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Impact of Pesticides on Soil Health-a Comparative Study conducted on Conventional and Organic Tea Gardens of Dooars Region, West Bengal

Rahul Kumar Mishra, Soumya Shukla* and Md. Abdullah Khan
Department of Geology, Sikkim University, Gangtok Sikkim, India.

(Corresponding author: Soumya Shukla)*
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ABSTRACT: Tea, world's second most popular beverage is drunk for its numerous health benefits and refreshment. Tea grows well in warm humid climate with an annual rainfall of more than 115 cm. The environmental conditions such as high relative humidity and temperature above 35˚C is favourable for disease development and to control them synthetic pesticides are used extensively. Dooars – Terai regions of North Bengal which contributes 21% of India's total tea production has background of highest pesticide use in the country. Pesticide residues have many adverse effects on soil health and even on human health. Present study aims to study the impacts of these pesticides on the beneficial soil microflora and physico-chemical properties of soil of both conventional and organic tea gardens. This study has been conducted in the Western Dooars region of North Bengal. Samples of two different age groups (10 years and 40 years old tea gardens) were collected from 7 tea estates (five conventional and two organic) from Jalpaiguri and Kalimpong districts and were analyzed. The samples were collected during the December 2022 to January 2023. For physico-chemical properties pH, Total Organic Carbon, Available nitrogen, phosphorus, and potassium were studied. For microflora total bacteria, total fungus, *Actinomycetes, Azospirillum* sp., *Pseudomonas, Micrococcus, Azotobacter* sp., etc. were studied. Serial dilution and plate count method was used to study the microflora whereas physico-chemical properties were studied by their respective methods. The results revealed almost all conventional soil samples have less microbial counts than the soil samples taken from organic tea gardens. Some conventional soil has high content of available Nitrogen, available Phosphorus but they have less N_2 fixing bacteria, phosphate solubilizing microorganisms which is a matter of concern. Pesticides do not have any negative impact on the *Actinomycetes* and *Azotobacter* and their CFU count in both the sample soil types were similar. Pesticide alters the pH of the soil which leads to changes in the solubility of macronutrients and micronutrients. For proper productivity and sustainability of soil ecosystem tea producers should focus more on biopesticides and other alternatives.

Keywords: Pesticides, Microflora, Sustainability, Ecosystem, Health.

INTRODUCTION

Tea (*Camellia sinensis* (L.) Kuntze) is a dicotyledonous and perennial crop belonging to the family *Theaceae.* Tea is one of the most important cash crops in India. Tea is second largest non–alcoholic beverage in the world next to water (Gurusubramanian *et al.,* 2008). Tea contains polyphenols (catchiness), amino, tannic acid and other antioxidants. Drinking tea is considered beneficial for human health, including the prevention of many diseases. Because of its numerous health advantages and various refreshing effects, consumption is rising significantly all over the world. Tea is an excellent source of many natural bioactive compounds that are healthy for people. Tea's benefits for health include cardiovascular prevention, anti-inflammatory, antiviral, antidiabetic, weight management, neuroprotection, antihypertensive, and chemo-preventive (anticancer) properties (Debnath *et al*., 2022).

Tea cultivation requires warm and humid climate for adequate growth and development. Tea is basically a rain-fed crop. It is grown well in areas where annual rainfall varies from 1150mm to 6000mm. Due to its perennial nature and the favorable micro- and macroclimate for the growth of many insect pests and fungal diseases, it is estimated many species of insect pests and pathogens infect tea plants (Chen and Chen 1989) across the world. Only 300 species of insects (tea pests) are recorded in India (Das *et al.,* 2005). Majority of these infect plant leaf, stem, and root, which ultimately decreases the quantity and quality of tea production. Several diseases are prevalent in the Dooars region of North Bengal. Synthetic pesticides are certainly considerably more efficient, but they also come with a number of drawbacks, including environmental damage, health risks, phytotoxicity, and the development of resistance, resurgence, and residues in tea.

The current trend of using synthetic pesticides excessively in tea crop protection programs throughout North-East India, West Bengal, Tamil Nadu has led to environmental disturbances, pest resurgence, variation in susceptibility, residue issues in tea production, impedance for natural regulatory agents, and lethal and sublethal effects on non-target pests (Mukhopadhyay and Mondal 2017). Significant changes in the tea production system have occurred recently as a result of rapid changes in the market and population strain. As a result, both soil degradation and land use intensity have increased. The average use pattern of synthetic pesticides was estimated to be highest (16.75Kg/ha) in Dooars -Terai region of North Bengal (Gurusubramanian *et al.*, 2008).

Rich diversity of micro and macro flora can be found in tea garden soil, which is a living, highly complex, and dynamic ecosystem. In a 1 g sample of soil, tentatively contains billions of microbes, of different species, making soil as most diversity rich material on the planet (Torsvik and Ovreas 2002). These organisms have an impact on the soil's characteristics as well. It maintains a balance between physical, chemical, and biological factors and is primarily composed of inorganic mineral nutrients, organic matter, and vast numbers of living things. In order to support plant growth, soil fertility, and structure, these microbes are very important and stimulators for the decomposition of organic plant and animal matter. In addition to its most well-known function as a medium for tea plant growth, soil also plays different other important roles; facilitating the exchange of gases, movement of energy, nutrients and water also helps in detoxification of pollutants (Jacoby *et al.*, 2007). Therefore, maintenance of soil biodiversity along with microbial diversity, and ensures sustainable agricultural production, based on soil health are current need of research. And drop in use of synthetic pesticides will provide health to soil, and a healthy soil devoid of pollutants will not further contaminate the local water bodies both surface and groundwater resources. This step will be a small initiation in saving health conditions of both human and animals. Healthy forest life and sound economy of the region will be the by-products of this initiation followed by preservation of soil's health. Therefore, in the present study we are checking the health condition of both conventional and organic Tea Gardens by calculating its pH, TOC, total N_2, P, K and microflora population. A healthy soil environment is represented when all the parameters are found balanced.

MATERIALS AND METHODS

A. Study Areas

The present study has been done in Jalpaiguri and Kalimpong districts of West Bengal, India. These are located in the Western Dooars region of North Bengal. The North Bengal part of Dooars stretches from river Teesta on the West to river Sankosh on the East covering an area roughly 130km in length and 40Km in width. These areas are located in the foothills of the Himalayas and acts as gateway to North-East India and Bhutan. The Dooars region of North Bengal is divided into three parts- Western Dooars, Central Dooars and Eastern Dooars. The present study area lies under the Western Dooars region (Fig. 1).

The samples were collected from seven tea gardens, out of which five were conventional (they use synthetic pesticides and fertilizers) whereas two were organic (they use biopesticides and biofertilizers, organic manure), five tea gardens are from Jalpaiguri district whereas two are from Kalimpong district (Table 1, Fig. 1).

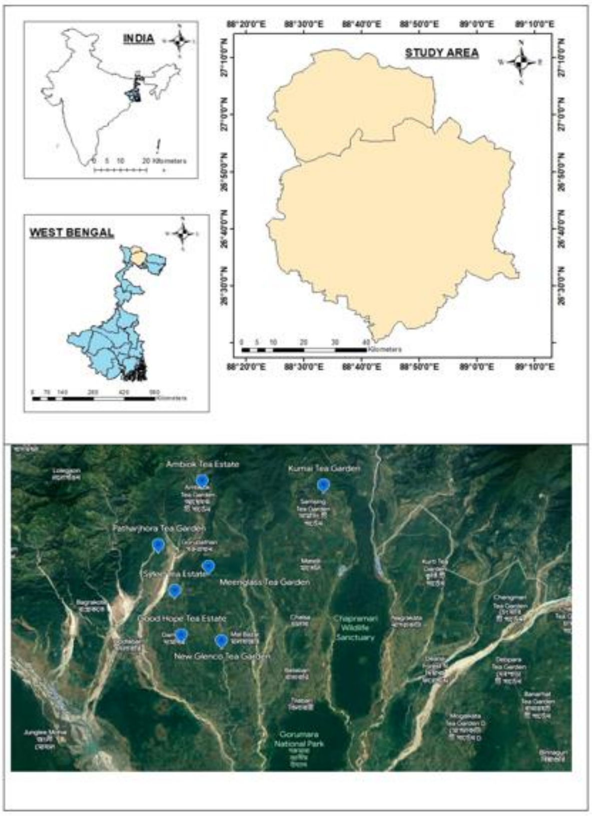

Fig. 1. Map of Study area and locations of tea gardens.

Table 1: Tea gardens and their geographical locations.

	Name of Tea Garden	District	Type	Latitude (°N)	Longitude (°E)	Altitude (in m)
	Ambiok Tea Estate	Kalimpong	Conventional	27.003315	88.698981	672.28
	Good Hope Tea Estate	Jalpaiguri	Conventional	26.857735	88.680317	174.78
	Kumai Tea Garden	Kalimpong	Organic	27.001060	88.827164	745.85
	Meenglass Tea Garden	Jalpaiguri	Conventional	26.923251	88.703133	284.42
	New Glenco Tea Garden	Jalpaiguri	Conventional	26.511301	88.430506	159.27
	Patharjhora Tea Garden	Jalpaiguri	Organic	26.947138	88.653066	293.71
	Sylee Tea Estate	Jalpaiguri	Conventional	26.898740	88.673335	234.17

B. Collection of rhizospheric soil samples

During 2022-2023, 200 g soil samples were collected in three replicates from the selected tea gardens in pre-sterilized Ziploc bags for the analysis of microbial population and physicochemical properties.

A section of tea garden (1 hectare) was divided into 3 transects and surface soil (0-20cm depth) from 3 to 4 portions of each transect was collected in Ziploc bags with the help of sickle and tube auger after removing the surface litter and mulch.

To make composite mix of each section, a square polythene sheet was spread and all the samples from a particular section was spread in the polythene sheet and visible plant debris and pebbles were separated gently by hand. The square was divided into four parts and the diagonally opposite squares were discarded. This step was followed 3 to 4 times until about 500g soil remained. The soil was sieved (> 2mm) and a portion of it was air dried. Similarly, composite mix was prepared for all samples.

The collected soil samples were brought to the laboratory and after air-drying overnight each sample was processed for analysis of various physicochemical properties, such as pH, total organic carbon, available nitrogen, available phosphorus and available potassium.

C. Determination of pH

The pH of collected soil samples was determined following the methodology of Dwivedi (2015); Baghel (2015).

This analysis was done using a pH meter. For the determination of pH**,** 25g of air-dried soil was taken in a 250 ml conical flask and 50 ml distilled water was added to it. The mixture was stirred well and left undisturbed for 1 hour. The pH machine was calibrated with two buffer solutions of pH 4 and 9.2. After cleaning the electrodes properly, the electrodes were put in the conical flask and after the 'Ready' sign the reading was recorded. The experiment was carried out in three replicates.

D. Determination of total Organic Carbon

This analysis was done by Walkley and Black method (Dwivedi, 2015, Baghel, 2015). For the determination of total organic carbon content in each sample, 1g soil sample was taken in 500 ml conical flask and 10 ml 1N $K_2Cr_2o_7$ was added to it. 20 ml conc. H_2SO_4 was added to the flask carefully. The mixture was shaked gently and left undisturbed for 30 minutes. 200 ml distilled water was added to it followed by 10ml H_3PO_4. 1ml diphenylamine indicator was added. The solution was then titrated with 0.5 N Ferrous ammonium sulphate. As soon as the color changes from violet to bright green the titration reading was recorded. Similarly, a blank sample was run. The experiment was done in three replicates.

E. Estimation of available Nitrogen

The available nitrogen in each sample was estimated adopting the methodology of Kjeldahl (Amule, 2015).

1g soil was taken in Kjeldahl flask (tube) and 20ml of distilled water was added to it. 7ml $K_2Cr_2O_7$ was added to the tube. 0.8g $CuSO_4$ was added to the tube. Then 12ml conc. H_2SO_4 was added to it and the tubes were fixed in the rack of the digester and the digester was switched ON. The Scrubber was also switched ON. The digestion program was run for 40mins. Now, the distillation was done using automatic distillation unit for 5mins. The green solution obtained after distillation was titrated with 0.02N H_2SO_4 and the burette reading was recorded. Similarly, a blank was also run. The experiment was conducted in three replicates.

F. Analysis of available phosphorus

This analysis was done by Olsen method (Thakur, 2015). A 5g soil was taken in a 250ml conical flask and a little activated charcoal was added to it. 100ml distilled water was added to it and the flask were shaken for 30 minutes in a mechanical shaker. The suspension was filtered using Whatman No. 42 filter paper and 5ml aliquot of the extract was taken in 25ml volumetric flask. 1ml working solution of $SnCl_2$ and 5ml Ammonium molybdate solution was added and distilled water was added to make up the volume to 25ml. The transmittance of the solution was measured using spectrophotometer at 660nm. Similarly, a blank was also run. The experiment was carried out in triplicates.

G. Analysis of Available Potassium

Analysis of available potassium was carried out adopting the methodology of using Metson (*Baghel*, 2015). For analysis, 5g soil sample was taken in a conical flask and 25ml N neutral ammonium acetate solution was added to it. The flask was shaked for 5mins in a mechanical shaker and it was filtered using

Whatman No. 42 filter paper and the filtrates were used in the Flame photometer for the analysis. The experiment was conducted in three replicates.

H. Analysis of soil samples for microbial populations

This study was done at Mycology & Microbiology Laboratory, Tea Research Association, North Bengal Regional R & D Center, Nagrakata West Bengal. To examine the increase or decrease in beneficial microbial population in conventional and organic gardens after application of synthetic pesticides, each soil sample was subjected for microbial population analysis (CFU-colony forming unit/g) by serial dilution method. In the collected soil samples, total fungi, total bacteria, nitrogen fixers, phosphate solubilizers and actinomycetes were examined using selective and differential media described in literature (*Aneza*, 2005). The culture media used during the study includes, Potato dextrose agar for fungi, Nutrient agar for bacteria, Picovaskaya's agar for Phosphate solubilizers, Kenknight agar for actinomycetes, Okon's for *Azospirillum*, and Ashby's Mannitol agar for *Azotobacter*. All the culture media were purchased from HiMedia, India. 10g of each soil sample was taken in a conical flask and 90ml distilled water was added to it and shaken well. Serial dilution was done for 6 test tubes and dilution factors 10^5 and 10^6 were used. Precisely, from 10^{-5} dilution of each soil sample, 0.5 ml soil suspension was uniformly spread onto pre-prepared agar plates for fungi and from 10^{-6} dilution for bacterial species in three replicates. After spreading the plates, were incubated in a BOD (Biochemical Oxygen Demand, Reico, India) incubator at 28 °C with 12 h white light for 24-48 h for bacteria and 5 days for fungi. After stipulated incubation, the colonies of microbial species appeared on agar plates were counted and results were expressed as CFU/g.

I. Analysis of phylloplane microflora

For analysis of leaf microflora serial dilution technique (Johnson and Curl 1972) was adopted. For this 10.0 g leaves of tea cultivars collected from each garden after one day of spraying of pesticides were taken in 250 ml conical flask containing 100 ml sterile distilled water and stirred for 15 minutes. 1 ml of the suspension from 10^{-4} dilution for fungi and 10^{-5} for bacteria were plated on pre-sterilized potato dextrose agar (for fungi) and nutrient agar (for bacteria) plates respectively. Inoculated plates were incubated in three replicates in a BOD incubator at 28°C for 2 days for bacteria while 5 days for fungi under 12 h white light. The plates were examined for the viable colonies and results were reported in terms of CFU/gram.

RESULTS

A. pH

All the soil samples were acidic in nature. The lowest pH was recorded 4.28 for Good Hope T.E. (10 years old plantation) while the highest pH was 6.32 for Sylee T.E. (40 years old plantation). Soil samples with low pH shows high Available Nitrogen and high Available Potassium. Phosphate solubilizing bacteria flourish best in soil with around pH 5.5. The Microbial population is best at pH around 5 to 5.5 (Fig. 2).

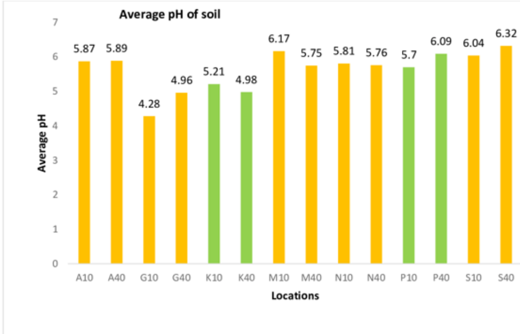

Fig. 2. pH of soil of different Tea Estates.

B. Total Organic Carbon

Total Organic Carbon was found to be highest (1.2%) in soil with low pH (Good Hope T.E. 40 years old plantation). Sylee T.E 10 years old plantation having a high pH value is found to have the least TOC (0.43%). Soils with high TOC are found to have high CFU of Total Bacteria (Fig. 3).

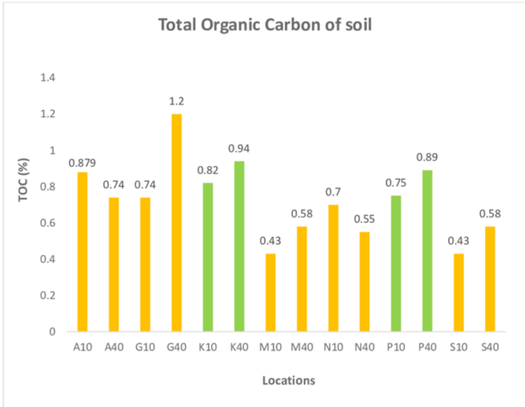

Fig. 3. TOC of soil of different Tea Estates.

C. Available Nitrogen

Almost all the soil samples have Available N_2 in low to medium range. Sylee T.E 10 years old plantation has the lowest available N_2 159Kg/ha whereas Ambiok T.E. 40 years old plantation has the highest available N_2 395.32Kg/ha. Some Conventional tea garden's soil have more available N_2 than the Organically managed Tea gardens and the CFU of free living N_2 fixing bacteria is also less as compared to Organic tea gardens (Fig. 4).

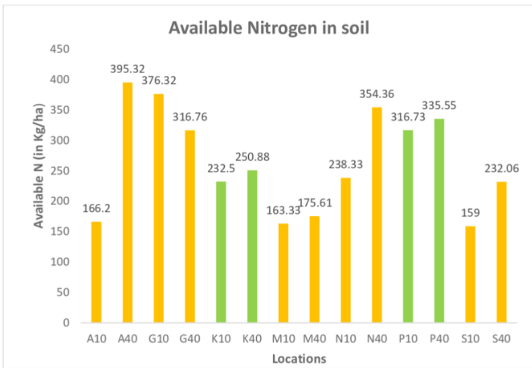

Fig. 4. Available Nitrogen in soil of different Tea Estates.

D. Available Potassium

Ambiok Tea Garden 40 years old plantation has the highest available K (524.99 Kg /ha) whereas least available K was observed in the soil sample of Patharjhora Tea garden 40 years old plantations (135.63Kg /ha). Conventionally managed tea gardens have much better available K than the Organically managed tea gardens. In most of the cases, the available K is more in 10 years old plantation than the 40 years old plantations (Fig. 5).

E. Available Phosphorus

Sylee T.E (40 years old plantation) has the highest available P 27.54 Kg/ha whereas Good Hope T.E. (40 years old plantation) has the least amount of available P 3.68 Kg/ha. Organic Tea Gardens (Kumai & Patharjhora) having medium range of available P show good number of PSB and PSF as well as *Actinomycetes.* More amount of available P is found in the samples of 10 years old plantation than 40 years old plantation except New Glenco Tea Estate (Fig. 6).

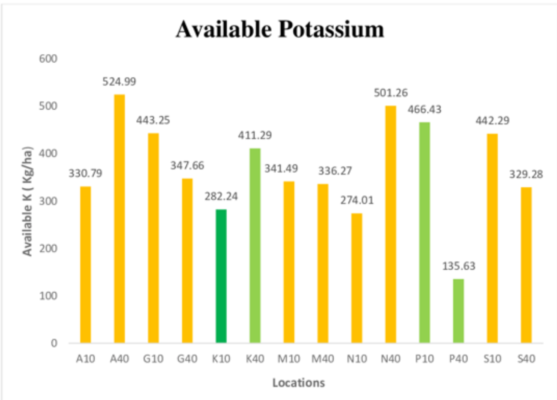

Fig. 5. Available K in soil of different T.E.

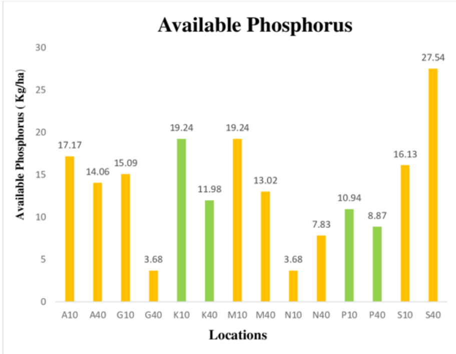

Fig. 6. Available Phosphorus in soil of different T.E.

F. Microflora

Organic Tea Garden's soil has more Total bacteria than conventional tea garden's soil. Highest total bacteria were found estimated in the soil sample of Kumai T.E 40 years old plantation (3.8×10^7CFU/g) and lowest in soil of Good Hope T.E 10 years old plantation (9.4×10^6CFU/g). The CFU of Total Bacteria is found to be more in 40 years old plantations than 10 years old plantation (Table 2).

Conventional soil samples tend to have less total fungus than Organic tea garden's soil. Highest total fungus is recorded in the soil sample of Patharjhora T.E. (10 years old plantation) 7.4×10^5CFU/g and lowest in Good Hope (10 years old plantation) 2.2×10^5 CFU/g.

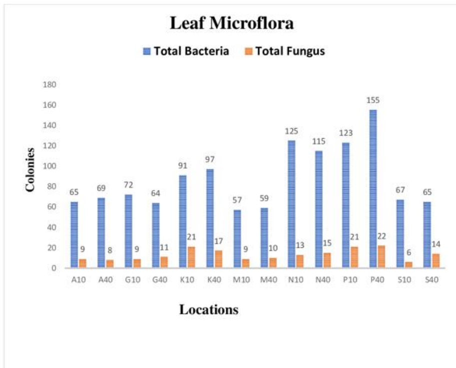

Fig. 7. Leaf Microflora colonies of different T.E (K10, K40, P10 & P40 are from organic tea gardens others are from conventional tea gardens).

Table 2: Total microbial counts in soil samples collected from different organic and conventional tea gardens in North Bengal, India.

Tea gardens (age in years)	Total CFU count/g					
	Bacteria ($\times10^5$)	Fungi ($\times10^4$)	PSF ($\times10^4$)	PSB ($\times10^5$)	N-Fixer (*Azospirillum*) ($\times10^5$)	N-Fixer (*Azotobacter*) ($\times10^5$)
Ambiok 10	226	40	46	14.2	198	66
Ambiok 40	178	26	26	8.4	226	90
Good Hope 10	96	22	15	6	52	154
Good Hope 40	168	32	11.6	7.2	64	176
Kumai 10	292	46	32	14.6	206	250
Kumai 40	384	50	22	12.4	214	244
Meenglass 10	274	24	22	9.4	156	128
Menglass 40	168	26	28	7.4	138	110
New Glenco 10	320	18	22	9.4	132	146
New Glenco 40	338	22	20	10.4	162	186
Patharjhora 10	210	44	26	15	270	124
Patharjhora 40	186	74	54	17.6	238	90
Sylee 10	202	26	14	12.6	116	112
Sylee 40	270	22	22	18.8	146	116

PSF: Phosphate Solubilizing Fungi, PSB: Phosphate Solubilizing Bacteria

Phosphate solubilizing bacteria varied a lot in terms of age of plantation and Organic & Conventional. The maximum CFU of PSB was estimated in the sample of Patharjhora Tea Garden 40 years old plantation (1.76×10^6 CFU/g) and least in the soil of Good Hope T.E 10 years old plantation (6×10^5 CFU/g). The estimated CFU of Phosphate Solubilizing Fungus is highest in Patharjhora T.E. 40 years old plantation (5.4×10^5 CFU/g) and lowest in Sylee T.E. 40 years old plantation (1.4×10^5). The range of PSB in Conventional tea gardens is low to medium whereas in case of Organic tea gardens it medium to high.

The highest CFU of *Actinomycetes* was found in the sample of New Glenco T.E. 10 years old plantation (2.58×10^7) whereas the least CFU of it was found in Ambiok T.E 40 years old plantation (6.8×10^6). Actinomycetes did not varied much among the age of plantation and even some conventional tea gardens have similar or even higher *Actinomycetes*. They may be able to withstand high concentration of pesticide's residue.

The estimate CFU of *Azospirillum* differs a lot. The highest CFU was recorded in the soil sample of Patharjhora T.E. 10 years old plantation (2.7×10^7 CFU/g) whereas least CFU was recorded in Good Hope T.E. 10 years old planation (5.2×10^6 CFU/g).

Azotobacter sp. from soil and the CFU/g is comparatively good in most of the tea gardens. Highest CFU of *Azotobacter* was found in the sample of Kumai T.E 10 years old plantation (2.5×10^7 CFU/g) and lowest CFU was found in Ambiok Tea Estate 10 years old plantation 6.6×10^6 CFU/g. The data suggests that pesticides have no negative impacts on *Azotobacter* sp.

The number of total bacterial CFU in the leaf varied a lot among different tea estates but the difference is very less among different age group of the same tea garden. The highest CFU of total bacteria was observed in the leaf sample of Patharjhora T.E 40 Years old plantation (3.1×10^7 CFU/g) and least in Meenglass T.E 10 years old plantation (1.18×10^7 CFU/g).

Organic Tea Gardens leaves are observed to have high total fungus than the Conventional tea gardens. The highest CFU/g of total fungus was observed in the leaf sample of Patharjhora tea Garden 40 years old section (4.4×10^5 CFU/g) whereas the least CFU/g was observed is Sylee 10 years old plantation (1.2×10^5 CFU/g).

DISCUSSION

Based on the results above we find that all soil samples are acidic in nature but very few are in the range of 4.5 and 5.5(G40, K10, K40), the most suitable condition for the growth of tea plant. If we see percentage vies, 75% i.e., 3 out of 4 samples of the organic tea garden are in the range, whereas among the conventional only 1 sample is maintaining the required pH condition. This study promotes non-use of synthetic pesticides, to maintain soil health. Similar condition is observed in case of available nitrogen, here the nitrogen content of organic tea gardens are lying mostly in the medium range, which indicated about a healthy soil environment. In case of conventional tea gardens either the nitrogen content is too high (that may be due to fertilizers added) or too low (this may be due to loss of N_2 fixing bacteria's). This imbalance is not a good sign in favour of soil health.

The available phosphorous content also shows medium range conditions for all the samples (except 1) of organic tea gardens, but the data for conventional tea gardens is showing a vast variation from lowest (G40, sN10) and highest (S40). The very low value for phosphorous is showing nutrient deficiency in soil, whereas a high value is an indication of overuse of chemical fertilizers, may happen due to leaching of mineral apatite or loss of phosphate solubilizing bacteria from the soil. The loss in phosphate solubilizing bacterias is another flag in support of poor health of soil (Yu *et al.*, 2022).

Organic Tea Garden's soil has more Total bacteria than conventional tea garden's soil. Soil acidification, soil compaction, pollution of N and P into neighboring water bodies is few but worst consequences happening in the regions where practice of Tea Cultivation takes place (Xie *et al.*, 2022). The events are creating pollution of soil directly and pollution in water bodies as a secondary consequence. Pollution in both soil and water is directly affecting health of local people and aquatic organisms (Das, 2020). It is a cyclic event which will create turmoil in the entire ecosystem. If we observe deeply, we will find that Dooars-Terai region has lost many birds, aquatic organisms and wild animals due to the disturbance in ecosystem. A healthy environment enriched with microorganisms is a basement for healthy existence for macroorganisms. The complex interactions of agricultural chemicals, pesticides and various field management practices may interfere in the build-up of predators, parasites and beneficial and entomopathogenic microbial population. If synthetic pesticides are used indiscriminately, the ecological balance between pests and natural enemies would be disturbed (Banerjee, 1983; Borthakur *et al.*, 1993, 2005; Gurusubramanian *et al.*, 2005).

Also, the health of local people is not giving good sign; there are many cases of stomach related ailments in the region (Das, 2021). There is report of surface contamination of rivers by local pollutants, which may be brought by dissolution of tea garden soils into the river or due to dolomite mining in the Bhutan region. But unhealthy digestive system of the locals, seen in form of gastric related problems, stomach ache, diarrheal infections are very common in the Dooars region. Also, with regular use of synthetic pesticides, the regional water bodies are also suffering contamination, which is leading to water related health issues in the region. By drinking contaminated water both humans and wild animals are getting affected. This problem is causing decrease in number of wildlife, and poor health of humans which is affecting economy of the region.

This problem may be the basic reason behind low economic status of the people, where work gets suffer due to water borne diseases. Tea cultivation and use of pesticides is being practiced in this region from more than 100 years back. The history of tea cultivation and use of synthetic pesticides is isochronous, this statement adds many scopes for future studies, that is how use of synthetic pesticides in soil contaminates water and contaminated water adds poor health status to the region.

If one component in the system is disturbed then definitely other will also get disturbed, because soil, water and air are in regular interaction process. In order to maintain balance, regular check-up of soil health becomes a necessary part of life, also the factors (especially synthetic pesticides) should be reduced or best way is to replace them with biopesticides e.g., *Bacillus* species and *Trichoderma* species. In order to manage pests and worms, ecological food chain methods of introducing consumer insects of those pests should be introduced (Deka and Babu 2021).

Awareness programmes related to soil health and its side effects to water and wildlife should be conducted in these remote areas especially in schools and colleges. Because when public will become aware of all pros and cons of the activity, then they only will be the flag bearers of the new era of use of biopesticides and bioinsecticides in order to bring sustainable development. The development in which entire ecosystem attains balance and each and every organism gets proper space and healthy environmental conditions for living.

CONCLUSIONS

The pH of all the soil samples is found to be acidic but some tea estates have pH of around 6 and more which is a matter of concern as high pH reduces the solubility of macronutrients as well as micronutrients. Pesticides have no side effect on *Azospirillum* sp. (free living N_2 fixing bacteria), rather they degrade the pesticide to some extent and use it as a source of energy. Although some conventional tea gardens have medium to high amount of Phosphorus but the CFU of Phosphate solubilizing bacteria and Phosphate solubilizing fungus is low which may lead to series adverse impacts in the productivity as well as soil health. Organic Tea Garden's soil has more total bacteria than Conventional tea garden's soil. The number of Total Bacteria is found to be more in 40 years old plantations than 10 years old plantation. In comparison with some conventional tea gardens, organic tea gardens with relatively high fungus and nitrogen-fixing bacterial populations have slightly lower available nitrogen levels. There is cause for worry since some conventional tea gardens with a lot of readily accessible nitrogen do not have many free-living N_2 fixing bacteria. The use of biological pest control agents (natural enemies of insect pests), biopesticides should be done in order to minimize these side effects and ensure proper productivity, quality and sustainability of tea ecosystem.

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Conflict of Interest. None.

FUTURE SCOPE

This paper opens scope in the field of soil and water pollution control, where water bodies are regularly getting contaminated with the overuse of chemical pesticides. Also, the study encourages use of biopesticides, which is a boon in the field of pollution control and increase in total yield of tea crop.

REFERENCES

Amule, F. C. (2015). Laboratory Manual on Soil and Plant Analysis National Training on Climate Resilient Soil Management Strategies for Sustainable Agriculture; Department of Soil Science and Agricultural Chemistry College of Agriculture, J.N.K.V.V., Jabalpur.

Aneja, K. R. (2005). Experiments in Microbiology Plant Pathology and Biotechnology, Fourth Edition.

Banerjee, B. (1983). Problems of pests and diseases on tea: Possibilities of integrated approach. In: Proceedings of *10th International congress on plant protection*. pp. 1026-1028.

Borthakur, M., M. Sarmah, A. Rahman and N. N. Kokoty (1993). Population dynamics of tea pests and their natural enemy complex in relation to various agro-management practices in tea. In: Proceedings of the international conference on Tea science and human health, TRA, Culcutta. pp 158-164.

Borthakur, M. M. Sarmah, A. Rahman and G. Gurusubramanian (2005). Seasonal population fluctuation of *Stethorus gilvifrons* and effects of conventional pesticides and some herbal extracts on its survival and feeding potential. In Proceedings of 34th Tocklai Conference pp: 332-339.

Baghel, S. S. (2015). Laboratory Manual on Soil and Plant Analysis National Training on Climate Resilient Soil Management Strategies for Sustainable Agriculture; Department of Soil Science and Agricultural Chemistry College of Agriculture, J.N.K.V.V., Jabalpur.

Chen, Z. M. and Chen, X. F. (1989). An analysis of world tea pest fauna. *J. Tea Sci., 9*(1).

Das, S., M. Sarkar, S. Das, and A. Mukhopadhyay (2005). Changing diversity of hymenoptereran parasitoids from organically and conventionally managed tea ecosystem of North Bengal, India. *J. Environ. Biol.*, 505-509.

Das, A. (2020). Water quality assessment of the river Murti for the safety of Wildlife.

Das, A. (2021). Impact of some natural hazards on the quality of water: River Diana, District Jalpaiguri, West Bengal, India.

Debnath, B., Haldar, D. and Purkait, M. K. (2022). Environmental remediation by tea waste and its derivative products: a review on present status and technological advancements. *Chemosphere, 300,* 134480.

Deka, B. and Babu, A. (2021). Tea Pest Management: A microbiological approach. *Applied Microbiol Open access 7*, 206

Dwivedi, B. S. (2015). Laboratory Manual on Soil and Plant Analysis National Training on Climate Resilient Soil Management Strategies for Sustainable Agriculture; Department of Soil Science and Agricultural Chemistry College of Agriculture, J.N.K.V.V., Jabalpur.

Gurusubramanian, G., Rahman, A., Sarmah, M., Ray, S. and Bora, S. (2008). Pesticide usage pattern in tea ecosystem, their retrospects and alternative measures. *Journal of Environmental Biology*, *29*(6), 813-826.

Jacoby, R., Peukert, M., Succurro, A., Koprivova, A. and Kopriva, S. (2007). The Role of Soil Microorganisms in Plant Mineral Nutrition-Current Knowledge and Future Directions.

Johnson, L. F. and Curl, E. A. (1972). Methods for research on the ecology of soil-borne plant pathogens. Burgess Publishing Co., Minneapolis.

Mukhopadhyay, M. and Mondal, T. K. (2017). Cultivation, Improvement, and Environmental Impacts of Tea.

Thakur, R. K. (2015). Laboratory Manual on Soil and Plant Analysis National Training on Climate Resilient Soil Management Strategies for Sustainable Agriculture; Department of Soil Science and Agricultural Chemistry College of Agriculture, J.N.K.V.V., Jabalpur.

Torsvik, V. and Ovreas, L. (2002). Microbial diversity and function in soil: from genes to ecosystems. *Curr Opin Microbiol*, *5*, 240.

Xie, S., Yang, F., Feng, H., Yu, Z., Wei, X., Liu, C. and Wei, C. (2022) Potential to reduce chemical fertilizer application in Tea Plantations at various spatial scales. *In. J. of Environ. Res. and Public Health*. *19*, 5243

Yu, H., Wu. X., Zhang, G., Zhou, F., Harvey, P. R., Wang, L., Fan, S., Xie, X., Li, F., Zhou, Zhao, X. and Jhang. X. (2022). Identification of the Phosphorous-Solubilizing Bacteria Strain JP233 and Its Effects on Soil Phosphorous Leaching Loss and Crop Growth.

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