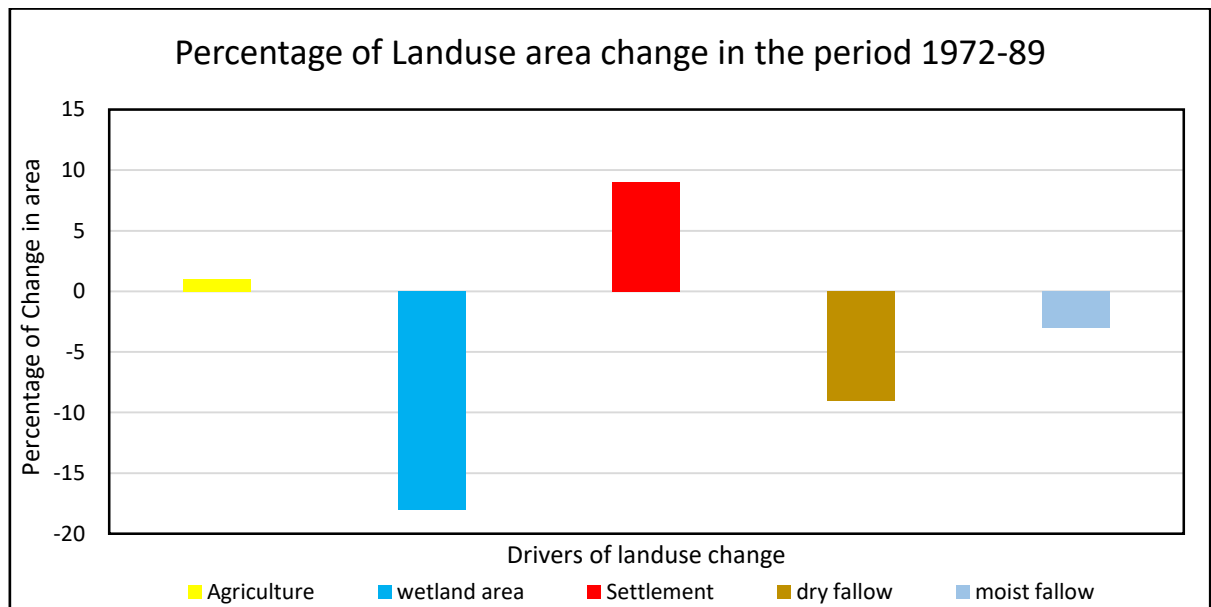
Fig. No.7
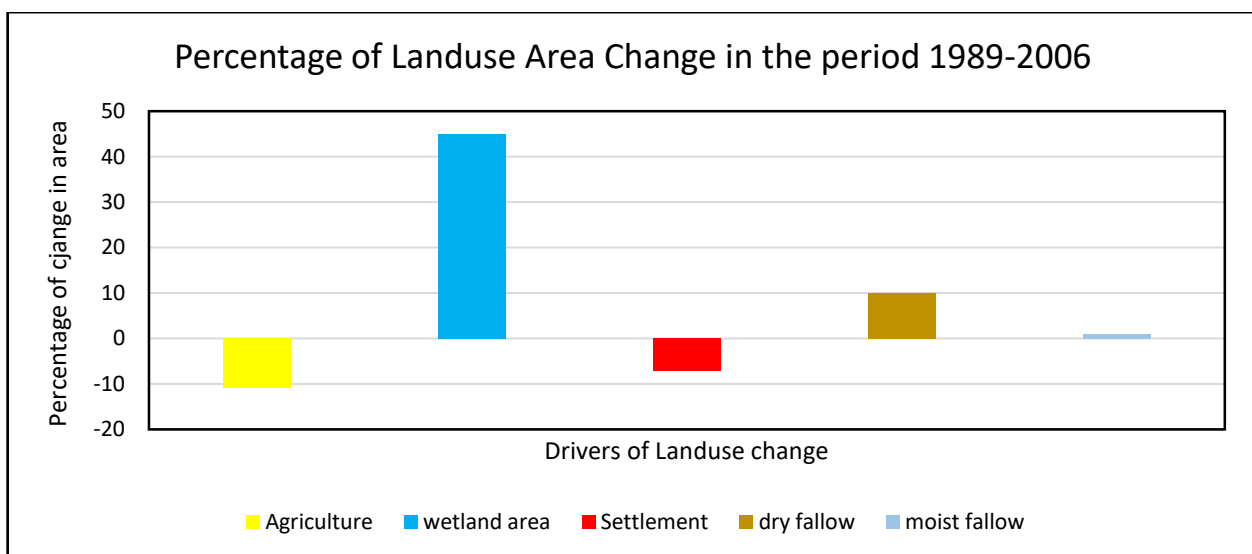
Fig. No.8
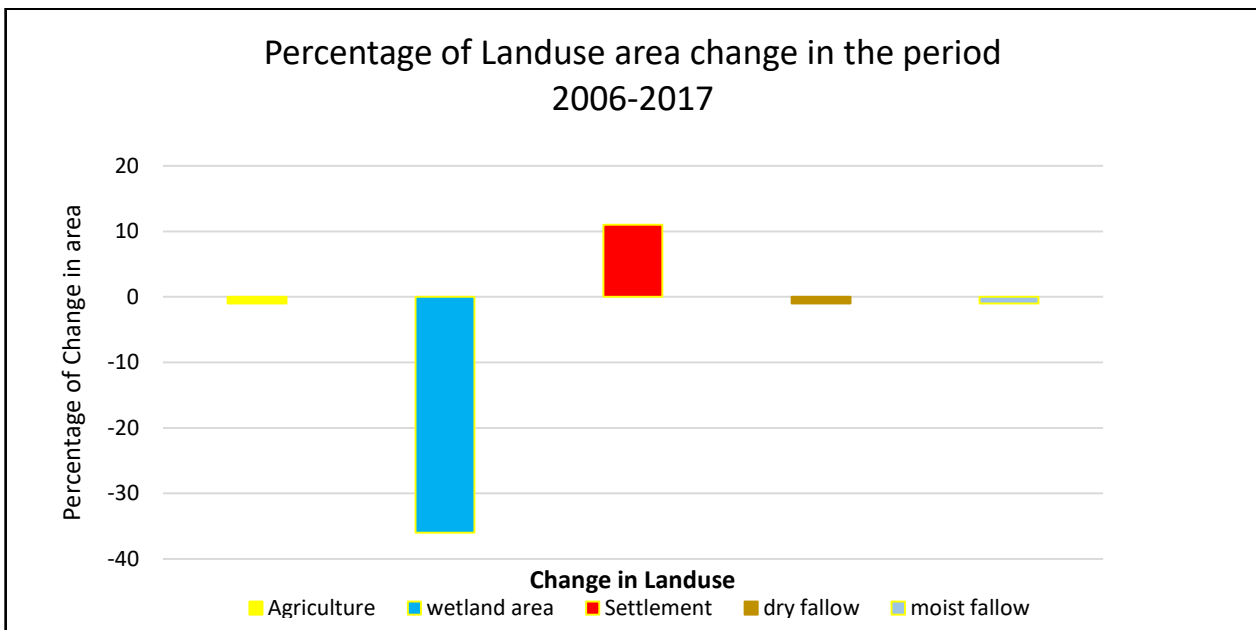
Fig No.9
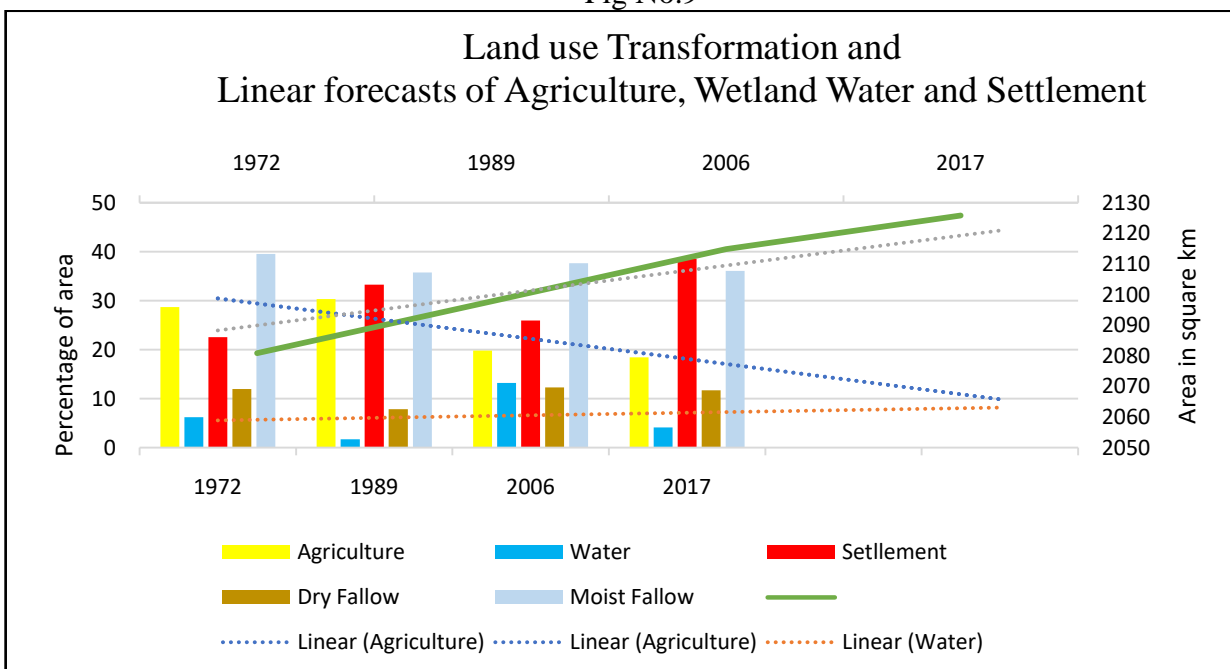
Fig No.10

The linear forecasts computed in the graph above (Fig 10) from the available data indicate that the settlement and housing development would continue to increase in future keeping in mind the burgeoning population in the state. The water content of the wetland would continue to fluctuate and may improve with only proper conservation of the Nowai and other canals, banning of further encroachment by human beings and implementation of proper managing techniques in the wetland area. The agricultural practices however show a very insubstantial expectation with mostly indication of decline of this activity in the vicinity of the area in near future thus paving way to rapid urbanization.

Major Findings

Land use changes have enormous impact on the overall environment. Land use change apart from bringing in economic development in the region along with overall infrastructural development is however lopsided as the other side effects of it on the environment are undesirable. When reclaimed wetland is put to use for any kind of infrastructural development it leads to non-point source water pollution, increased overland or storm water flow from

the concretization of roads, rapid pace of urbanization as a follow up of economic development leads to air pollution, formation of heat islands etc. Land utilized for agricultural purpose can affect the quality of water of the beel, result in loss of native species and reduce biodiversity, it can also lead to fragmentation of the wetland area where wetland habitat is separated by agricultural patches. The study above indicates the following findings:

- The study indicates a massive loss of wetland area by 36% in 2017 compared to the last phase from 1989-2006. The loss of wetland area has resulted in the regional ecological disbalance. The numbers of migratory birds nesting in the wetland have also declined as was found from field interviews.

- The agricultural activity has also declined by 11% in 2017 compared to 1972. The decline in fertility of the soil may be a reason for this decline. The farmers here in this wetland find it difficult to grow and harvest crops because of this lack of fertility of the soil during the pre-monsoon and post monsoon times. The only way of utilizing the beel was to convert the wetland into small bheries for pisiculture. However, this use of the land also does not show very remunerative prospect.

- The increase in human habitation shows an increase by 13% indicating the transformation of the wetland area to a dwelling habitat for human beings. The rapid rate of rise in population and a shift from a completely rural to a urban area may substantiate the fact. Many villages comprising the wetland have turned into towns as per the 2011 census suggesting the rapid rate of urbanization and above transformation.

- The fragmentation of the wetland area is a result of the various human interventions in the form of agricultural activity, pisiculture, human settlement, and infrastructural development.

- As gathered from locals during field study, the water of the beel has become polluted over the years from the industrial effluents discharged and also from the use of various

pesticides by farmers. Thus, the agricultural activity may be partly responsible for this decline in water quality of the beel.

- The change in land use and human interventions have disturbed the pristine wetland and this have resulted in less no of migratory birds nesting in the area, loss of many native species due to disturbed ecology, thus transforming the wetland.

- Wetlands acting as a sponge to absorb any excess water in the form of storm water which helps in maintaining the hydrology of the region. Now with urbanization and concretization and the loss of wetland area, any excess water may cause severe flood in the region.

Suggestions

The land use change of a wetland area has severe ecological, agricultural and economic implications. The study is therefore important as a first step towards quantification of the rate and volume of wetland area change in the study area. The second step towards land use management is to look for institutional regulatory interventions for addressing the negative changes that accentuate degradation. The third step should be to introduce new improved agricultural techniques and reform all the strategies in this regard. The fourth step should be to divert the rural economy towards other uses apart from depending on the wetland area. The promotion of ecotourism, zonation to regulate human activities in the wetland area and taking wetland restoration strategies are the following steps towards wetland land use management. Also mention may be made of all the canals connected to the wetland that needs to be desilted occasionally to maintain the water flow regime of the wetland. The maintenance of water quality is also very essential at regular intervals for sustaining the wetland health.

Conclusion

The landuse and land cover changes refer to the change in spatial dimension of land use over a temporal variation. The changes in land utilization are brought about by various drivers both biotic and a-biotic. The above study could identify the drivers of change in land use pattern of the wetland area. It was necessary to

find out ways to plan a proper land use design to arrest the undesirable changes taking place in the land use and land cover. This quantification of the rate and volume of change in a wetland area with the help of geospatial technology and ground level survey was necessary to combat all the ecological, climatic as well as economic implications for achieving the future sustainable goal in regard to wetland land use management.

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PERCEPTION ABOUT PLASTIC WASTE MANAGEMENT OF LOCAL PEOPLE OF THE HILLY REGION :A CASE STUDY OF DARJEELING DISTRICT ,WEST BENGAL

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ABSTRACT

Plastic products have become an integral part of our daily life and as a result of which now a day the plastic polymer is produced at a massive scale worldwide. On an average, the production of plastic globally crosses 150 Million tonnes per year. Its broad range of application is in packaging films, wrapping materials, shopping and garbage bags, fluid containers, clothing, toys, household and industrial products, and building materials. It is estimated that approximately 70% of plastic packaging products are converted into plastic waste in a very short span. Approximately 9.4 million TPA(tonnes per annum) plastic wastes are generated in the country, which amounts to 26,000 TPD(tonnes per day). Of this, about 60% is recycled, most of it by the informal sector. While the recycling rate in India is considerably higher than the global average of 20%, there is still over 9,400 tonnes of plastic waste which is either disposed in landfill or ends up polluting air and water bodies. Plastic Waste Management has assumed great significance in view of the urbanisation activities. Plastic wastes generated by the polymer manufacturers at the different stages like production, extrusion, quality control & laboratory testing etc., as well as, from the consumer's end require urgent disposal and recycling facilities to avoid health hazards. Various strategies are being devised to mitigate the impact of plastic waste in West Bengal. The study investigated plastic waste management practices in the 'Mall market' region households along the Darjeeling Coochbehar road as case study sites. The aim of the study was to investigate plastic waste management practices employed by the households through the identification of the types of plastic waste generated, estimation of the average daily amount of generated plastics and establishing their management practices. The study concluded that most of the households are still using traditional methods of managing plastic waste, even though recommended plastic waste management practices such as reusing and recycling were found amongst some households in the Darjeeling Coochbehar road.

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Keywords: plastic wastes, landfill, waste management, health hazard, reusing, urbanisation, disposal

Introduction

Non-biodegradable plastic waste is one of the significant environmental problems in developing countries like India. Plastic also poisons the seas and oceans. Tons of plastic packaging wastes are inundated at the bottom of the seas and oceans creating adverse impact on marine biodiversity. The plastic bags and other items are broken down into small pieces and they are eaten by fish and other sea mammals resulting in various metabolic disorder. Plastic is versatile, lightweight, flexible, moisture resistant, strong, and relatively inexpensive. Those are the attractive qualities that lead us, around the world, to such a voracious appetite and overconsumption of plastic goods. However, the properties like durability and very slow degradability made plastic materials ultimately becoming waste. Our tremendous attraction to plastic, coupled with an undeniable behavioural propensity of increasingly over-consumption, discarding, littering and thus polluting, has become a combination of lethal nature. The disposal of

plastics into nature is one of the least recognized aspects of plastic usage in our daily life and therefore we are heading towards irreversible ecological impact. Ironically, one of plastic's most desirable traits: its durability and resistance to decomposition, is also the source of one of its greatest liabilities when it comes to the disposal of plastics. The natural microorganism is not capable of breaking down the synthetic chemical bonds in plastic, creating the tremendous problem related to the material's persistence in natural ecosystem.

Types of Plastic Waste

a. **Microplastics** are small plastic pieces of less than five millimeters in size.

- Microplastic includes microbeads (solid plastic particles of less than one millimeter in their largest dimension) that are used in cosmetics and personal care products, industrial scrubbers which are used for aggressive blast cleaning, microfibers used in textiles

and virgin resin pellets used in plastic manufacturing processes.

- Apart from cosmetics and personal care products most of the microplastics result from the breakdown of larger pieces of plastic that were not recycled and break up due to exposure to the sun or physical wear.

b. **Single-use plastic** is a disposable material that can be used only once before it is either thrown away or recycled, like plastic bags, water bottles, soda bottles, straws, plastic plates, cups, most food packaging and coffee stirrers are sources of single use plastic.

Plastic Waste Generation in India

- According to the **Central Pollution Control Board (CPCB)**, India generates close to 26,000 tonnes of plastic a day and over 10,000 tonnes a day of plastic waste remains uncollected.(2019-20)
- According to a **Federation of Indian Chambers of Commerce and Industry (FICCI)** study the plastic processing industry is estimated to grow to 22 million tonnes (MT) a year by 2020 from 13.4 MT in 2015 and nearly half of this is single-use plastic.(2017)
- India's **per capita plastic consumption** of less than 11 kg, is nearly a tenth of the United States of America (109 kg).(2018)

Brief Description of the Study Area

Darjeeling town is situated between 26°31' to 27°31' N and 87°59' to 88°53' E in the district of Darjeeling , West Bengal. It is one of the prided tourist town of West Bengal. Every year this town is visited by thousands of tourist from within the country as well as from foreign countries. Darjeeling lies in fragile ecology zone. In recent years this small town has seen an increase in the natural calamities as landslides during monsoon. Most of the people are of the view that this increase can be attributed to the urbanisation with sharp increase in population, mass tourism as well as the excessive use of plastics and its inadequate management system in the town. Individual Volunteers, Club Members, Members of KRFC Students and teachers from 'Ghoom Jorebunglow Degree College' and people from

every walk of life, came together to lend a hand to the first ever massive and widespread effort to clean up the mountains and do something about the growing plastic waste accumulation that threatens the beauty of mountains across India.

In short, plastic waste management is the efficient and precise conversion of plastic waste into innovative products that are better, environmentally-friendly, and cost-effective.

Advantages of implementing plastic waste management:

- Reduced environmental pollution
- Reduced virgin plastic production
- Reduced toxic waste generation
- Localised employment opportunities
- Energy savings
- Protection of native plant and animal species

Literature Review

Youcef Ghernouti et al. 1 The study present the partial replacement of fine aggregate in concrete by using plastic fine aggregate obtained from the crushing of waste plastic bags. Plastic bags waste was heated followed by cooling of liquid waste which was then cooled and crushed to obtained plastic sand having finesse modulus of 4.7. Fine aggregate in the mix proportion of concrete was replaced with plastic bag waste sand at 10%, 20%, 30% and 40% whereas other concrete materials remain same for all four mixes. In fresh properties of concrete it was observed from the results of slump test that with increase of waste content workability of concrete increases which is favorable for concrete because plastic cannot absorb water therefore excessive water is available. Bulk density decreases with increase of plastic bags waste. In harden state, flexural and compressive strength were tested at 28 days and reductions in both strengths with increasing percentage of plastic bag waste sand in concrete mix. Plastic waste increases the volume of voids in concrete which on other hand reduce the compactness of concrete simultaneously speed of sound in concrete is also decreased. Strength reduction in concrete mix was prime concern; however they recommend 10 to 20% replacement of fine aggregate with plastic aggregate. Use of admixtures to address the strength reduction

property of concrete with addition of plastic aggregate is not emphasized.

Raghatate Atul M.2 The paper is based on experimental results of concrete sample casted with use of plastic bags pieces to study the compressive and split tensile strength. He used concrete mix by using Ordinary Portland Cement, Natural River sand as fine aggregate and crushed granite stones as coarse aggregate, portable water free from impurities and containing varying percentage of waste plastic bags (0%, 0.2%, 0.4%, 0.6% 0.8% and 1.0%). Compressive strength of concrete specimen is affected by the addition of plastic bags and with increasing percentage of plastic bag pieces compressive strength goes on decreasing (20% decrease in compressive strength with 1% of addition of plastic bag pieces). On other hand increase in tensile strength of concrete was observed by adding up to 0.8% of plastic bag pieces in the concrete mix afterward it start decreasing when adding more than 0.8% of plastic bags pieces. He concluded that utility of plastic bags pieces can be used for possible increase in split tensile strength. This is just a basic study on use of plastic bags in concrete. More emphasis was required by varying the shape and sizes of plastic bags to be use in concrete mixes.

Zainab Z. Ismail et al. [2007]3 they have conducted comprehensive study based on large number of experiments and tests in order to determine the feasibility of reusing plastic sand as partial replacement of fine aggregate in concrete. They conducted tests on concrete samples for dry/fresh density, slump, compressive and flexural strength and finally toughness indices on room temperature They have collected waste plastic from plastic manufacture plant consist of 80% polyethylene and 20% polystyrene which was crushed (varying length of 0.15-12mm and width of 0.15-4mm). Concrete mix were produce with ordinary Portland cement, fine aggregate (natural sand of 4.74mm maximum size), coarse aggregate (max size below 20mm) and addition of 10%, 15% and 20% of plastic waste as sand replacement. Their test results indicate sharp decrease in slump with increasing the percentage of plastic, this decrease was attributed to the presence of angular and non uniform plastic particles. In spite of low slump

however, the mixture was observed with good workability and declared suitable for application. Their tests also revealed the decrease in fresh and dry density with increasing the plastic waste ratio; however increase was reported in dry density with time at all curing ages. Decrease in compressive and flexural strength was observed by increasing the waste plastic ratio which can be related to decrease in adhesive strength between plastic waste particles with cement. However, load-deflection curve of concrete containing plastic waste showed the arrest of propagation of micro cracks which shows its application in places where high toughness is required. The study has shown good workability in spite of low slump but w/c content kept constant in all samples. They should have reduced the water content in order to improve the strength when workability was not an issue.

A Bhogayata et al. [2012] 4 they have studied the environment friendly disposal of shredded plastic bags in concrete mix to be use in construction industry which have dire need for alternative material to be use in lieu of conventional materials. Different test results were analyzed after testing on 48 x concrete cubes(150mm x 150mm x150mm) prepared from varying percentage of polyethylene fibers (0.3, 0.6, and 0.9 to 1.2% of volume of concrete) with conventional concrete material to prepare mixes. Two type of plastic bag fibers were used, one cut manually (60mm x 3mm) and another shredded into a very fine random palettes. Cubes were tested for 7&28 days compressive strength and compaction. They concluded that good workability was shown by the mix added with shredded fibers due to its uniform and higher aspect ratio evenly sprayed in the mix. Addition of plastics up to 0.6% is considered suitable after which reduction in compressive strength and compaction is seen affected. They observed that strength loss was less in concrete having shredded fibers of plastic as compare to hand cut macro fibers. Their research focus was only on comparative study of compressive strength but no work was carries out on other concrete properties like tensile strength, modulus of elasticity and density of concrete.

Pramod S. Patil.et al 5 This study presents the use of plastic recycled aggregate as

replacement of coarse aggregate for production of concrete. They used forty eight specimen and six beams/cylinders casted from variable plastic percentages (0, 10, 20, 30, 40 and 50%) used as replacement of coarse aggregate in concrete mixes. They have conducted various tests and observed decrease in density of concrete with increase percentage of replacement of aggregate with recycle plastic concrete. They also reported decrease in compressive strength for 7 and 28 days with increase in percentage of replacement of coarse aggregate with recycle plastic aggregate. They have recommended feasibility of replacing 20 % will satisfy the permissible limits of strength. Again these researchers limited their research to only compressive strength property and no work was carried out to study the other important properties of concrete. Their research also lacks use of various admixtures in concrete to cater for the loss in strength.

P. Suganthy et al.[2013]6 This study investigate the application of pulverized fine crushed plastic (produce from melting and crushing of high density polyethylene) as replacement of fine aggregate in concrete with varying known percentages. Their main focus was on optimum replacement of natural sand by pulverized plastic sand. Five concrete mixes were produced from specified concrete materials having replacement of fine aggregate (sand) by 0, 25, 50, 75 and 100% respectively to study the test graph results of various concrete properties. The results showed increase in water/cement ratio with increase replacement of sand with plastic particles to achieve desired 90mm concrete slump. They have also observed from the results that gradual decrease in strength of concrete specimen for plastic replacement up to 25% but afterward the decrease in strength israpid which shows suitable replacement up to 25% of sand with plastic pulverized sand. They have also concluded after testing of specimen (having different proportion of plastic replacement) for Ultimate and yield strength that both strength decreases with increase replacement of sand with pulverized plastic particles. Their study lacks detailed testing of properties of concrete because only compressive strength and w/c ratio tests will not be sufficient to study the matrix as a whole

to be suitable for construction. No efforts were made to explore the use of admixtures in controlling of compressive strength reduction in a mix containing pulverized plastics.

Objectives

1. Identification of Types of plastic waste which are daily used by every households in the study area
2. To study the plastic waste management system in Darjeeling coochbehar road local area
3. To know the status of people's perception about plastic waste management in local area
4. To investigate the present scenario of plastic waste disposal place in the hilly region
5. To know the concern about segregation of biodegradable and non biodegradable wastes of all households
6. To know the people's knowledge about plastic pollution which stated in local media

Material and Methods

- The site survey and 'one – to – one interview' methods were adopted to conduct the study. The randomly selected local households of Darjeeling coochbehar road hilly region have been surveyed for plastic wastes generation every day and the scenario of waste management is really well developed. In the present study a total of 20 households are selected for their concern about plastic waste management. Majority of people are well aware about the threat of the use of plastics materials and its disposal. The short survey was conducted from 21st June to 24th June (3 days)

The details of the methodology used for this study are given below.

1. Detail survey was conducted in local households of the study area. The Darjeeling Cooch behar road is one of the most developed residential areas in the region. Moreover, a huge number of hotels are located here including popular 'Mall market' which is overcrowded throughout the year for the tourist.
2. Total 20 households under the study area were interviewed to collect information on

the plastic waste management scenario which is generated daily from their day to day work. A standard questionnaire was used for the purpose of interview.

3. In the questionnaire a rating scale has been used for all households so that they can give a rating about plastic pollution in their area. The range in the scale was set from 0 to 5 with decreasing plastic pollution.

4. 20 households were surveyed to understand their view about plastic pollution and the threats of plastic waste during the peak time of tourism

5. Mall market area was visited several times to acquire practical experience about the use of plastic products by seller and consumer also.

Results and Discussion

Table - 1 Plastic Waste Generation From Each Household And Mode Of Plastic Waste Disposal

House No	Name Of The Respondant	Sex	Age	Daily Plastic Waste Generated From House (Approx /Gm)	Dumping Place
House No 1	Amal Chetri	M	30	7	Hand Over To Waste Collector
House No 2	Lily Tamang	M	29	8	Collection Bin Placed Near Roadside
House No 3	Malay Gurum	M	40	9	Collection Bin Placed Near Roadside
House No 4	Saman Chetri	M	41	8	Collection Bin Placed Near Roadside
House No 5	Prayash Thapa	M	45	7	Hand Over To Waste Collector
House No 6	Arshid Gurum	M	38	9	Hand Over To Waste Collector
House No 7	Ramjan Mahato	M	50	9	Hand Over To Waste Collector
House No 8	Anik Lama	M	49	10	Collection Bin Placed Near Roadside
House No 9	Shankar Lama	M	50	9	Collection Bin Placed Near Roadside
House No 10	Mankar Bhave	M	42	10	Collection Bin Placed Near Roadside
House No 11	Sangat Chetri	M	41	9	Collection Bin Placed Near Roadside
House No 12	Mahal Chetri	M	47	8	Collection Bin Placed Near Roadside
House No 13	Tabasum Gurum	M	46	8	Collection Bin Placed Near Roadside
House No 14	Rahan Khawas	M	44	7	Hand Over To Waste Collector
House No 15	Nandaja Tamang	M	49	8	Collection Bin Placed Near Roadside
House No 16	Mardam Khuswana	M	42	7	Collection Bin Placed Near Roadside
House No 17	Rangan Paswan	M	47	7	Collection Bin Placed Near Roadside
House No 18	Angad Tharu	M	43	10	Hand Over To Waste Collector
House No 19	Kalyan Lama	M	44	9	Hand Over To Waste Collector
House No 20	Pushkar Pillai	M	49	7	Collection Bin Placed Near Roadside

The information about the perception of plastic waste management of local residents has been gathered from a very short time survey work in the study area where both the residential houses and shops are located. The respondents of the survey are all between 20 to 50 years old. The heads of the families surveyed are engaged either in business or in government services. Everyone has given their opinion about the use of plastic in daily life and also plastic waste generation .According to the survey done on 20 households, the average plastic waste generation from each household about 8 to 10 grams per day . The most admirable point is that they do not throw plastic waste where ever they are, but dump waste to waste collectors in roadside dustbins. Some respondents are aware of the fact that the government has completely banned the use of plastic products in hill area. During the survey everyone in the whole sample size excepting one person expressed their view on plastic waste management in positive note. They are satisfied with the ongoing planned waste management system.

Table -2 Rating About Plastic Waste Management In The Locality

House No	Name Of The Respondant	Rating
House No 1	Amal Chetri	3
House No 2	Lily Tamang	4
House No 3	Malay Gurum	4
House No 4	Saman Chetri	5
House No 5	Prayash Thapa	2
House No 6	Arshid Gurum	3
House No 7	Ramjan Mahato	3
House No 8	Anik Lama	3
House No 9	Shankar Lama	4
House No 10	Mankar Bhave	4
House No 11	Sangat Chetri	4
House No 12	Mahal Chetri	4
House No 13	Tabasum Gurum	4
House No 14	Rahan Khawas	4
House No 15	Nandaja Tamang	5
House No 16	Mardam Khuswana	5
House No 17	Rangan Paswan	5
House No 18	Angad Tharu	5
House No 19	Kalyan Lama	4
House No 20	Pushkar Pillai	4

SCALE -0-5 .0-highly polluted , 5- least polluted

Maximum households under the survey gave their rating either 4 or 5 indicating low level plastic pollution in their locality. Many of them stated that plastic waste management is really satisfactory and local NGOs and clubs have taken initiatives for campaigning against plastic pollution and increasing awareness of the local community.

Table 3 Disposal Methods For Plastic Wastes Adopted By Households

Handover To Waste Collectors	Municipal Corporation Collection Bins	Open Dumping	Burning
7	13	-	-

Pie Graph Showing Disposal Methods For Plastic Wastes Adopted By Households
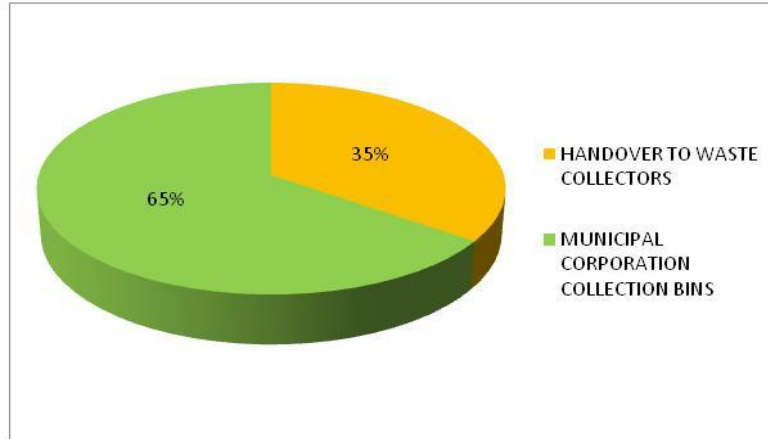
Maximum households are really aware of the danger of plastic pollution. The door to door survey revealed that 35% of the families handover the plastic wastes and other wastes to the local waste collector and 65% of the families disposed their plastic wastes to the collection bins of municipal corporation .It is to note that they do not use any method of open dumping and burning of waste materials. Also it has been come to know from some households that even if the tourists throw plastic carelessly in public places, the civic authority takes appropriate measures by imposing fine for that act.

Table 4 – Use Of Alternatives Of Plastic Bags By Households For Shopping

House No	Name Of Household	Plastic Bags	Paper Bags	Cloth Bags	Others
House No 1	Amal Chetri		√		
House No 2	Lily Tamang			√	
House No 3	Malay Gurum	√		√	
House No 4	Saman Chetri	√			
House No 5	Prayash Thapa		√		
House No 6	Arshid Gurum		√		
House No 7	Ramjan Mahato	√		√	
House No 8	Anik Lama	√		√	
House No 9	Shankar Lama				√
House No 10	Mankar Bhave				√
House No 11	Sangat Chetri				√
House No 12	Mahal Chetri	√	√	√	
House No 13	Tabasum Gurum	√	√	√	
House No 14	Rahan Khawas		√	√	
House No 15	Nandaja Tamang		√	√	
House No 16	Mardam Khuswana				
House No 17	Rangan Paswan	√		√	√
House No 18	Angad Tharu	√		√	√
House No 19	Kalyan Lama		√	√	
House No 20	Pushkar Pillai		√	√	

Although they do not use any polyethylene bag in their daily life, they use plastic buckets, plastic bottles, packaging materials and some disposable plastic products. The survey also revealed that when someone use ,plastic bottles they painted a colourful image on it after use and planted a tree sapling in it. In this way waste plastic bucket and bottles are reused with planted trees with the help of soil .The rest of the plastic waste material was thrown in the dustbin on the side of the road.

Members of majority families carry paper bags or cloth bags with them when they go for shopping. However, some middle class families expressed their view that they carry plastic bags because the cloth bags and paper bags are costlier than plastic bags. The shopkeepers often ask people to come to the market with cloth bags.

Conclusion

Plastic is undeniably one of the most used materials in the world. However, the current condition of handling plastic waste is causing irreversible harm to the environment, and this impact has caused environmentalists to hastily call off the use of plastics altogether. There are four municipalities such as Darjeeling, Kurseing, Mirik and Kalimpong lie in the autonomous hill districts of Darjeeling and Kalimpong. These places are also popular tourist destinations and accordingly have a significant amount of floating population .Although it is a tourist place but it is well understood during survey that all the rules and regulations set by the government on plastic waste, every person here follow properly. Even tourists are fined if they inadvertently throw plastic anywhere. Plastic Waste Management has assumed great significance in view of the urbanisation activities and it is clearly seen that the people of the areas along the Darjeeling coochbehar road are very much concerned about plastic pollution and its impacts. They always try to maintain environment-friendly plastic waste disposal **solutions.** In this process it seeks to ban the use of plastic bags and plastic products, and reduce plastic littering across the locality. This waste, if not managed properly, has numerous ill-effects on the environment and living beings. The local people follow some simple ways to reduce plastic waste generation like,

- During shopping time they bring their own bag
- Stop to buying the bottle water frequently
- Carry their own thermos to the coffee shop
- Skip the disposable razor
- Switch from disposable diapers to cloth
- Re-think about their food storage

People in the hilly region of Darjeeling are cautious about the plastic pollution as well as safe disposal of plastic waste. Everyone here is highly cooperating in reducing plastic waste to keep their city clean and follow all the rules and regulations of clean city.

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PERCEPTION OF SCHOOL-CHILDREN ON THE USE OF PLASTIC AND IT'S IMPACT ON ENVIRONMENT: A CASE STUDY ON CHRIST'S MISSION PUBLIC SCHOOL, KOLKATA, WEST BENGAL

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ABSTRACT

Plastic, the most widely used non-biodegradable product makes a greater concern to the world nowadays; specifically when it turns into micro level (micro-plastic). This study tries to find out about the awareness and the perspective of the school-children towards the plastics and its alternatives. The study has also emphasized on the knowledge of micro-plastics among the pupils which sound so unfamiliar to them. But most of them have supported to ban this material and ready to accept the alternatives such as bio-plastics. The report was based on their viewpoint and aims to aware people through them to make an eco-friendly environment.

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Keywords: *plastics, micro-plastics, alternatives of plastic, bio-plastics, awareness*

Introduction

Plastic is a synthetic material which is widely used in a variety of different sectors. It has high molecular weight and it is made up of organic compounds such as ethylene, vinyl chloride, vinyl acetate, vinyl alcohol and so on. The basic components required for the production of plastic are obtained from petroleum, natural gas and coal. Due to its light weight, strength, durability, low cost, design capabilities and easy availability, plastic has a wide range of applications such as packaging, construction, electrical goods, furniture, automobiles, household, medical equipments like disposal syringes, intravenous bags etc.

As a result of extensive applications, the production of plastic has been also increased, which has lead to numerous environmental issues. As plastics are not readily degraded and are very stable in the environment, their disposal created a considerable pollution problem. When plastic is disposed off, it does not decompose easily and pollutes the land, air and water. When it is burned in the open air it pollutes the air and when it is dumped in the landfills, it interacts with the water and forms hazardous chemicals. When these chemicals seep into the underground, it pollutes the groundwater and degraded the water quality.

There are another type of plastic which also has adverse effect in the environment and ecosystem i.e. micro-plastic. Tiny fragments, fibers and granules of plastic are termed as micro-plastic. These micro-plastics are of two types namely primary micro-plastics and secondary micro-plastics. Primary micro-plastics are manufactured to be of microscopic size and these are used in facial cleansers, cosmetics or as air blasting media while their use as vectors for drugs is also increased, whereas secondary micro-plastics are defined as tiny plastic fragments that are derived from the breakdown of larger plastic debris. Due to their micron size particle nature, the micro-plastics are mistaken as food and ingested by the marine biota such as corals, planktons, sea urchins, lobsters and fishes etc and ultimately transferred to the higher trophic level. The harmful effects of micro-plastic ingestion are an issue of concern especially in case of sea birds as this could cause alteration in their feeding behavior, reproduction and mortality. (Kara Rogers, 2020)

Such environmental problems related with the disposal of non biodegradable plastic litter can be reduced by biodegradable plastics that are termed as bio-plastics or some other reusable alternatives. Bio-plastics are made up of biomass such as sugarcane and corn. These bio-plastics have capability to improve the environmental impacts. It can reduce green house gas emission and save fossil fuels; able to reduce land litters and environmental

pollution. Bio-plastics could be a good replacement of plastics only by banning the use of one-time used plastics and public awareness.

Literature Review

Dhanya.Babu et al.(2016) conducted survey on plastic usage among the Teenagers at Alappuzha Town, Kerala where it found that plastic pollution has become a global problem and an incredible number of research is being carried out to study the effects of it on living organisms. As plastic is non-biodegradable, it cannot be removed from the Earth and thus it causes various life threatening changes in the physiology of living organisms exposed to chemicals leaking from them. Plastic is made up of polystyrene and polyvinyl chloride. The study reported that the rate of plastic piling up has been increased in the Marine environment. Floating plastic fragments have been reported in the Northern Hemisphere Subtropical gyres since the early 1970's in the North Atlantic and North Pacific. Plastic pollution, originating from sea and land based sources, migrates into subtropical gyres where it forms accumulation zones of micro-plastic particles distinct from surrounding waters relatively free of plastic pollution. Plastic pollution enters the marine environment via rivers, beaches, maritime activities and illegal dumping at sea. Under the effects of UV degradation and hydrolysis, plastic loses its elasticity and by wind and waves it gradually breaks into smaller particles. And these smaller particles are mistaken by the Marine animals as food and it affected them through entanglement and ingestion. According to this study government bodies should have been taken control measures in the form of fine, penalty and ban in order to control the use of plastic.

Siddiqui and Govind Pandey (2013) a review study on plastic waste management stated that plastics have made significant contributions in almost every field of human activity like agriculture, medical, transportation, piping, packaging, manufacturing of household and electronic goods etc. Packaging is one of the most important applications of plastic. About 40% of plastic materials worldwide are used in packaging applications. Versatility of plastics has allowed creating an efficient pilfer proof, hygienic and cost effective packaging of food products like milk, spices, edible oil, bread, confectioneries, rice, wheat, snack, foods and various types of Medicines. Plastics are also used for packaging of toiletries, cosmetics in urban cities or in the villages. Despite all these benefits, plastic is contributed towards causing waste management problems and choking of the drains in urban cities. The solution to waste management problem lies in segregation of solid waste at the source for which an effective mass awareness campaign is very important. Various schemes are being implemented to mitigate the impacts of plastic waste in India. Recycling is one such scheme for waste management of plastic products. Recycling of waste plastics is an efficient way to improve the environmental performance of the polymer industry.

Prof. T. Z. Quazi et al.(2015) conducted a Study at Thane Municipality Corporation in Navi Mumbai, India on 'Sustainable Plastic Waste Management'and found that Thane is growing rapidly since last few decades and the solid waste generation in the Thane Municipal Corporation area is around 650 MT per day, out of which plastic waste generation is about 60-70 MT per day. Thane Municipal Corporation don't have any system for processing this plastic waste. Most of the big cities in country produce waste at a rate that outpaces its capacity to collect and dispose it off in a environmentally safe and sound manner. It's need proper management. Plastic waste pyrolysis is an ideal technology which is eco-friendly as well as generates furnace oil, carbon and hydrocarbon gas as productive output.

Saharan et al. (2012) conducted a review on 'Bio-plastics For Sustainable Development' and stated that bio-plastics can be defined as plastics made of biomass such as corn and sugarcane. These substances have been increasingly highlighted as means for saving fossil fuels, reducing CO_2 emission and plastic wastes. Biodegradability of bio-plastics has been widely publicized in society and the demand for packaging is rapidly increasing among retailers and the food industry at large scale. Population growth has led to the accumulation of massive volume of non-degradable waste materials across our planet. The accumulation of plastic waste has become

a major concern in terms of the environment. Conventional plastics not only take many decades during decomposition, but also produce toxins while degradation. Hence, there is need to produce plastics from materials that can be readily eliminated from our biosphere in an "eco-friendly " manner. Biodegradability of Bio-plastics has been widely publicized in society and the demand for packaging is rapidly increasing among retailers and the food industry at large scale. The plastic which is available in market is very dangerous as it is non-biodegradable. Therefore, it is the demand of the day that biodegradable plastics should be produced and used.

Objectives

1. To identify the various uses of plastic products and awareness about plastics among the school-goers.
2. To identify the kind of disposal of plastic bags in their daily life.
3. To verify the awareness about the adverse effects of using plastic products on environment and human health.
4. To examine the preferences of using alternatives of plastic products.
5. To recognize the awareness about micro-plastics and related hazards.

Materials and Methods

This survey was conducted through the method of interview among the students of IX to XII standards in Christ's Mission Public School, Kolkata. The selection of student was random specially those who were interested to attend the interview. This made a variation on the goal of the study and helped to identify 'the kind of plastic products are used regularly', 'the way of disposal is preferred', 'willingness of reusing plastic bags', 'awareness on environmental and health hazards for plastics', 'concept on micro-plastics and related hazards', ' kind of alternatives they would like' etc. The study was carried out on January to March, 2021. The detail methodology of the study is followed by-

Designing Survey Questionnaire:

The first step of the study was to form a questionnaire to carry out survey. Questionnaires are the most commonly used tool in survey research. However, the results of a particular survey are worthless if the questionnaire is written inadequately. Questionnaires should produce valid and reliable demographic variable measures and should yield valid and reliable individual disparities that self-report scales generate.

It needs to follow several steps to form a questionnaire that will produce reliable and valid results. These steps are -

➢ First, to decide what kind of information should be collected.
➢ Second, to decide how to conduct the questionnaire.
➢ Thirdly, to construct a first draft of the questionnaire.
➢ Fourth, the questionnaire need to be revised.
➢ Next, the questionnaire need to be pretested.
➢ Finally, the questionnaire is edited and the procedures for its use is specified.

Survey:

After forming the questionnaire, the survey was carried out through online and offline modes. In online mode, it is done through video calls and in offline mode personal interviews are done.

Sort Out The Survey Reports:

After completing the survey, the data were picked out by maintaining their accuracy.

Forming Report:

The report of the study was formed by analyzing the sorted data and then it was discussed briefly.

The standard questionnaire used for the survey is given herewith.

SECTION – I (Profiles of Respondents)

Name:

Sex: Age:

Educational background (Class):

SECTION – II (Survey Questions)

1.   Do you use plastic bags ?
       a) Yes (   )   b) No (   )

2.   What are the different kind of plastic products you usually use ?
       a) Bags (   )   b) Cups (   )   c) Bottles (   )   d) Packing   (   )

3.   Which plastic products do you use excessively ?
       a) Plastic bags (   )
       b) Plastic liquid containers {bottles} (   )
       c) Plastic buckets, bins and barrels (   )
       d) Plastic shoes (   )

4.   Why do you prefer to use the plastic products especially plastic
       Bags ?
       a) They are cheap (   )
       b) They are light weight (   )
       c) They are easy available (   )
       d) Lack of alternative materials (   )

5.   How often do you use plastic products ?
       a) Always (   )   b) Sometimes (   ) c) Seldom (   ) d) Never (   )

6.   In a week, how many plastic bags do you use ?
       a) 5   (   )   b) 6 – 10 (   )   c) 10 (   )

7.   From where you obtain plastic products ?
       a) Buy for use (   )   b) From shopping (   )

8.   After using plastic products, what do you do with it ?
       a) Dustbin (   ) b) Litter (   ) c) Reuse (   ) d) Burn (   )

9.   Do you reuse plastic products ?
       a) Yes (   )   b) No (   )

10. If yes, how many times you reuse plastic products ?
       a) Always (   ) b) Sometimes (   ) c) Seldom

11. Is the use of plastic products increasing ?
       a) Yes (   ) b) NO (   ) c) I don't know (   )

12. Are you aware of the environmental effects / impacts of plastic ?
       a) Yes (   ) b) No (   )

13. If yes, how many of the following impacts you aware ?
        a) Plastic contribute to global warming   (   )
        b) Burning of plastic leads to air pollution (   )
        c) When inhaled causes respiratory problems (   )

14. How would you feel if the government banned the use of
       Plastic products ?
       a) It doesn't bother me (   ) b) I think it is a great solution (   )

15. Do you think plastic should be completely banned ?
       a) Yes (   )   b) No (   )

16. If plastic are banned, what could be the alternatives ?
       a) Fabrics (   ) b) Paper (   ) c) Bio-plastic (   )

17. Do you hear about micro-plastics ?
       a) Yes (   )   b) No (   )

18. If yes, what are the sources of micro-plastic?
       a) Soda bottles (   ) b) Fishing nets (   ) c) Plastic products (   )

19. Do you know about the harmful effects of micro-plastics in
       Human health?
       a) Yes (   )   b) No (   )

20. If yes, which of the following you aware?
       a) Micro-plastics block digestive tracts (   )
       b) Micro-plastics reduce growth and reproduction (   )
       c) Causes some species starve and die in oceans; Water bodies( )
       d) Causes soil pollution (   )
       e) Damage immune system (   )

21. Do you aware about bio-plastics?
       a) Yes (   )   b) No (   )

22. Are bio-plastic good for the environment?
       a) Yes (   )   b) No (   ) c) Don't know (   )

23. Which material do you prefer to use?
       a) Bio-plastic bags (   )
       b) Paper bags (   )
       c) Fiber bags (   )

24. Who should take step to aware public against plastic?
       a) Government organization   (   )
       b) Non Government organization (   )
       c) Both (   )

Result and Discussion

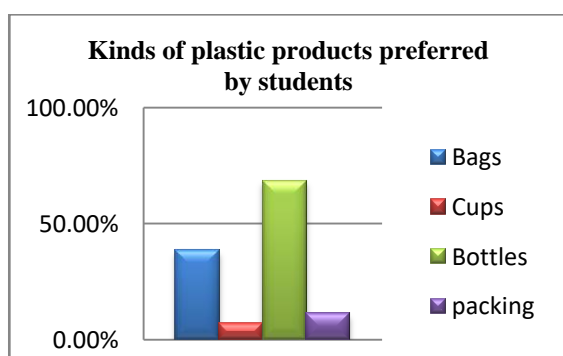1. The following table is representing the percentage of responses of few randomly asked questions.

Table 1: Perception of the Students on Different aspects of Plastics

Different Aspects of Plastic	Yes	No	Don't Know
i. Plastic bags used.	78.5%	21.5%	NA
ii. Plastic bags reused.	54.6%	45.4%	NA
iii. Uses of plastic products increasing..	64.2%	2.8%	33.0%
iv. Aware of Environmental impacts/effects of plastic.	97.1%	2.9%	NA
v. Plastic should be completely banned.	68.5%	31.5%	NA
vi. Hear about micro-plastics.	22.9%	77.1%	NA
vii. Know about harmful effects of micro-plastics on human health.	35.7%	64.3%	NA
viii. Aware about Bio-Plastic.	80.0%	20.0%	NA
ix. Bio–Plastic are good for environment.	50.0%	NA	50.0%

2. Most of the total students were agreed that they use different kinds of plastic products like plastic bags, cups, bottles, shoes, furniture, toys, home appliance and for packing also. Among them 38.50% said that they used plastic carry bags excessively among all the products, 7.10% said that they used plastic cups excessively, 68.5% said that they used plastic bottles in their regular life and 11.40% said they used plastic for packing over other materials. Whereas 15.70% said that they used plastic shoes, raincoats excessively due to it's durable and waterproof characteristics and 24.20% said that they used plastic buckets, bins and barrels.

3. 70% of the surveyed students agreed that they use plastic products like carry bags, cups, bottles etc. and after using these products they throw it in the dustbin by crushing and they also use separate bins from the wet waste for segregation of plastic wastes so that it could be easily collected by the rag pickers for recycling. Whereas 2.90% of them are unaware of this segregation process and thus they do not use bins and increase plastic litter. 27.10% of them said that as plastic products like toys, furniture, bags, bottles can be used again due to its unbreakable nature, they reuse the items. None of them burn plastic products, they either dustbin or reuse plastic products after using.

Table 2: Kinds of Plastic Products Preferred By Students

Type of plastic products	Percentage
Bags	38.50%
Cups	7.10%
Bottle	68.50%
Packaging	11.40%

Table 3: Opinion for the Disposal Method of Plastic Products

| Way of disposal	Percentage
Dustbin	70.00%
Litter	2.90%
Reuse	27.10%
Burn	0%
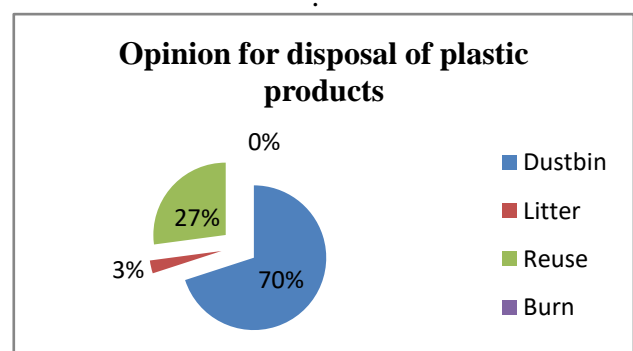
Figure: 1

Figure: 2

4. 54.30% of the surveyed individuals admitted that plastic pollution contribute to global warming as it emits greenhouse gases and it needs to be concerned. 67.10% said that plastic burning leads to air pollution and thus they suggested to reuse or recycle it but not to burn and 24.30% of them additionally said that plastic has dangerous health impacts, it causes respiratory problems when inhaled.

5. The total percentage of students who were admitted to known about micro-plastic are mostly unaware about its impacts. Very few of them 8.60% said that through micro-plastic are tiny fragments, it's inhalation may block digestive tracts, 2.90% said that it can reduce growth and reproduction of an organism, 5.70% said that through micro-plastics are tiny fragments and it increases coastal plastic litter it may cause death to the animals. Water animals may intake it which cause them to starve and leads them to death. Whereas 4.20% said that it can cause soil pollution and 5.70% are well aware they said it can damage immune system, if intake or enter into an organism's body.

Table 4: Awareness on the Impact of Plastic Pollutions

| Impacts	Percentage
Micro plastic block digestive tracts	8.60%
Micro-plastics reduce growth and reproduction.	2.90%
Cause some species to starve and dies in oceans; water bodies	5.70%
Cause soil pollution	4.20%
Damage immune system	5.70%
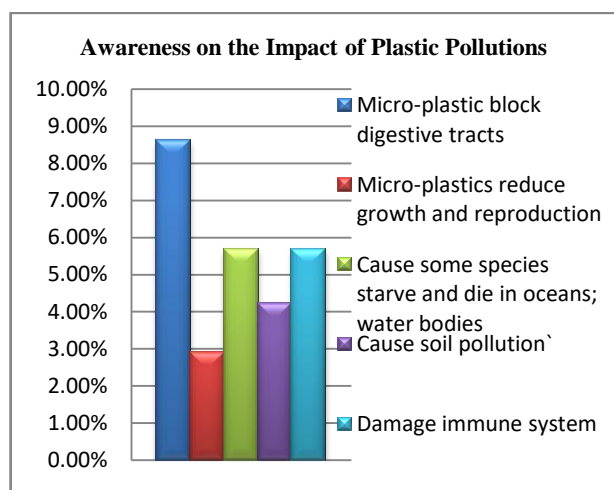
Figure: 3

6. The survey report reveals that 24.30% said that proper substitute of plastic could be fabrics like cloth bags, jute bags as these are re-usable and bio degradable, thus these are also eco-friendly. While 25.70% have suggested that paper could be an alternative of plastic and 50% suggested that bio-plastics could be a good alternative as these are bio-degradable plastic and just like plastics in term of use.

Table 5: Opinion for the Alternatives of Plastic

Alternatives	Percentage
Fabrics	24.30%
Paper	25.70%
Bio-Plastic	50.00%
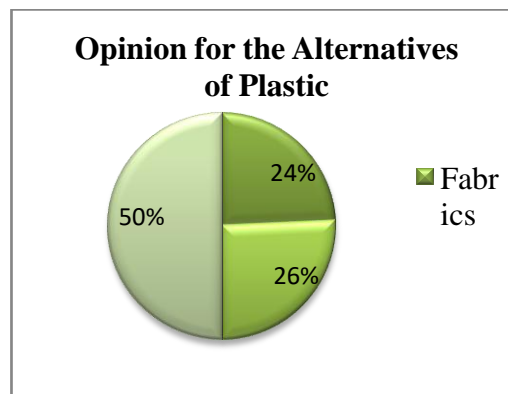
Figure: 4

7. It was found on the basis of the survey report that 11.40% of the surveyed students think that to aware the common people about the harmful side of plastic initiatives should be taken by the governmental Organizations, whereas 88.60% believe that Government is unable to generate awareness in society about plastic whereas Non-Governmental Organizations (NGOs) should also take the initiatives to help the Government. The harmful effects of plastics can be reduced effectively by the combined effort of Government and NGOs. The students also said that they are the future of the society and they should also have taken part in the awareness program.

Conclusion

The outcome of the present study indicates that most of the school children are in favour of banning the production, distribution and use of

plastic products. They are well aware of the adverse effects of plastic on the environment. But some of them are not supporting the idea of complete ban on plastic products as there is no alternative of plastic is available in the market. Concept of micro-plastic and bio plastic is not adequate to them as they are not tried on large scale till date. So, it is a prior duty to aware the young generations about micro-plastics and to encourage them to use the alternative products especially fabric bags though they preferred bio-plastics as it could be easily available in the market by government initiatives.

A drastic step should be taken by the Government to sustain human civilization and the biodiversity on our mother Earth. And here, Non-Governmental Organizations have a great role to serve for the society by organizing campaigns on the disadvantages of plastics. Thus, it might be possible for the human being to live and enjoy on this planet for few more decades.

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A REVIEW ON THE ORDURE OF THE COVID-19 PANDEMIC IN INDIA

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ABSTRACT

The first two waves of COVID-19 brought unexpected changes in social, political, and economic life worldwide. A disease that can make the entire human race feel powerless that was never predicted before. Millions of human lives ended, and millions got infected and survived anyway. The invention of proper drugs and vaccines took a bit of time and finally the vulnerability to the virus could be lessened. Government and non-governmental bodies, groups, and individuals worked a lot around the hour to bring the world out of this phase of uncertainty. The vast usage of protection kits, face masks, and face shields helped a lot to stop the spread of the deadly virus. The issue discussed here is the fate of this single-use or reusable plastic protection kits, gloves, and masks. These got added in huge quantities to the country's solid waste, whereas, solid waste management got stuck for a prolonged period during the lockdowns. India is among those countries that are still suffering from the large solid wastes generated during the pandemic and are still being produced due to changes in lifestyles.

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1. Introduction

In December 2019, a remarkable chapter started in global health as the novel coronavirus broke out in Wuhan, China, and eventually broaden its boundary taking most of the provinces into it just within a few months. Infections in respiratory tracts involving symptoms like chills, cough, and sneezes, fever, shortness of breath, energy drops are the major symptoms. Pneumonia caused by this virus had stopped around the globe. Human-to-human transmission through contacts or even nasal swabs or saliva droplets is the route of transmission. Even, an asymptomatic person has been reported to be a vector and was able to infect many healthy humans. World Health Organization (WHO) declared COVID-19 a Public Health Emergency of International Concern within a month. This unpredictable and unparallel spread led the governments to opt for complete lockdowns to maintain social distancing as much as possible. In the case of India, all but the emergency sectors (*i.e.,* health, rations, fresh veggies, poultries, milk, etc) remained to shut down. Private sectors continued partially using virtual mode, and education and other governmental and non-governmental bodies started their virtual journey later on.

In the health departments, the workers continued the toughest job, though the hospitals, nursing homes, health centers, and isolation buildings started overflowing. The medical practitioners were involved throughout the event to cure the infected lives as much as they could. The health workers were provided with an ample number of Personal Protective Equipment (PPE) which mainly included foot guards, gloves, eye/ head shields, face masks, and body shields. Initially in India, there was a dearth of PP equipment due to the lesser production compared to the high demand, moreover, importing these was not possible as there was a complete lockdown and strict restrictions on transnational exchanges of goods. With time the crises were gone as the state understood the necessity of the kits for the survival of the countrymen. Data shows that in 2020, the PPE production in India started from zero in March, accelerated growth of production with 8,000 in a month and 4.5 lakhs by the middle of May [1].

Our current study is an inquest on the extent of changes like environmental pollution as the inclusion of huge amounts of PPE, and different masks have been and being added to the country's solid waste loads. To visualize the scenario, a few research papers, news, and information from the governmental bodies have been jotted down and analyzed.

2. Uses of PPE

PPE and Face Masks are still in use and should be mandatory in an overpopulated country like ours.

The PPE was mandatory in the following sectors/ services:

A. Immigration points
- Heath desk
- Immigration counters, customs, and security
- Temperature recording station
- Holding area
- Airport Health Officer (APHO)
- Sanitary and administrative staff
- Triage area

B. Hospitals and other health centers
- Triage area
- Screening, help desk, registration counter
- Temperature recording station
- Holding area
- Doctors chamber
- Sanitary staff
- Visitors with a minor or elderly patient
- Isolation room
- Intensive care and critical care units
- Sanitation
- Non-COVID departments
- Other administrative staffs
- Emergency
- Ambulance
- Mortuary
- Laundry
- ASHA and Anganwadi staff
- Supervisors/doctors in the field

- Healthcare staff in quarantine centers
- Support team
- Pathological staffs

Besides, three-layer masks and N95 (specific uses) were mandatory whenever stepping outside. Social distancing uses of sanitizers had become a part of living and are still maintained in several cases [2].

3. Production and supply of PPE

As the United Nations Environmental Program (UNEP) reports, the worldwide production of PPE jumped up to 300% as the pandemic broke out, besides, the production of medical masks escalated by around four times that of the PPE kits. As we've already discussed, India enjoyed a boomed business of PPE and masks within a few months.

4. COVID 19 vaccination

As per the latest available report (1st July 2022) published by the Ministry of Health and Family Welfare, Government of India, 1,97,74, 71, 041 is the total number of vaccine doses charged among the population. The number includes the precaution doses too. The distribution of the vaccine doses is shown in the following figure (Fig. 4.1).
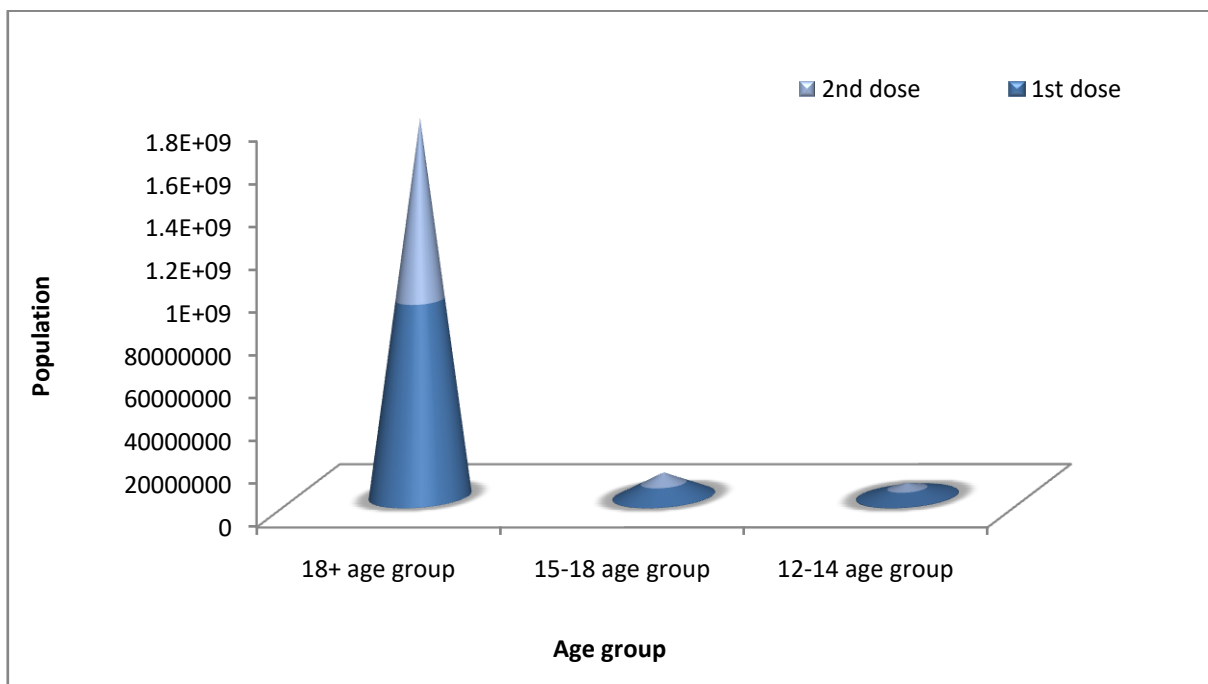

Fig 4.1. The Status of vaccination in India (reported on 01.07.2022)

The major part of the adult population has already received both the doses and the vaccination of the minor age groups are rapidly running on.

5. COVID 19 and Solid Wastes

The prime concern has been to arrest the spread of the deadly virus and thus secure the human race since the foremost span of the viral spreads. With time, strategies have been modified, facilities have been upgraded and alternatives have been invented. Although the public services, education, and a few other segments remained closed for a while, these resumed within a few months in unconventional ways. The emergency services stayed uninterrupted hence huge uses of PPE along with single-use masks played a crucial role to lessen the swelling up of the curve of COVID positivity. The triple-layered surgical masks are way too cheaper than the N95 masks, thus being used widely. Even in recent days, a good number of citizens, including students and academic staff, other professionals, and office goers mostly prefer medical masks [3, 4].

A report published by the Central Pollution Control Board (CPCB) discloses that an enhancement of more than 47 thousand tons of COVID-related wastes was produced from August 2020 to June 2021[5, 6]. Whereas, around 600 tons of biomedical solid wastes per day were generated before the pandemic as the report says. A huge weight of littered medical wastes such as PPE kits, masks, gloves, and head shields have been found in the municipal solid wastes, landfills, riverbanks, beaches, and crematoriums through the CPCB had enough arrangements of incineration of around 800 tons/day as the Board claims. Hundreds of kilograms of these PPE wastes are being recovered from the surface water bodies, sometimes being dredged from the oceanic beds. Even, PPEs are found in the flood water during the flood in 2021 in Assam. In 2021, the river Ganges and Mekong were reported to carry face masks the most among all plastic and non-plastic wastes.

The global scenario is almost identical; the estimation of COVID-related plastic waste production was up to 15.1 million tons among which 25 thousand tons are aggregated in the oceans and coasts, as of the 3rd quarter of 2021. Out of this huge mass, more than 85% came from the hospitals. The International Coastal Cleanup Campaign (ICC) by Ocean Conservancy has added a new category of coastal waste, *i. e.*, PPE since 94% of their volunteers working worldwide, found PPE items while cleaning up.

A report published in late 2021 states that the huge drive of mass vaccination was effective but produced massive toxicity in the environment. Starting from the large-scale production and storage of vaccines, up to the discarding of the used vials and syringes, gloves, disinfectants, and masks, each step contributed to global environmental pollution. Improper disposal is the major problem as pointed out.

Several experiments have been carried out in different laboratories around the world to estimate the efficacy of the masks used to stop the spread of the virus. Tests report that FFP2 masks are capable of filtering up the particles having a diameter of 0.075 microns. It can stop droplets having a 3-micron diameter. Whereas the efficiency of that the N95 masks is almost equivalent (fig 5.1), it is not certified worldwide.

Once a single-use or reusable mask is thrown, it gets added up to the solid wastes. This kind of solid waste breaks down into microplastics and takes more than 450 years to get degraded (fig. 5.1), hence might be marked as the non-biodegradable one. In many cases, these microplastics have been reported to be eaten up by sea animals, thus hampering the aquatic ecosystem. Moreover, surgical masks are also made up of polypropylene which is again a part of the plastic family.
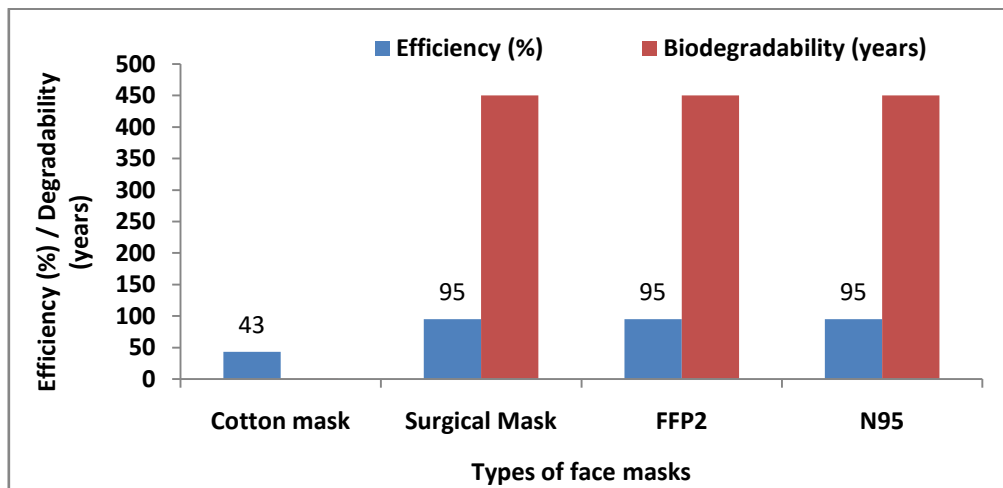
Fig. 5.1. Efficiencies and biodegradability of various face masks (source: https://bioplasticseurope.eu/facemasks

5.1. Pandemic led to changes in lifestyles

A lifestyle change has been vastly noticed globally, enhanced uses of delivery systems, be it food items, groceries, veggies, fish, or anything. Social distancing and lockdowns have boosted people's tendency towards packaged foods and other commodities wrapped with single-use plastic for health safety. In countries like Malaysia, Thailand, and Singapore, the plastic waste due to these changed habits have been recorded to be up to 200%. These practices have been mostly sustained even after the restrictions are removed.

In the country, the e-commerce companies have swelled up their businesses to double to three times more than it was before the pandemic. Official reports portray that e-commerce has increased its growth by 25% and the production of single-use cutleries, plates, cups, and carry bags jumped up due to the vast demands [7, 8].

5.2. Virus, Lockdown, and solid waste management

The growing quantity of solid waste was not the only concern during and after the pandemic waves, waste management became a vital problem due to lockdowns. Besides, the methods of waste collection and segregation were challenging for the workers. The recycling sectors in the country failed to work properly due to the spread of the virus. Although solid waste collection work never stopped, it forced the workers into health insecurity. During the second wave, as the majority of the infected were having mild symptoms, they were kept in home isolation; the household wastes started to become a potent source of infection. The waste pickers weren't properly trained; hence a portion of this community has been reported to get infected. It was the darkest phase for the waste pickers and the small waste recyclers since they're the daily wagers and they were unable to sell dry solid wastes to the kilns and larger recycler units. Space problems compelled these businesses to shut down, ending their daily revenues. Apart from the hospitals and health centers, isolation centers also started to generate infectious wastes which were being cleaned soon as it had been mandatory to keep these premises clean and infection-free [9, 10, and 11].

6. Recent scenario

As the report issued by the Partnership in Environmental Management for the Seas of East Asia (PEMSEA), the recyclers in India are working up to 25 -50% of the entire capacity. The country is still struggling to manage the waste generated during the last few years. India could achieve a better waste management status once the policymakers implement the circular economy model, as adopted by a few of the neighboring countries. Few states are doing well in waste segregation and recycling; the drive should be holistic to resolve the issue and to get prepared for such a scenario in the future [12].

7. Conclusions

The restrictions on single-use plastics had been removed during the pandemic. In 2022 again, the Government of India pledged to enact the ban. All India Plastic Manufacturers' Association (AIPMA) called for a few months of relaxation. Finally, the Ministry of Environment and Forest and Climate Change (MoEFCC) mandates a ban on the production, import, distribution, stocking, sale, and use of single-use plastics from July 1, 2022.

Corona Pandemic brought several consciousnesses in the human, the value of lives are well understood, human is unable to dominate the earth, money couldn't buy lives; there's no record of surviving a rich over a poor. Still few lifestyle changes have detrimental impacts too; *viz*., private transport is being referred over the public transports, uses of home delivery of food items, groceries, etc are still on, wastes are being generated much higher than in pre-pandemic periods.

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THE PERCEPTION OF URBAN PEOPLE ON THE ROLE OF URBAN FORESTRY TO MITIGATE CLIMATE CHANGE AND ENVIRONMENTAL POLLUTION IN URBAN AREAS: A SURVEY ON THE CITIZENS OF LAKETOWN, KOLKATA IN WEST BENGAL

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ABSTRACT

Uprising environmental pollution and climate change emerge a great challenge to the urban environment nowadays. This study explores the role of urban forestry to mitigate climatic changes the thoughts of people for managing urban forests. The finding of this study was to identify the concerns of citizen regarding climatic changes and urban forest management. Knowledge of urban residents on the role of tree to combat environmental pollution and climate change is inadequate. They plant trees for improving aesthetic value of their home. This study ideologically prioritized the ecosystem services provided by the urban forest to improve the surroundings and some factors such as the sources of information and application of managing plants in home and how it may motivates the need of plantation for their own sustained living. The results of this study suggest that a proper planning and awareness could mitigate the effects of climate change in urban areas and pollution free city could be come up.

Keywords: Urban forestry, climate change, urban residents, urban forest management plans

Introduction

Trees are the most important part in this world. These living things serve the other creatures throughout their life. It is estimated that there may be up to 1, 00,000 tree species, representing 25% of all living plant species (Oldfield, Lusty, & MacKinven, 1998). Trees play important roles in terrestrial ecosystems. They provide food, fuel and shelter, are source of oxygen, store carbon, stabilize soil, filter nutrients, and provide habitat for wildlife.

Urban forests are one of the fundamental part of community ecosystems as they help to regulate temperature, reduce energy consumption, improve urban air quality, reduce wind speeds and mechanical noise. Urban trees also help to recharge the ground water table as well as could able to improve urban biodiversity and stability of ecosystem. Urban forests can effectively maximize infiltration of rainfall, detain storm water, and slow the volume and rates of water entering the system of rivers in and around urban areas (Gill, Handley, Ennos, & Pauleit, 2007).

This planet is now going through severe climatic changes; uprising heat, abrupt rainfall, consequent floods, wind-damage and coastal erosion are the result of felling down trees randomly. Such manners of climate changes affected the forest too. Lots of plat species become threatened or endangered due to lack of ability in adaptation of climate change. This dramatic shift will not only affect global forest systems, but also urban forests, which are increasingly recognized for the important provision of ecosystem services, as well as social and cultural contributions. It will be a good approach for present urban environment to replace several coolant amenities by plants. Sustainable lifestyle of urban citizens may contribute a good impact to the urban environment.

Literature Reviews

Munishi, P.K.T et al. (2008) stated in "The Role of Urban Forestry in Mitigating Climate Change and Performing Environmental Services in Tanzania" that the possibility of global climate change, due to increasing levels of CO_2 concentrations is one of the key environmental concerns today, and the role of terrestrial vegetation management has received attention as a means of mitigating carbon emissions and climate change. In this study tree dimensions and assessment of plant species composition were used to quantify the potential of urban ecosystems in acting as

carbon sink and mitigating climate change through carbon assimilation and storage and the potential of the system to enhance biodiversity conservation taking the Morogoro Municipality as a case study. The carbon content was computed as 50% of the tree biomass. Urban forestry can store large amount of carbon in addition to biodiversity conservation especially where they cover extensive areas like parks, gardens and avenues managed over long periods, as is the case in urban ecosystems. Improved management of urban forests will likely improve the potential for carbon storage by terrestrial vegetation as a means of mitigating CO_2 emissions and climate change as well as biodiversity conservation.

C. Ordonez et al. (2010) expressed in "Climate Change Mitigation and Adaptation in Urban Forests: A Framework for Sustainable Urban Forest Management that sustainable urban forest management is important to sustain the myriad values associated with urban trees. These values are threatened by the advent of climate change. Urban forests responses to this change should be framed appropriately in our interpretation of urban forest sustainability and its management. This paper demonstrates that climate mitigation and adaptation can be integrated in a sustainable urban forest management framework that is inclusive of climate considerations and strives to sustain a strong array of environmental, social and economic values. It is shown here that such a framework may contain management practices that consider the net effect of both decreasing vulnerability and emissions.

Francesc Baro et al. (2014) conducted a study on Contribution of Ecosystem Services to Air Quality and Climate Change Mitigatation Policies in Barcelona, Spain and found that the contribution of ecosystem services provided by urban forests to quality of life in cities. These services are rarely explicitly considered in environmental policy targets. They quantify regulating services provided by urban forests and evaluate their contribution to comply with policy targets of air quality and climate change mitigation in the municipality of Barcelona, Spain. They apply the i-Tree Eco model to quantify in biophysical and monetary terms the ecosystem services ''air purification,'' ''global climate regulation,'' and the ecosystem

disservice ''air pollution'' associated with biogenic emissions. As a result, they get that the contribution of urban forests regulating services to abate pollution is substantial in absolute terms, yet modest when compared to overall city levels of air pollution and GHG emissions. Finally they conclude that in order to be effective, green infrastructure-based efforts to offset urban pollution at the municipal level have to be coordinated with territorial policies at broader spatial scales.

Avolio, M. et al. (2015) reviewed that urban plant biodiversity is influenced by both the physical environment and attitudes and preferences of urban residents for specific plant types. They postulate that local climatic and environmental factors can also affect preferences for plant attributes. Therefore, spatial and temporal patterns in urban tree biodiversity may be driven not only by the direct effect of environmental variables on plant function, but also by the effect of environmental variables on attitudes toward trees and associated choices about which types of trees to plant. Here, they tested the relative effects of socio-economic and local environmental factors on preferences toward tree attributes in five counties in southern California in and surrounding Los Angeles, based on 1,029 household surveys. Specifically, people located in hotter climates (average maximum temperature 25.1 °C) were more likely to value shade trees than those located in cooler regions (23.1 °C). Additionally, people located in desert areas were less likely to consider trees to be important in their city compared with people located in naturally forested areas. Accounting for these factors can contribute to the growing interest in understanding patterns of urban biodiversity.

Zhaowu Yu et al. (2020) assessed on the cooling effect of urban blue-green space and presented the latest progress and controversies on the studies of the cooling effects of waterbodies, greenspaces, and parks. In order to do this research, international search engines were employed to systematically search peer-reviewed articles, including the cooling effect of blue-green space and threshold-size-based UHI mitigation studies. After that, the inductive analysis is used to analyze the

relevant literature. The review also revealed the controversies over the effects of blue-green space size, shape, landscape composition and configuration on cooling effect. Besides, we pointed out that the uncertainties (i.e., the optimal proportion of blue-green space in a park) and the reasons of controversial results of the cooling effect need to be further investigated. We also suggested that more attention should be paid to quantify the contributions of local background climate and landscape characteristics to the cooling effect (threshold-size) of blue-green space. This review would give us a deeper understanding of the field and provide insights into actionable climate adaption planning.

Aims and Objectives

1. To study how urban forestry might help cities to mitigate climate change.
2. To gauge India's urban inhabitants' level of awareness, beliefs, and perceptions of climate change and ultimately, how those variables may impact support for urban forest systems in the face of a changing climate.
3. To know, how many Indian citizens are concerned about climate change could affect the urban forest environment.
4. To learn, how belief and perceived knowledge about climate change affect motivation to support urban forestry.
5. To determine, how much urban forestry is essential to create habitats for wildlife in cities, and also identify the species that have adapted to living in the disturbed conditions of the built environment by utilizing urban green spaces.
6. To provide context to inspire urban inhabitants to plant trees.
7. Making awareness among common people through this survey.

Methodology

Methodology of a study is a set of procedures or methods used to conduct research. It can be defined also as the study or the description of method. A methodology can be considered to include multiple methods, each as applied to various facets of the whole scope of the methodology.

1. At first the study was undertaken through research. Many types of articles which were similar with this topic studied it and tried to understand thoroughly.
2. Study planning is the most important stage for any type of research work. This study also started with a huge plan like firstly, choose a proper title for it, create a concrete questionnaire, choose the survey process, survey data collection, data analysis and make a report. Without planning the study was not be able to complete smoothly.
3. The study collected socio demographic information including completed age, gender, educational background and occupation. In addition, additional questionnaires for climate change, urban forestry might help improve climate change and environmental pollution were also incorporated. To know participant's beliefs about the occurrence, causes, and consequences of climate change, level of perceived knowledge of climate change, the level of concern that climate change will impact trees, and the likeliness of participants supporting tree planting as an adaptive measure. Further, questionnaires on urban forestry's importance, motivation of tree planting etc were used in the study.
4. The study has been conducted on January to March, 2021 at Ward no.30 of South DumDum Municipality. The study area includes Lake Town which is a part of Kolkata, the capital city of West Bengal in India.
5. In total, responses were collected from 50 participants (26% male, 74% female). The age of respondents ranged from 18 to above 60. The educational backgrounds of respondents were Higher Educated (20%), Graduate (52%), Higher Secondary Education (22%), Primary Education (2%) and Illiterate (4%). The occupations of them were 40% of students, 34% of service, 4% of business, 2% of retired person and 20% of home-maker.
6. The data obtained through questionnaire survey. Due to pandemic, maximum survey had done digitally (through video call and mail) and very less survey had done physically.

7. All data collection was done with traditional pen and paper method. The analysis was carried out by calculating the simple percentage. The graphical representations of survey data, was done by drawing bar graphs and pie diagrams using MS Excel.

8. With the merger of the data base, it could able to interpret the research findings and form a report on the base of that survey data and graph.

The standard questionnaire used for the survey is given herewith.

Section I. Profile respondents

- Name:-
- Sex: ☐ Male ☐ Female
- Age:- ☐ 18years ☐ 19-20years ☐ 21-30years
  ☐ 31-40years ☐ 41-50years ☐ 51-60years
  ☐ >60years
- Educational Background:-
  ☐ Illiterate ☐ Primary Education ☐ Higher Secondary Education
  ☐ Graduate ☐ Higher Education
- Occupation:- ☐ Student ☐ Service ☐ Business

Other (Please specify) ——————————

Section II. Survey Questions

1. Do you believe, in our urban areas should be-

   ☐ a. More trees

   ☐ b. Sufficient trees

   ☐ c. Fewer trees

2. Do you support more tree-planting in parks, streets and other public places?

   ☐ a. Extremely support

   ☐ b. Somewhat support

   ☐ c. Neither support nor unsupport

3. In your opinion, why is urban forestry important?

   ☐ a. Trees would reduce summer heat

   ☐ b. Trees would reduce flooding

   ☐ c. Trees would filter dust

   ☐ d. Trees would add more oxygen

   ☐ e. Trees would improve scenery

   ☐ f. Trees would reduce pollution

   ☐ g. Trees could provide food

   ☐ h. All of the above

4. Do you agree/disagree, "Is roadside planting curse or blessings?"

	Strongly agree	Somewhat agree	Strongly disagree
a. Trees could combat traffic/ vehicular pollution			
b. Trees could combat noise pollution			
c. Trees could give shading and cooling			
d. The falling trees would damage the electricity pole			
e. Trees would create problems to make wide roads			

5. What do you think on climate change?
    - [ ] a.   High rise temperature
    - [ ] b.   Small rainfall
    - [ ] c.   Later winter
    - [ ] d.   All of the above

6. Do the trees able to combat the effect of climate change?
    - [ ] Yes   - [ ] No

7. If yes, in your opinion, how important is planting more trees in reducing climate change impacts?
    - [ ] a.   Extremely important
    - [ ] b.   Very important
    - [ ] c.   Moderately important
    - [ ] d.   Slightly important

8. Do you believe, gardening keeps your home or surroundings cool?
    - [ ] Yes   - [ ] No

9. What is/are the major source/s of urban air pollution?
    - [ ] a.   Less trees
    - [ ] b.   Vehicular emission
    - [ ] c.   Industries
    - [ ] d.   Huge population
    - [ ] e.   All of the above

10. In your opinion, could planting trees in urban areas improve the quality of the air we breathe?
    - [ ] Yes   - [ ] No

11. Last 1 year, how many trees have you planted?
    - [ ] a.   No trees planted
    - [ ] b.   1-5 trees planted
    - [ ] c.   6-10 trees planted
    - [ ] d.   More than 10 trees planted

12. Which type of trees did you planted?
    - [ ] a.   Flowering plant
    - [ ] b.   Indoor plant
    - [ ] c.   Kitchen gardening
    - [ ] d.   Medicinal plant

13. Which type of gardening do you prefer most?
    - ☐ a. Rooftop gardening
    - ☐ b. Balcony gardening
    - ☐ c. Container gardening
    - ☐ d. Green wall gardening
    - ☐ e. Indoor gardening

14. How can you take care of your plants, from where do you know it?
    - ☐ a. Nursery
    - ☐ b. Family/friend
    - ☐ c. Internet search
   - ☐ d. All of the above
    - ☐ e. Other ──────────────

Results and Discussion

1. The survey on planting more trees is important in reducing climate change impacts revealed that, the majority of respondents (76%) indicated that they believed planting more trees were extremely important in reducing climate change impacts. Some respondents (24%) indicated that they believed planting more trees were very important in reducing climate change impacts.

2. The idea on major sources of urban air pollution to the citizens found the majority of respondents (72%) indicated that they believed less trees, vehicular emission, industries, huge population all were the major sources of urban air pollution. However, some respondents (22%) indicated that they believed vehicular emission was the major source of urban air pollution. 12% of respondents and 10% of respondents indicated that they believed less trees and industries were the major source of urban air pollution respectively. However, few respondents (4%) indicated that they believed that huge population was the major source of urban air pollution. Figure: 1 shows the overall calculation of the major source/s of urban air pollution.

Table 1: Calculation of the major source/s of urban air pollution according to people's opinion

|	People's opinion
Less Trees	12%
Vehicular emission	22%
Industries	10%
Huge population	4%
All of the above	72%
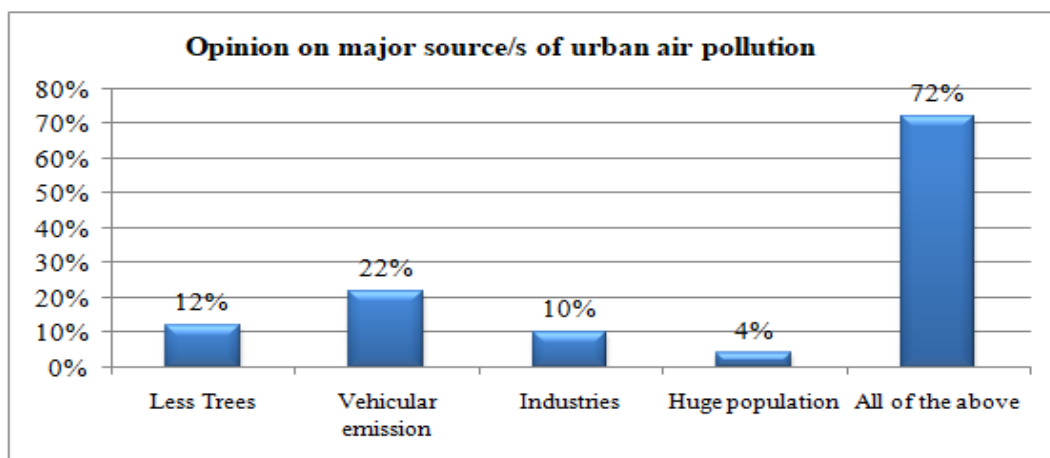
Figure: 1

3. The thought on the importance of urban forestry indicated that the majority of respondents (78%) believed that urban forestry is most important. However, some respondents (10%) indicated that urban forestry is important because trees would reduce summer heat. 16% of respondents indicated that urban forestry is important because trees would add more oxygen. 14% of respondents indicated that urban forestry is important because trees would reduce pollution. However, few respondents (8%) indicated that urban forestry is important because trees would reduce flooding. 4% of respondents indicated that urban forestry is important because trees would filter dust. And fewer respondents (2%) indicated that

urban forestry is important because trees would improve scenery and could provide food. Figure: 2 shows the overall calculation of urban forestry's importance.

Table 2: Calculation of urban forestry's importance according to people's opinion

|	People's Opinion
Reduce Summer Heat	10%
Reduce Flooding	8%
Filter Dust	4%
Add more Oxygen	16%
Improve Scenery	2%
Reduce Pollution	14%
Provide Food	2%
All of the above	78%
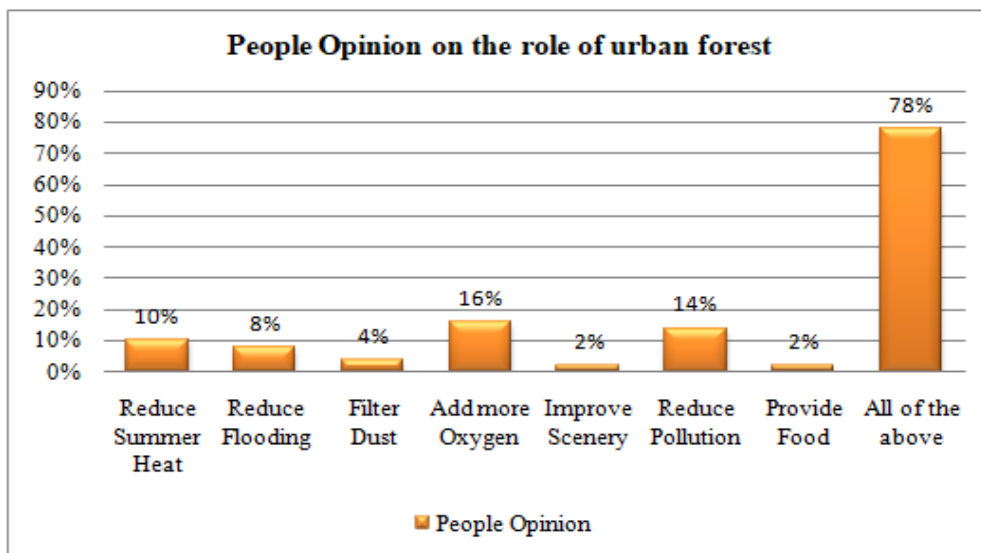
Figure: 2

4. When the question came on roadside planting is curse or blessings, the majority of respondents (92%) strongly agreed that trees could combat traffic/ vehicular pollution and 8% respondents somewhat agreed that trees could combat traffic/ vehicular pollution. However, most of the respondents (44%) indicated that they strongly agreed that trees could combat noise pollution, comparing themselves to others, respondents either considered themselves to be "somewhat agreed" (34%) or "strongly disagreed" (22%) that trees could combat noise pollution. However,

among respondents, 40% were strongly agreed, 54% were somewhat agreed and 6% were strongly disagreed that the falling trees would damage the electricity pole. However, majority of respondents (54%) indicated that they somewhat agreed, some respondents (34%) indicated that they strongly disagreed and few respondents (12%) indicated that they strongly agreed that trees would create problems to make wide roads. Figure: 3 shows the overall calculation of roadside planting is curse or blessings.

Table 3: Calculation of the people's perception on roadside plantation

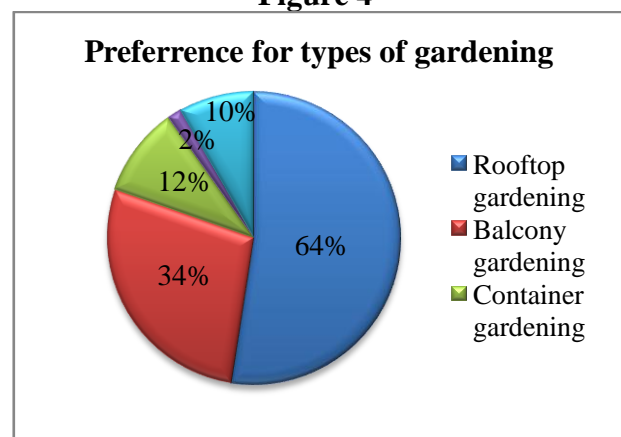|	Strongly agree	Somewhat agree	Strongly disagree
Trees could combat traffic/ vehicular pollution	92%	8%	-
trees could combat noise pollution	44%	34%	22%
The falling trees would damage the electricity pole	40%	54%	6%
Trees would create problems to make wide roads	12%	54%	34%
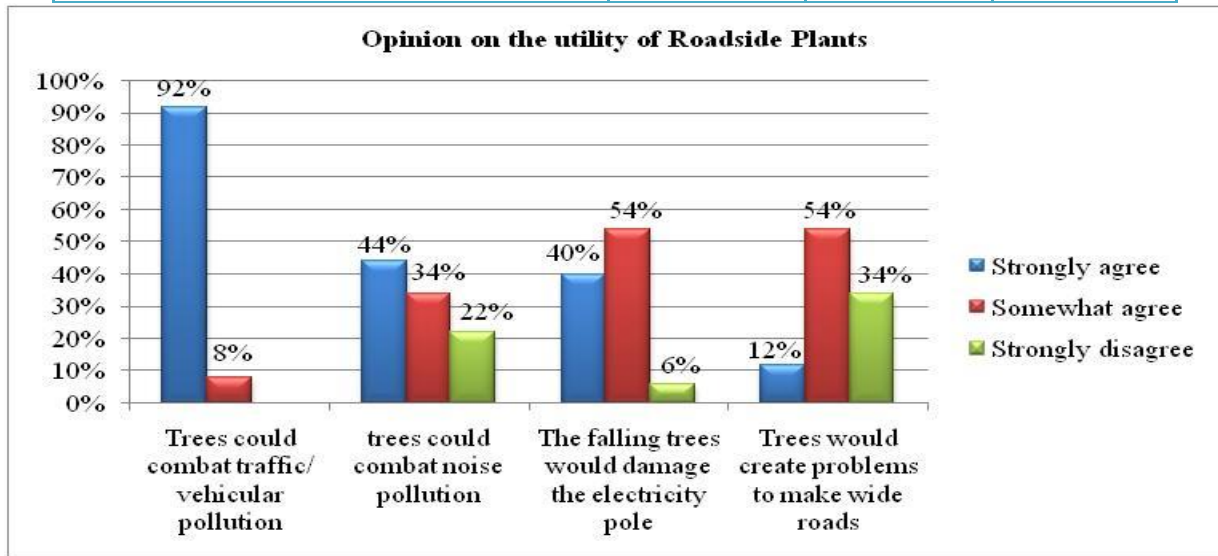
Figure 3

5. The survey on the preference of people for the types of trees revealed that, the majority of respondents (52%) indicated that they had chosen flowering plants most of the time to plant. However, some respondents (18%) indicated that they had chosen medicinal plant also beside flowering plants to plant. Fewer respondents (14%) indicated that they had preferred to plant indoor plant and kitchen gardening sometimes.

6. Among the respondents in the survey on the types of gardening they preferred, majority (64%) rooftop gardening. Some respondents (34%) indicated that they had preferred balcony gardening most. 12% of respondents and 10% of respondents indicated that they had preferred container gardening and indoor gardening most respectively. Fewer respondents (2%) indicated that they preferred green wall gardening most. Figure: 4 shows that the overall calculation of types of gardening should be preferred most.

Table 4: Calculation of the people's preference for the types of gardening

	People's opinion
Rooftop gardening	64%
Balcony gardening	34%
Container gardening	12%
Green wall gardening	2%
Indoor gardening	10%

Figure 4

Conclusion

It may be concluded from the study that a major portion of the urban population under study area are aware of the advantages of urban forestry and also roadside plantation for the control of air pollution, global warming and maintaining ecological balance. It is to note that a considerable number of urban people still remain unaware of the issues like climate change and importance of planting trees. Most of the common people may want to focus their attention on promoting planting trees that are both aesthetically pleasing and resistant to tree threats.

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RELATIONSHIP BETWEEN DISTURBANCE INDICATING SOIL MICROBIAL PARAMETERS AND PENDIMETHALIN DEGRADATION IN A CLAY LOAM SOIL

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ABSTRACT

The study focuses on relationship between degradation and effect of pendimethalin application at field rate (FR), 2-times FR (2FR) and 10-times FR (10FR) on soil microbial variables in clay loam alluvial soil (Typic fluvaquent) under laboratory conditions. The laboratory incubation study was carried out at 60% of maximum water holding capacity of soils and at 25°C. The microbial parameter estimated includes soil microbial biomass-C, Basal and Substrate induced soil respiration (BSR and SIR). Eco-physiological quotients namely microbial metabolic quotient (qCO2) and microbial respiration quotient (Q_R) were also estimated to identify the eco-physiological status of soil microbial community in relation to pendimethalin degradation. The half-life values of pendimethalin varied from 12.04 to 14.26 days, depending on the initial concentrations. The results show an initial inhibitory effect of pendimethalin on soil microbial community and the effects are strongly related to residence time of pendimethalin in soil. It can be concluded that no harmful effects should be expected in the short term when pendimethalin is applied at doses equivalent or higher than those usually applied in the field.

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Keywords: Pendimethalin, Degradation, Field recommended rate (FR), Soil microbial biomass carbon (SMBC), Basal soil respiration (BSR), Substrate induced soil respiration (SIR), microbial metabolic quotient (qCO2), microbial respiration quotient (Q_R).

1. Introduction

Intensification of modern agriculture has changed the agroecosystem functioning due to different management practices including increasing use of chemical fertilizers and pesticides. Intensive application of synthetic agrochemicals to maximize crop productivity has lead to accumulation of a large amount of potentially toxic compounds and thus created unwanted side effects on the environment. The soil microbial community is mainly responsible for the utilization of these xenobiotics as a source of carbon and energy to promote their growth (Durkin 2003). Since the soil microbial ecosystem always maintain a stabilized equilibrium condition in soil for their optimal growth, thus any disturbances related to nutritional, functional or compositional differences affected their population and activity. Theses disturbances, in turn, manipulated the soil quality through changing the different chemical, physico-chemical, and biochemical soil processes related to soil fertility (Bollag et al. 1992; Schaffer 1993). Moreover, the disturbed soil microbial community seriously influenced the microbial degradation of pesticides which ultimately resembles as a great concern of environmental hazards. Thus, recent days, evaluation of the disturbance caused due to different anthropogenic factors are main concern to predict and understand the fate of used pesticides in soil and how they interact with soil microbiota.

Biologically and biochemically mediated processes in soil are of the utmost importance to ecosystem function. Soil microbes are the driving force behind many soil processes including transformation of organic matter, nutrient cycling and degradation of xenobiotics. Several biological parameters have been used to assess soil quality as affected by agricultural practices (Frioni 1981; Filip 2002; Anderson 2003; Benedetti and Dilly 2006). Among them, microbial parameters are expected to be more efficient indicators than physical and chemical parameters as they are able to respond immediately to environmental changes (Nannipieri et al., 2002; Avidano et al., 2005). The recommended approach for assessing the effects of pesticides on microbial communities

is the simultaneous measurement of structural, functional and ecological parameters of soil microcosms rather than reliance on a single assay (Nannipieri et al., 2002; Burrows and Edwards, 2004; Joergensen and Emmerling, 2006). In this aspect, there was a great need of sensitive and early bio-indicators which precisely indicated the state of disturbance and the actual response of microbial community in a broader scale. Number and biomass of microorganisms are basic properties of ecological studies, and which can be related to parameters describing microbial activity (Bolter et al., 2006) as well as the efficiency of microbial catabolic processes. Microbial biomass in soil is considered to be an important attribute to the soil quality (Doran and Parkin 1994) and indicator of ecosystem disturbance. For proper appreciation and ecosystem functioning, microbiological parameters related to metabolic activities and eco-physiological quotients are also being considered as potential indicators of the disturbance imposed in the ecosystem. Soil respiration activity viz. basal respiration and substrate induced respiration, is a commonly used, sensitive parameter for the observation of toxicity of pesticides on soil microorganisms (Jones and ananyeva 2001; Brohon et al. 2001). In many studies, microbiological parameters were correlated or combined as an disturbance index (Nannipieri 1994). Nevertheless ratios between microbiological parameters have often been used for evaluating the microbial eco-physiological implying an interlinkage between cell- physiological functioning under the influence of environmental factors (Anderson 2003). The combining microbial activity and population measurements (biomass specific respiration, qCO_2) or degree of substrate mineralizing capacity (microbial respiration quotient, Q_R) appears to provide more sensitive indications of soil disturbance than either activity or population measurement alone (Brookes 1995). Both the eco-physiological indexes are recognized to have valuable application as a relative measure of how efficiently the soil microbial biomass is utilizing the substrate carbon and resuscitate the equilibrium condition again.

The persistence pattern of dinitroaniline herbicide, pendimethalin (n-(1-ethylpropyl)- 3,4-dimethyl-2,6- dinitrobenzenamine, a widely used pre- and post emergence herbicide in India for rice, onion, chili, soybean cultivation etc., in soil was widely studied, but there was little in-depth studies regarding the response of the soil microorganisms and their functional behaviour changes to the toxicity of pendimethalin. The application of pendimethalin in soil might affect the non target microorganisms and inhibited their metabolic activities, while it was also assumed that the disturbed ecosystem restore their equilibrium with time. However, little research has dealt on the effect of pendimethalin application on the soil microbial population or their activity. Thus, the dynamics of changes of microbial population as well as the activity with the residual concentration of pendimethalin may help to understand the behavioural pattern of microbiota in response to pesticide application. Keeping in view the above mentioned points in concern, the present study was conducted to ascertain the degradation of pendimethalin under different concentration in a laboratory condition and subsequently, to determine the relationship of herbicide degradation and soil microbial parameters.

2. Materials and methods

Soil (Typic fluvaquent, clay loam) for the present investigation was collected from the agricultural experimental farm of University of Calcutta located at Baruipur ($88^0 26'$ E longitude and $22^0 2'$ N latitude), South 24 Paraganas, West Bengal, India. The field moist surface soil, up to depth of 15 cm was collected at random from the plot, having no history of receiving pendimethalin six months prior to this study, was composited and taken to the laboratory in a sealed polythene bag. The soil was sieved (~2 mm) in field moist condition to remove plant material, soil macrofauna and stones. After sieving, the soil sample was homogenized and stored at 60% water holding capacity of soil at 25^0C in the dark for 7 days (pre-incubation).

The soil pH was determined in a 1:2.5 soil : water suspension. Organic carbon was determined as reported by Nelson and Sommers (1982). Sand, silt and clay percentage were measured by the International Pipette

Method (Piper 1966). Chemical, microbiological and biochemical parameters were expressed on moisture-free basis (Table 1).

a. Soil treatment

The herbicide formulation, Pendiguard (30% EC) (pendimethalin: N-(1-ethylpropyl)- 2,6-dinitro-3,4-xylidin) was obtained from Gharda Chemicals Ltd., India. The aqueous solution of pendimethalin (passed through 0.2μm membrane) was applied to soil (100 g) to obtain the final concentration level at 0.5, 1.0, and 5.0 mg a.i. kg^{-1} corresponding to FR i.e Field Recommended Dose (1.0 kg a.i. ha^{-1}), 2FR, and 10FR respectively. The conversion of the field application to mg of pendimethalin per kg of soil was calculated assuming an even distribution of herbicide in the 0 - 15 cm layer and a soil density of 1.5 g cm^{-3}. The moisture content of soils were maintained at 60% of maximum water holding capacity of soils by adding sterile distilled water. The higher application rates than recommended field rates were chosen to magnify whether the initial concentrations imposed any side effects (Sommerville, 1987) or produced any changes in the soil microbial variables (Vischetti et al., 2002). The soil was incubated at 25^{0}C for 90 days in an incubator. Soil moisture level was monitored weekly and maintained by addition of sterile distilled water when necessary. The control sample received only required amount of water to maintain the same moisture condition and undergo the same procedure. The soil samples were analyzed at different time intervals (1, 3, 7, 15, 30, 45, 60, 75 and 90 days after pendimethalin application for pesticide concentration and microbiological properties.

b. Pesticide analysis

The soil sample (10 g) was extracted with 100 ml (3 times) acidified methanol (2% HCl v/v) under vacuum through a Whatman No. 1 filter paper. The solution was evaporated to dryness and partitioned with 20 ml 0.1 N HCl and n-hexane (100ml x 3 times). The organic layer was collected, dried and subjected to column chromatography for clean up. The concentrated materials was cleaned by passing through a glass column (30 cm length and 1 cm internal diameter.), previously filled with florisil. The concentrated sample was transferred onto the florisil column by washing with 10 ml n-hexane and kept for few minutes for adsorption. The n-hexane was eluted out (50 ml) and then the column was eluted with 150 ml of acetone-hexane mixture (1:1, v/v). The organic layer was collected, dried and subjected to gas chromatographic analysis. Gas liquid chromatography was performed with Agilent Model 6890N Network Gas Chromatography instrument equipped with Ni^{63} electron capture detector packed with capillary column (DB 608, length 30 m, 0.45 mm ID, 0.7 μm inner thickness). Operating parameters were as follows: initial oven temperature-150^{0}C for 2 min, increase 6^{0}C min^{-1}, final temperature-250^{0}C for 18 min, injector temperature- 250^{0}C; Detector temperature- 310^{0}C and carrier gas (He) flow- 5 ml min^{-1}; N$_2$ make up flow- 30ml min^{-1}. The residues of pendimethalin were quantified in comparison with external standard (1 ppm of analytical grade pendimethalin, 99.5% purity). The average recovery was 93.3-94.7% for pendimethalin and the limit of detection was 0.02 ppm. (Methodology Reference if any)

c. Microbiological assays

Soil microbial biomass C content was determined by fumigation-extraction method (Joergensen, 1995) followed by determination of K$_2$SO$_4$ extractable carbon (Vance et al. 1987). Soil samples were fumigated for 24 hrs with ethanol-free CHCl$_3$. Fumigated and unfumigated soils were extracted with 0.5 M K$_2$SO$_4$ and the C was quantified by oxidation with 0.4 N K$_2$Cr$_2$O$_7$. Biomass C content was estimated as follows: Microbial Biomass Carbon = 2.64 Ec, where Ec is the difference between the organic C extracted from the fumigated and unfumigated soils.

Basal and substrate induced respiration were determined by the method described by Alef (1995).

d. Microbial metabolic quotient and respiration quotient

Microbial metabolic quotient was calculated as: basal respiration / Microbial biomass carbon Microbial respiration quotient calculated as: basal respiration / substrate induced respiration

e. Statistical analysis

All data are derived from five replicates and the data are subjected to statistical analysis. Degradation data were subjected to ANOVA followed by Duncan's test at 5% level of significance to evaluate homogeneity between the treatments using SPSS (Windows 10.0 version) statistical software package.

3. Results and discussion

The regression equation, degradation rate constant and half lives of pendimethalin in soil at three initial concentrations are reported in Table 2. The half-life values were calculated from the best fit lines of logarithm of residual concentrations versus incubation periods following first order reaction kinetics. The half-life values varied from 12.04 to 14.26 days, depending on the initial herbicide concentrations (Table 2). Significantly (P<0.05) higher half-life values at higher herbicide concentration treatment showed strong influence of initial concentration on the degradation of pendimethalin which was also observed by Lin et al. (2007). The higher half-life values with increasing herbicide concentration could be attributed to the inhibition of microbial activity in soil at higher herbicide concentration (Ali et al. 1995) or limitation in number of reaction sites in soil (Das et al. 2008).

The relationship between herbicide persistence and different soil microbiological parameters resulted parabolic curves (P<0.05) (Fig. 1-5). Microbial parameters vs. pesticide residue data were regressed against each other by using a parabolic function; R^2 values were used to measure the goodness of fit. In this study, the pesticide treatments showed significant influence on the soil microbiological parameters (microbial biomass C content, substrate induced respiration, microbial metabolic quotient and respiration quotient). Significant decreases of microbial biomass C content over control, was observed initially followed by the considerable increase (> 100% of biomass C content of control) at all treatments. A strong relationship between the residence times of pendimethalin in soil and the size of microbial biomass C content was observed in this study. From the changes of microbial biomass C content, the maximum depression of biomass C content was registered generally during the period of the herbicide concentration ranging about 50% of the initial concentrations. But the inhibitory effect of higher concentration (i.e. 10FR) on microbial biomass C content was found to be more intense which was prominent from the maximum decrease of biomass C content at the time before 50% of the herbicide was disappeared from the soil (Table 3). This was most likely attributable to the condition that microbes are killed or reduced in numbers at higher concentration of pesticides. The maximum decrease in the microbial biomass C content and the corresponding herbicide concentrations can be deduced from the vertices of the parabolas (Fig. 1). Nonetheless, maximum depression of microbial biomass C content at FR, 2FR and 10FR treatments never exceeded 10.67%, 25.14% and 58.05% over initial condition, respectively (Table 3). The persistence of the inhibitory effect on microbial biomass C content might be either due to the inhibition of degrading microorganisms (Gan et al. 1995; Gevao et al. 2000) or to the production of higher levels of toxic metabolites. It was reported that different dinitroaniline herbicides (benfluralin, trifluralin) showed inhibitory effect on the several microbial species viz. bacteria, fungi, actinomycetes etc. and their activities due to their mode of actions (acetolactate synthase inhibitors and mitosis inhibitors) (Vischetti et al. 2002; Strandberg and Scot-Fordsmand 2004). Similar inhibitory effect of pendimethalin application on soil bacterial, fungal, actinomycetes (Nayak et al. 1994; Sidhu et al. 1985) and algal (Shabana et al. 2001) population was found with increasing initial concentration. Previous studies reported a good correspondence between soil microbial biomass and transformation of the pesticides 2,4-D (Bolan and Baskaran 1996), atrazine, diazinon and carbofuran (Levanon et al. 1994), 2,4-D and dicamba (Voos and Groffman 1997). The microbial biomass C content returned to the excess of initial values after varying time at all initial concentrations which indicated the resilience and restoration of the microbial community by using cell debris of killed organisms by the survivors under reduced microbial competitive environment (Martin 1963).

The substrate induced respiration (SIR) activity of soil microbiota is mainly governed by metabolically active part of the soil microbial ecosystem. The variation of SIR similarly pointed out the buildup of disturbed condition due to pendimethalin application and the maximum impairment of SIR activity as compared to initial was observed at the time of 50% of herbicide residue remains in the soil (Fig. 2). The initial concentration of pendimethalin application also influenced the metabolically active population of the microorganisms which was revealed from the higher magnitude of SIR activity depression at the initial period of incubation (Table 3). The maximum reduction of SIR activity at FR (38.13%) and 2FR (47.47%) treatments was observed at pendimethalin residue concentration of 53.62 and 53.43% of initial doses, while the maximum reduction of SIR activity at 10FR (68.27%) was registered when 59.3% herbicide residue was remain in soil. From the parabolic nature and maximum reduction of SIR activity, the inhibitory effect of higher initial concentration was prominent, but recovery of the activity was found to start during later period of the incubation. It was evident that the disturbed soil favored the fast-growing microbial community (Odum 1985). The increasing SIR activity at later period might be a community shift towards the fast-growing organisms due to the availability of more substrates with less competition (Golovlev 2001, Steele and Streit 2005). Thus, transformation rate of herbicide pendimethalin was higher in soil of less undisturbed biomass or respiration activity, suggesting that biomass or SIR may be considered as reliable indicators of the herbicide degradation in soil. Torstensson and Stenstrom (1986) reported a close positive correlation between the rate of soil respiration and the degradation rate of linuron and glyphosate in agricultural and forest soils. Jayachandran et al. (1998) observed that mineralization of ^{14}C- atrazine was closely correlated (r=0.81) to atrazine-degrading microbial populations in different soils. These studies illustrate the complexity and diversity of natural soil ecosystems and the difficulty of developing predictive means for assessing degradation rates for organic chemicals.

To evaluate the extent or the residence time of the disturbance, the eco-physiological quotients (microbial metabolic quotient and microbial respiration quotient), reflecting the eco-physiological status of soil microbial community and considered as a sensitive bioindicator (Anderson and Domsch 1985). The change of microbial metabolic quotient with herbicide concentration was presented in Fig.3. The vertices of the parabolic curve indicated the higher extent of disturbance caused due to pendimethalin application and it was observed that the initial concentration had a strong influence on the quotient value (Fig.3). The 10FR application rate recorded comparatively longer and highest level of disturbance (>80 days). The microorganisms under stress condition, might have utilized a large part of their energy budget for cell maintenance with lower metabolic efficiency than carbon assimilation for cell proliferation (Wardle and Parkinson 1990; Wardle and Ghani 1995; Yan et al. 2003). The maximum increase of qCO_2 value over initial never exceeded 13.94% and 23.03% for FR and 2FR, respectively, while 85.45% increase of qCO_2 value was noticed at 10FR treatment (Table 3). An increase in qCO_2 indicates the shifting of energy from growth to maintenance in an ecosystem (Dilly 2005). The changes of qCO_2 value over initial followed opposite trend of MBC and SIR and a sharp decreasing pattern in qCO_2 value was recorded with degradation of pendimethalin in soil. At lower initial doses treatment, the qCO_2 value at the end of incubation reached to the lower magnitude in comparing to initial ($\leq$ 100%) , whereas the qCO_2 value was similar with initial ($\approx$100%) in higher initial doses treatment (Fig. 3). The results suggested that the disturbance resulted from pendimethalin application was almost minimized and the ecosystem restored an equilibrium condition (Gomez et al. 2009; Das et al. 2007; Jones and Ananyeva 2001). Analogous to the trend of metabolic quotient, microbial respiration quotient (Q_R) also followed the similar trend and from the parabolic curves it was clearly evident that the higher initial doses had a strong negative influence on the metabolically active population of soil microbial ecosystem rather than overall microbial population (Fig.4). The

microbial respiration quotient pointed out the persisted inhibitory effect of pendimethalin application on the metabolically active population of soil microbiota which was reflected from the higher Q_R value over initial till the end. The maximum increase of Q_R value over initial recorded 150% increase at 10FR treatment, while increase of Q_R value never exceeded 66.67% and 79.17% at FR and 2FR, respectively (Table 3). In respect of initial, the extent of increase in Q_R was much more than that of qCO_2 at 10FR treatments which might be the consequent of the more reductive effect of pendimethalin to the zymogenous population (r-strategic) rather than autochthonous microbial population (k- strategic). However, during the later period of incubation, the decreasing Q_R value might be in accordance to the disappearance of disturbance from the ecosystem and the rapid growth rate of r-strategic (active & faster growing) community which establish a new equilibrium condition under more favourable growth environment.

The relative changes of microbial biomass C content and microbial metabolic quotient over initial with incubation time demonstrated the response of microbial population to the extent of disturbance and pointed out that microbial biomass C content decreased with increasing disturbance followed by an inverse trend during the later period of incubation. With decreasing microbial biomass C content, the increasing metabolic quotient value indicated the higher respiration activity per unit biomass and it suggested the higher maintenance energy of microorganisms with lower metabolic activity. The lower specific metabolic efficiency found with increased doses of pendimethalin would be reflecting a stress in the microbial communities due to inhibitory effect from the herbicide. Haney et al. (2000) similarly found that with increasing concentration of glyphosate treatment, the rate of mineralization of carbon was increased in spite of the decreasing trend of microbial biomass carbon. It was observed that the returning of microbial biomass C content and microbial metabolic quotient to the initial level was much earlier in the treatments of lower application doses than

at higher doses (Fig. 5). It might be attributed to the fact that the microorganisms, seriously affected due to higher concentrations, took more time to adopt with the disturbance and returned to the initial state with time. The maximum depression of the biomass C content over initial corresponded to the maximum increase of the qCO_2 which supported the concept of Odum's theory; under stressed condition, the microbial ecosystem utilize large part of their energy budget for cell maintenance rather than cell proliferation (Anderson and Domsch 1990) concomitant with reduced microbial efficiency. It was important to note that during the later period of incubation, the declining trend of qCO_2 and increasing trend of biomass C content, both were steeper in nature for both 2FR and 10FR compared to FR. This might be attributed to the less competitive environment, prevailed in the higher dose treatments, under which new fast growing community efficiently utilized the plenty of carbon resources derived from the degraded products of pesticide and cell biomass of susceptible organisms and accelerated their growth and proliferation with higher metabolic efficiency (Odum 1969; 1985).

In conclusion, the present study demonstrated an initial inhibitory effect of pendimethalin that affected the microbial community, indicating that no harmful effects should be expected in the short term when pendimethalin is applied at doses equivalent or higher than those usually applied in the field. The results are also substantiated the existence of relationships between pesticide dissipation and microbial parameters which may be useful for developing approaches for evaluating and predicting the fate of pesticides in the ecosystems.

Table 1. Characteristics of soil under experimental study

Soil Characteristics	
Soil pH	6.6
Organic carbon (%)	1.11
Sand (%)	31.15
Silt (%)	31.35
Clay (%)	37.5

Table 2. Regression equation, degradation rate constant (k), correlation coefficient (r^2) and half life ($t_{1/2}$) values of pendimethalin in Clay loam soil at 60% water holding capacity under laboratory condition

Treatment	Regression equation	k (d^{-1})	r^2	$t_{1/2}$ (d)
Pendimethalin FR	y = -0.02500x + 2.727	0.025	0.94	12.04[b]
Pendimethalin 2FR	y = -0.02480x + 3.051	0.0248	0.93	12.14[b]
Pendimethalin 10FR	y = -0.02110x + 3.735	0.0211	0.97	14.26[a]

Table 3. Microbial biomass C and substrate induced respiration decrease (%) and microbial metabolic quotient and respiration quotient increase (%) over control and corresponding pendimethalin concentration (%) over initial dosage

Initial dose	Maximum decrease/increase of microbial variables over initial and corresponding pendimethalin residue concentration over initial doses at day 15				
	Microbial Biomass C decrease (%)	Substrate Induced Respiration decrease (%)	Microbial metabolic quotient increase (%)	Microbial respiration quotient increase (%)	Residue concentration (%)
FR	10.67	38.13	13.94	66.67	53.62
2FR	25.14	47.47	23.03	79.17	53.43
10FR	58.05	68.27	85.45	150.00	59.37

Fig.1 Correlation between persistence of pendimethalin and biomass C content at 25^0C under different application rates (B% percent of biomass C content over initial; RC% percent of pendimethalin concentration over initial concentration) (a: FR treatments; b: 2FR treatments; c: 10FR treatment)
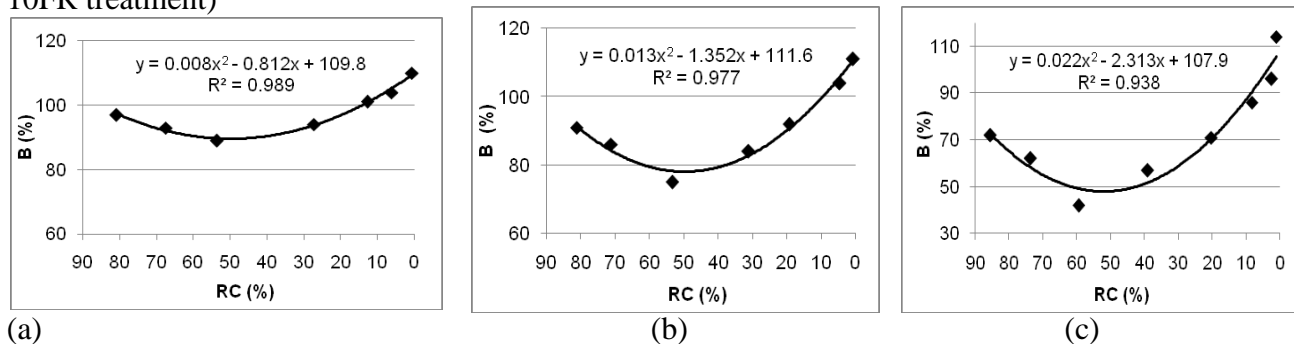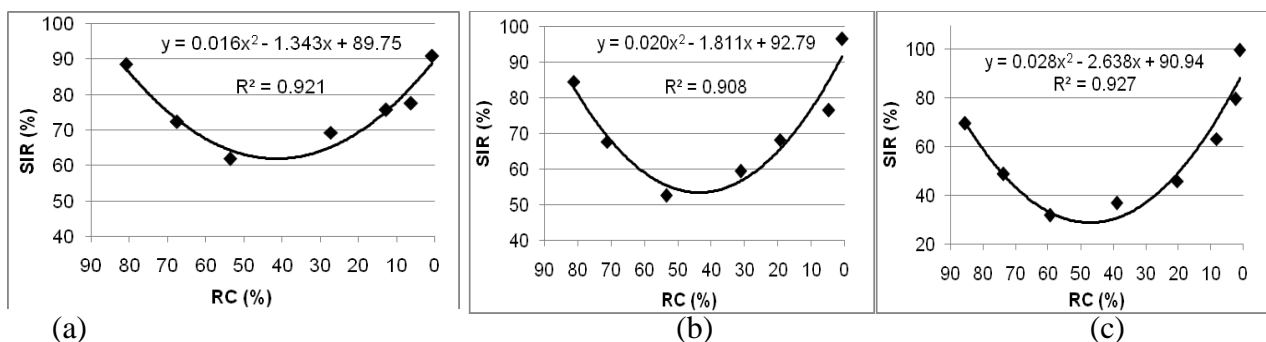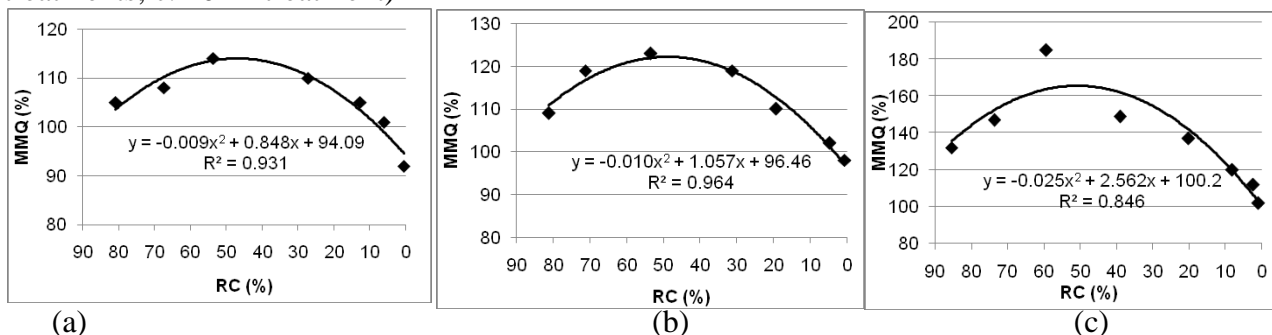

(a)   (b)   (c)

Fig.2 Correlation between persistence of pendimethalin and substrate induced respiration at 25^0C under different application rates (SIR% percent of substrate induced respiration over initial; RC% percent of pendimethalin concentration over initial concentration) (a: FR treatments; b: 2FR treatments; c: 10FR treatment)

(a)　　　　　　　　　(b)　　　　　　　　　(c)

Fig.3 Correlation between persistence of pendimethalin and microbial metabolic quotient at 25^0C under different application rates (MMQ% percent of microbial metabolic quotient over initial; RC% percent of pendimethalin concentration over initial concentration) (a: FR treatments; b: 2FR treatments; c: 10FR treatment)

(a)　　　　　　　　　(b)　　　　　　　　　(c)

Fig.4 Correlation between persistence of pendimethalin and microbial respiration quotient at 25^0C under different application rates (MRQ% percent of microbial respiration quotient over control; RC% percent of pendimethalin concentration over initial concentration) (a: FR treatments; b: 2FR treatments; c: 10FR treatment)

(a)　　　　　　　　　(b)　　　　　　　　　(c)
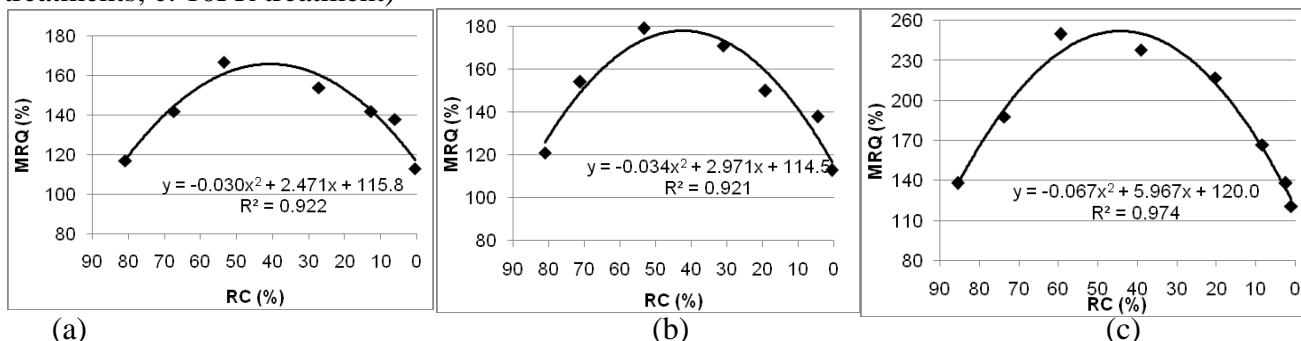
Fig.5 Variation of biomass C content (B%) and microbial metabolic quotient (MMQ%) over control with incubation time (days) at 25^0C under different application rates (a: FR treatments; b: 2FR treatments; c: 10FR treatment)

(a)　　　　　　　　　(b)　　　　　　　　　(c)
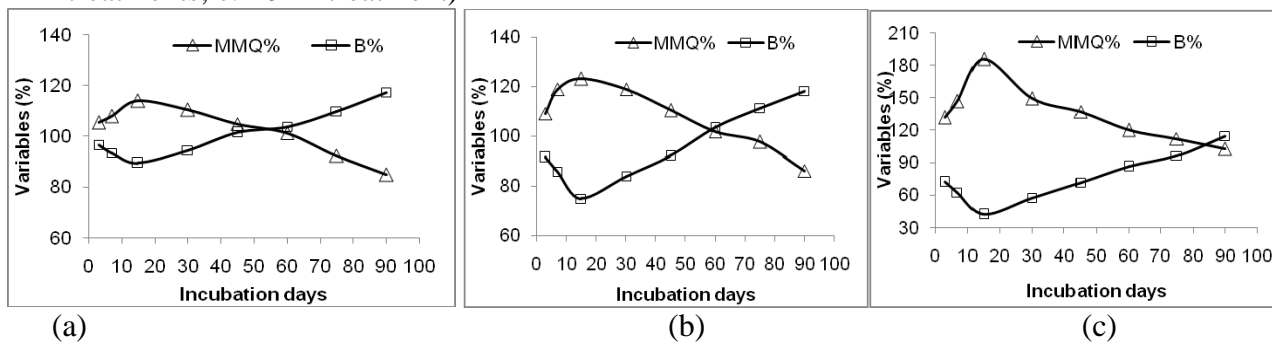
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HEALTH RISK OF VISITORS IN TAGORE'S MUSEUM BY MOULD EXPOSURE AND AIR POLLUTANTS:IMPLICATION OF INDOOR AIR QUALITY STANDARDS

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ABSTRACT

This study evaluates the effect of airborne mould and indoor air pollutants on human health in an old heritage building, presently use as a museum and identifies the indoor environmental factors that influence fungal growth. The museum conserves exhibits of the family of first Non-European Nobel Laureate, *Rabindranath Tagore.* Air sampling was carried out with the aid of the Anderson Sampler and High Volume Sampler for mycological and pollutant study respectively. The maximum and minimum spores were found to be 1272 CFU/m^3 at monsoon and 82 CFU/m^3 at winter season respectively. Fungi communities in the air samples were predominately the members of the genera *Paecilomyces*, *Aspergillus*, and *Penicillium*.The spore loads were above the standard recommended by World Health organization (500 CFU/m^3), European Commission, Health Canada (100 CFU/m^3) and Occupational Safety and Health Administration (1000 CFU/m^3). The chemical pollutants like SO_x and NO_x concentration were lower than recommended. Strategies aimed at reducing airborne fungi level may be most effective for the visitors.

Keywords Airborne moulds, indoor air pollutants, museum, visitors, health risk

1. Introduction

Museums, archives and libraries are institutions that are crucial for preserving cultural and historical heritage all over the world. Curators, librarians, conservators, storeroom workers and office staffs stay at least eight hours regularly in those institutions. Previous microbiological analysis in museums, libraries and archives has shown high microbial air contamination, which may pose a danger to historical objects and also to staff. Health threats in these institutions arise due to the inhalation of the micro-organism-contaminated air and by handling, cleaning and conserving items many of which are mould infested (Bhattacharyya *et al*., 2016).

Fungi are the important group of microorganisms present in all buildings. They are sometimes thought to be the most important type of microbes in indoor environments, but this view may be partly because fungi sometimes can be apparent to building occupants as visible mycelial growth and via their characteristic musty smell. Fungi present in both indoors and outdoors are a permanent risk factor as it links to health damage of epidemiological population. Fungi can be introduced to indoor environment of office or house through transport by workers and visitors via their bodies, clothes and carried items or with outdoor air through ''natural

gates'' such as doors and windows. Moreover, incorrectly operating air-conditioning system may also be a source of biological particles. In some cases, heating, air-conditioning, or ventilating systems may provoke serious fluctuations in temperature and relative humidity, which can cause harm to indoor components of old buildings. Fungal growth in building is usually connected with their biological corrosion caused by a wide spectrum of metabolic products associated with microorganisms including enzymes. Fungi use organic substances as a source of nutrients and can utilize water contained in the air (Naji *et al*., 2014). All fungi are not macroscopically visible in the early stages of growth or as airborne spores. They are visible only after considerable proliferation i.e., fungi have already caused some damage by the time they become visible. Many indoor studies have been carried out in India and throughout the world in different buildings, such as hospitals , homes , offices , schools , farms , library , markets , museums), etc. and a fungal profile was developed in an Indian heritage building presently used as museum of Baroda (Arya *et al*., 2001).

The frequency of fungal attack and vulnerability supposed to increase at different microclimatic conditions. The species diversity, dominance and dynamicity of species were other influential factors of the situation.

The microclimatic factor like relative humidity and temperature may control the fungal growth in the indoor environment of a heritage building. Sometime air-conditional system incorporates biological contaminants like pollen, bacteria, viruses, fungus, molds, etc. These contaminants can breed in stagnant water that was accumulated in humidifiers, drainpipes and ducts or where water was collected on ceiling tiles, insulation, carpets and upholstery. Malfunctioning of air-conditioning systems and poor ventilation can recirculate pathogens and spread them throughout the building (Wang *et al*., 2013)

Various air-sampling methods are in use to monitor the occurrence of fungal propagules in the atmosphere, such as non-viable sampling method (capture of total airborne fungal spores, fixation, microscopic identification, and enumeration) and viable sampling method (isolation of cultivable airborne fungi in growth medium for the purpose of identification and enumeration).The non-viable sampling method enables the microscopic identification of fungal spores deposited on an inert surface, and thus it allows access to the total airborne fungi. On the other hand, the viable sampling method permits identification of the predominant viable fungal propagules in air by way of isolating them in artificial growth media. But this method excludes the biotrophic parasitic fungi that do not usually grow on routine culture media   (Das and Gupta-Bhattacharya, 2012).

The aim of this study was to determine mycological contamination and indoor air pollutant in a frequently visited museum building and to identify the indoor environmental factors that influence the air borne fungal growth. This data may be helpful to evaluate probable health risk of workers and visitors of the museum.

2. Materials and methods

2.1 The Tagore Residence-Study area

The Tagore residence at *Jorasanko* (22°35'13"N and 88°21'38"E) Kolkata, India is the ancestral home of the Nobel Laureate poet Rabindranath Tagore. The house currently serves as Tagore museum. The museum preserves different items of Tagore family and Bengal province including books, photograph, newspapers, oil paintings, manuscript, fabrics, furniture and others.

2.2 Indoor fungal sampling

The Andersen two-stage viable (microbial) particle sampler (2-STG) was developed for monitoring bioaerosols. It is a multi-orifice, cascade impactor with 400 holes per stage, drawing air at a flow rate of 28.3 L min-1. The different stages separate the airborne particles in size fractions. For this study air sampling was done on Potato Dextrose Agar Medium (HiMedia, Mumbai, India) at one meter height from the ground. The sampler was operated for three minutes at the site in duplicate and an average was taken. For enumeration and identification of total viable type of fungal population present in air, the plates kept on upper stage of the sampler were taken. The level of airborne fungal spores is usually expressed in terms of colony forming unit per cubic meter (CFU/m^3). For this atmosphere $CFU/m^3$is calculated by using equation given by Senior (2006) with some modification. Colony forming unit per cubic meter (CFU/m3) is calculated from the following equation:

Colony Forming Unit (CFU) $= \frac{1000\,P}{RT}$CFU/m

Where P is the number of colonies counted on the sample plate after correction by using positive hole conversion table provided by Andersen (1958), T is the duration of the test in min (10min.), and R is the air-sampling rate in Liters/min(28.3 L min-1)

Indoor air was collected once a week, at 1 pm in the afternoon in the same place on the site of the study building for a period of one year from April 2014 to May 2015.

2.3 Identification of fungal groups

Indoor fungal samples thus collected were processed in the laboratory of the University. Potato dextrose agar plates containing fungi were incubated at 27 °C and were examined daily for fungal growth. To optimize the production of fruit bodies, a limited number of strains were cultivated on Malt-agar 3% and Czapedox agar. Fungal species were identified on the basis of their morphological characteristics when the development of the colonies was sufficient. The samples were stained with lactophenol cotton blue solution

and investigated under optical microscope (magnification×400).Confirming our result the isolated fungi were also identified by *Agharkar Research Institute* at Pune, India.

2.4 Indoor air pollutant and environmental factors

Suspended particulate matter (SPM), sulfur dioxide (SO_2), oxides of nitrogen (NO_x), temperature, humidity, luminance and wind speed were measured out for a period of one year from April 2014 to May 2015.

High volume air samplers were used for indoor air sampling. SPM was collected on fiber filter paper continuously for 8hours at a flow rate of 0.5–1.0 L/min, while gaseous sampling was carried out for 2–3 hours by drawing air at a flow rate of 1–2 L/min. SO_2 was determined by West and Geake colorimetric method, while NO_x was done by Jacob-Hochheiser colorimetric method. The whole experimental design was performed according to indoor air quality assessment done at Salarjung Museum, Hyderabad, India (Reddy *et al.*, 2005).

Determination of indoor environmental factors i.e. temperature, humidity, luminance and wind speed were carried out in daytime only i.e. during which museum are kept open for public.

2.5 Statistical methods

All results were evaluated using one-way analysis of variance (ANOVA) at the 0.05 significance level. Linear regression analysis was used to determine the effect of air humidity and temperature and pollutant on microbiological contamination of the air in tested buildings.

3. Results

3.1 Fungal load, diversity and identification

In the study carried out with the aid of the Anderson two stage air samplers a total of 11 types of cultivable fungal species were identified. The maximum (1272±36 CFU/m^3) and minimum (82±6 CFU/m^3) spores were found in living room 4 i.e. S11in monsoon season and in living room 2 i.e. S9 in winter season respectively. The maximum species diversity was observed in three sampling season whereas the minimum species diversity was observed only in winter. **Table 1** shows twenty sampling rooms with their present use and material present. As regards the identification of isolated fungi from different room, the highest percentage in all was found to be *Paecilomyces variotii* followed by *Aspergillus sp. (Aspergillus tamari, Aspergillus niger, Aspergillus ochraceous* and *Aspergillus fumigatus)* and *Penicillium oxalicum.* The other species like *Trichotderma sp, Alternaria sp., Verticillium sp, Fusarium semitectum, Cladosporium sp, Yeast sp, Curvularia lunata and Helminthosporium sp.* were found in few number (**Fig. 1**).

Table 1 Sampling location in *Jorasanko* Museum and availability of exhibit

Room No	Exhibit type	Use
S1	Wood, leather	Entry Room
S2	paper	Manuscript preservation room
S3	wood, paper, silver, ivory	Museum lounge
S4	cloth, silver, porcelain, wood	Family Living Room gallery 1
S5	Wood, paper,	Family Study Room gallery
S6	Wood	Family Kitchen gallery
S7	wood	Tagore Dining gallery
S8	wood, metal, lac	Music archives
S9	wood, cloth, mat, bamboo	Family Living Room gallery 2
S10	wood, cloth, mat, bamboo	Family Living Room gallery 3
S11	wood, cloth, mat, bamboo	Family Living Room gallery 4
S12	Oil paint, paper, metal	Art Gallery (Bengal School) 1
S13	Oil paint, paper, metal	Art Gallery 2

S14	wood	Family Maternity gallery
S15	wood, bamboo	Japan Gallery
S16	Oil paint, paper, metal	Renaissance Gallery
S17	cloth, oil paint, paper	18th Century oil painting gallery 1
S18	Cloth, paper, jute	18th Century oil painting gallery 2
S19	Cloth, paper, jute	18th Century oil painting gallery 3
S20	paper, book	Library and archives

However, the eleven dominated fungal species were not uniformly distributed in the indoor environment of the study area throughout the year, and considerable differences were found between different sampling sites. P*aecilomyces sp* were detected round the year in all sampling site in which its maximum occurrence (886±10) was found in the air of Art gallery 2 i.e. S13 in winter season. In summer season P*aecilomyces sp.* (504 ±12)in the manuscript preservation room (S2)was found to be maximum which is followed by *Penicillium sp.* (456 ±10) at entry gate (S1) and *Aspergillus sp.* (410 ±12) at Art Gallery (S13).The other species like *Alternaria sp.* (728±12 atliving room 3 i.e. S10), *Yeast sp.* (100±12 at dining room i.e. S7)*, Curvularia sp.*(85 at living room 2 i.e. S9)were above the 50 CFU/m^3 at the summer season (**Fig. 2**). Except *Helminthosporium sp* the loads of *Fusarium sp., Verticillium sp., Trichoderma sp. and Cladosporium sp.* were insignificant in the summer season (**Fig. 2**). In monsoon *Aspergillus sp.* and *Paecilomyces sp.*(566 ±22)showed the maximum loads which is followed by *Penicillium sp.*(456 ±10), *Alternaria sp.*(274±12),*Curvularia sp.*(172±14),*Yeast sp.*(158±20.), *Trichoderma sp.*(100±14.) and *Helminthosporium*
.

sp.(54±9.). The other fungal loads were below 50 CFU/m^3(**Fig. 2**). *Yeast sp., Trichoderma sp.* And *Verticillium sp.* were totally absent in winter where as all other species were more than 50 CFU/m^3(**Fig. 2**)
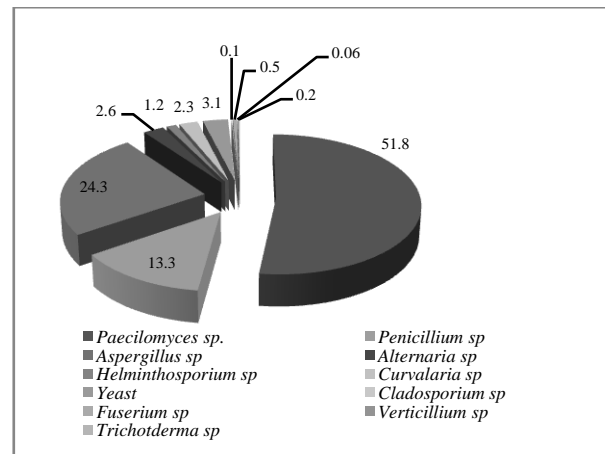

Fig.1 Average diversity (in percentage) of eleven isolated fungi

3.2 Indoor air quality

The indoor average seasonal variations of SO_2, NO_x data are given in the **Table 2**. The SPM level was not reported, as they are below detectable level in all seasons. The highest SO_x level was observed in winter followed by summer and monsoon. The same observation was found for NO_x level also

Table 2 Indoor air quality of study area

$\mu gm/m^3$	Summer	Monsoon	Winter	WHO standard*		Museum object degradation standard**
				short term exposure	Long term exposure	
SO_x	35.30	17.4	46.3	20	500	10
NO_x	9.42	6.4	8.3	40	200	10

* World Health Organization, 2005 and ** Jean, 2000

3.3 Microclimatic data

The highest temperature (37°C) was observed in the exhibition room present at the top floor of the heritage building in summer season where as the lowest temperature (21°C) was observed in the ground floor in winter season. Two rooms namely Art gallery 1and Art gallery 2 showed very less variation in temperature during the study period. The highest (77.5%) and lowest relative humidity (30.2%) was observed in manuscripts preservation room in the ground floor and Japan gallery in the first floor respectively. More or less the average relative humidity was highest in monsoon followed by summer and winter. The windows of all the room remained open at day time. Air flow was moderate to low and air conditioning systems were present in Art Gallery-1-Bengal School (S12), Art Gallery-2 (S13) and Japan Gallery (S15). Room having air conditioning system showed no air movement in both winter and summer season where as the highest air movement (3.8Km/hr) was found in summer season at the entry room of the museum. All the rooms had artificial light. Except rooms having air conditioning system the luminance of the museum rooms was not equal in all sampling points. On an average in summer they showed highest luminance followed by monsoon and winter. The highest luminance was found at entry gate (575.2 lux) in monsoon season and lowest in the library (10 lux) in winter season.

3.4 Statistical correlation study

The statistical correlation study revealed that only relative humidity and spore load has significant correlation ($P > 0.5$ and $R^2 = 0.7$). As the humidity increases the spore load increases. The other factor temperature shows almost same relation with spore load ($P > 0.1$ and $R^2 = 0.12$). As the concentration of SO_x and NO_x were not measured in all twenty sampling point, the data were not used in the correlation study.

3.5 Visitor profile

About thirty seven thousand people visited the museum in the year from April, 2014 to March, 2015. Most of the foreign people (55%) came in winter followed by school student and Indian visitors. The visitor loads were low in monsoon and summer seasons (**Table 3**).

Table 3 Visitor profile of the museum in the year April 2014 to March 2015

	Summer	Monsoon	Winter	Total
Foreign visitor	1025	842	2297	4,164
Indian visitor	6955	5149	10719	22,823
School student	1947	2860	5250	10,057

4. Discussions

This study describes loads and diversity of culturable fungi obtained from an indoor air samples in a heritage building established in colonial era of India collected during all three seasons of the year. Our results indicate the presence of sources of allergic disease in the indoor environment. The dominated fungi *Aspergillus* sp. *Penicillium oxalicum, Alternaria sp, Fusarium semitectum, Cladosporium* sp., *Curvularia lunata* in the museum are inducers of IgE-mediated sensitization and sources of allergic rhinitis or asthma. The presence of *Cladosporium, Alternaria, Aspergillus*, and *Penicillium* species in high concentration raise the chances of current asthma symptoms by 36 to 48% compared to people exposed to them in lower concentration (Sharpe *et al*., 2015). Common fungal spore belonging to the Indian indoor environment are species of *Aspergillus, Alternaria, Cladosporium, Helminthosporium, Curvularia, Rhizopus*etc. These can be compared with our study, where *Penicillium sp.*, *Aspergillus sp*., *Curvularia sp., Alternaria sp.*, *Trichoderma sp.* and *Paecilomyces* sp were dominated throughout the three seasons. The fungal load was compared with those of some other Indian or world studies. Our study showed the fungal spore load ranges from 82 CFU/m^3 to 1272 CFU/m^3 during all three seasons of the year (**Fig2**). These ranges can be compared with the work of Mendes *et al*. (2013) where they determined fungal spore load of an age old building ranging from 32 CFU/m^3 in bedrooms to 228 CFU/m^3.The higher fungal load of our study can be

explained by geographic differences in micro-climate, air flow rate, duration of sampling and culture media (Sharpe *et al*., 2015). The materials like wood, bamboo, silk fabric in indoor environment are supposed to be the breeding place of fungal species (Mendes *et al*., 2013).The spore loads were more (>1000 CFU/m^3) at the sampling site where items like papers, wood, cloth, mat, bamboo and oil paintings were present (**Table 1**).All the mentioned items present at the room are cellulose in nature. Most of the fungi associated with the damage of paper and oil paintings on canvas can dissolve cellulose fibers with the action of cellulolytic enzymes, or may discolour the support, dissolve glues and inks or degrade the oil binders (Sterflinger and Piñar, 2013). Wooden sculptures and art photographs temporarily stored in the quarantine room of the Cultural Center of Belgrade were subject to mycological analyses. Twelve fungal species were identified on the wooden substratum and five species were detected on photograph surfaces. The species have proven cellulolytic activity detected on the examined cellulose substrata (Grbić *et al*., 2013).

It has been noted that in the present study fungal loads depends on the relative humidity of the indoor environment. In monsoon as the relative humidity was high, the average spore load were also high in the Manuscript preservation room (S2), Living Room gallery 2, 3 and 4 (S9 to S11) and Art gallery (S13).In summer the spore loads were low followed by winter season. The spore loads were above the standard recommended by World Health organization (500 CFU/m^3), European Commission, Health Canada (100 CFU/m^3) and Occupational Safety and Health Administration (1000 CFU/m^3)(**Fig.3**). Almost similar findings are reported by Grbić *et al* (2013) where increasing humidity encourage the fungal growth in indoor air. Another finding showed, with relative humidity varying between 78 and 100% in a cave environment, highest fungal loads and diversity were observed at elevated humid condition. Dubey and Jain (2014) had cultured five fungi in a wide range of relative humidity under laboratory conditions and they also found similar results.

However, with the results regarding diversity of fungi isolated in indoor air during the three seasons, it was noticed that out of eleven major fungal genera, *Paecilomyces* was the dominated species which is followed by *Aspergillus sp* and *Penicillium sp* (**Fig. 2**). Literature shows almost similar observation in which some other workers found twenty-one filamentous molds and four genera of yeasts. They isolated and identified 112 fungi from selected archaeological wooden objects located at different areas of Islamic Art Museum. *Aspergillus* species (24.30%), *Penicillium* species (13.30%) and *Alternaria* species (2.6%) were the most encountered fungi in different studies (Khan *et al*., 2012). The prevalence of these three genera was previously observed in an indoor work environment and other old heritage buildings. This suggests that the diversity is one of the major variables in indoor environment and a serious reason of proliferation of disease in indoor object. In the current study though both room (S2 and S20) preserve only paper items, the fungal loads and diversity are different in all the seasons. The library room is present at the top floor and round the year the windows are closed. This suggests that the galvanized steel cabinet and fiberglass accumulates dust or lubricant oil residues which allow the growth of fungi (Khan *et al.* 2012). The other parameters like ventilation and temperature may play a significant role. Chadeganipour *et al*. (2011) have identified 1265 colonies of fungi belonging to 26 genera from the air and different surfaces of books and also from surfaces of shelves in libraries (Chadeganipour *et al* , 2011; Hayleeyesus and Manaye , 2014). Like the current observation *Cladosporium* sp., *Penicillium sp*., *Aspergillus* sp. and *Alternaria* sp. were the most common isolated fungi in libraries of Isfahan University of Medical Sciences. Some species of *Penicillium* and *Aspergillus* can able to grow from 22°C to 55°C (Olaf *et al*., 2011).

Regarding the data of indoor air pollutants, NO$_x$ and SO$_x$ levels are exceeding the limits (10 μg/m^3) prescribed for museums to prevent the deterioration of objects (Jean, 2000). However these data in terms of indoor air quality levels were lower than the WHO recommended guidelines (World Health

Organization, 2005). That is both the workers and visitors were safe in the short term and long term exposure of indoor air of museum (**Table 2**). The concentration of NO_x is usually high in an urban atmosphere, due to its emission by automobiles and the burning of the coal is the major sources of SO_x in environment. Our study area is located in a congested unban area where vehicular pollution is one of the major problems and the street food sellers still use coal based oven. Hence the sources of existing NO_x and SO_x contamination in indoor environment probably are the outside environment.

In the current study only relative humidity showed positive correlation with spore load and species diversity (**Table 3**). Indoor humidity is influenced by ventilation rates. Ventilation usually reduces indoor moisture levels. Very high indoor humidity is associated with increased growth of microorganisms such as mould and bacteria (Institute of Medicine, 2004). Steady microclimatic parameters, temperature of $20 \pm 2^{o}C$ and relative air humidity of 50 ± 3 %, are recommended for collection storage in the studied institution types (ISO 11799, 2003). In the studied museum the relative humidity deviated up to 7-8 % which is quite common. This was probably due to the lack of ventilation and air conditioning systems. Ventilation is intended to remove or dilute pollutants and to control the thermal environment and humidity in buildings. It must be sufficient either to remove pollutants or to dilute their concentrations to acceptable levels for the health and comfort of the occupants and must be sufficient to maintain the building's integrity and also combating fungal problem in better way (Hayleeyesus and Manaye, 2014).

Finally, most of the identified fungi and their average loads in the museum constitute a threat for the public 17. The study site is frequently visited by both Indian and foreigner (**Table 3**) in which near about ten thousand people are school student. The risk of allergy increased when the average fungal load ($619\pm24CFU/m^3$) of the study area was above the recommended standard of World Health Organization, Health Canada, United State, European Union and Singapur (OSHA, 2006). The maximum loads of fungi at monsoon season was two times higher (**Fig. 3**)The total load of fungi like *Aspergillus* sp. was near about 500 CFU/m^3 (at S2 and S9to S13 sampling sites) in the monsoon season (**Fig. 2**). The load of other fungi like *Penicillium sp* was also higher (> 250 cfu/m^3) in the same season (**Fig. 2**). Both the species are potent inducers of IgE-mediated allergy of Indian citizen (Das and Gupta-Bhattacharya, 2012). Factors like relative humidity, fungal diversity and the presence of potentially pathogenic micro-organisms should be taken into account in the microbiological assessment of working environments in museums. Those factors may affect the health of workers and visitors of the museum; however, it requires further study
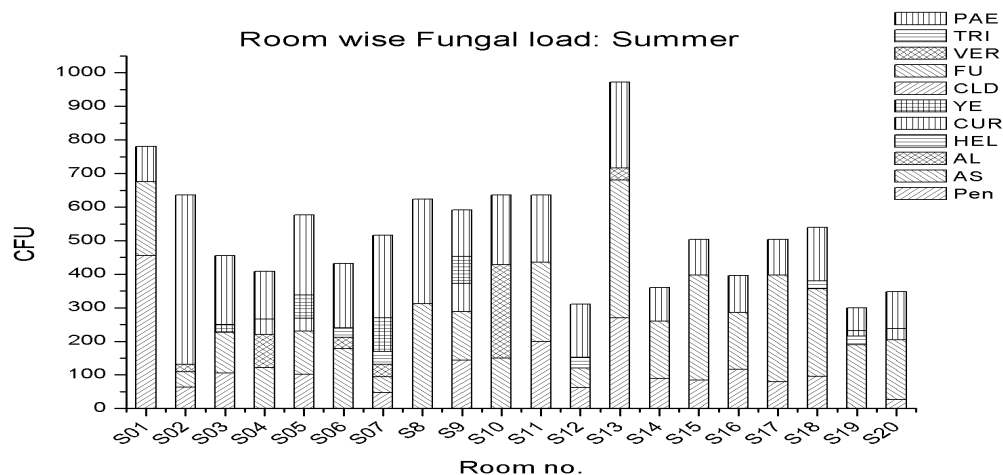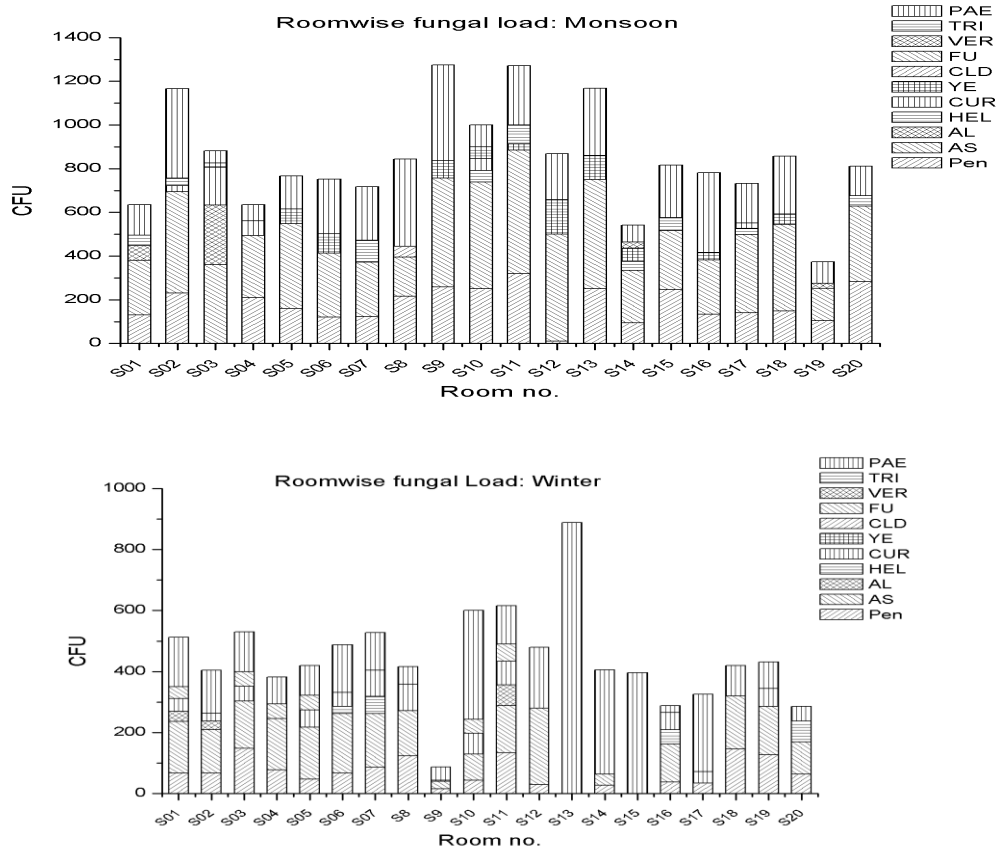
Fig. 2 Occurrence (CFU/m^3) of different species seasonally in different room of the *Jorasanko* Museum, India
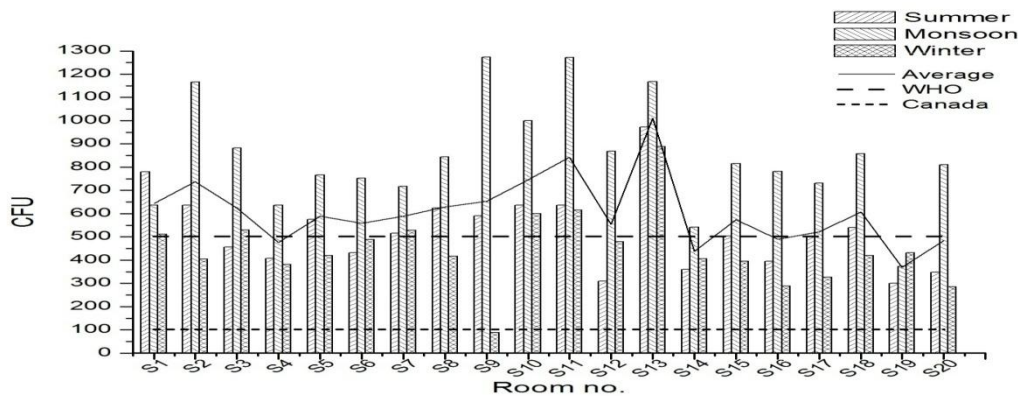
Fig.3 Average fungal spore loads (CFU/m^3) in the museum in different season with the different standard of spore loads mentioning in the guidelines of several countries and governing bodies

5. Conclusions

From the above study we can conclude that the load and diversity of fungi within museum were dependent on the humidity of the exhibit rooms and gallery. Fungal loads more than 1000 CFU/m^3 are present in those rooms that have items like papers, wood, cloth, mat, bamboo and oil paintings. The maximum fungal loads in the museum were two times higher than the WHO recommended limits. Fungi *Aspergillus sp* and *Penicillium sp* can cause adverse human health effects in both museum workers and visitors. The relative humidity, temperature and fungal contamination in the air were directly correlated. Both the SO$_x$ and NO$_x$ concentration were lower than the WHO recommended guidelines but are not below the limits prescribed to prevent the deterioration of objects.

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