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Society for Fertilizers and Environment
Bidhan Chandra Krishi Viswavidlaya
Mohanpur, Nadia,
West Bengal, India

From President's Desk

Soil health indexing for dynamic monitoring needs identifying new microbial indicators and focus on their diversity in soil

The theme area of the earlier issue of the Newsletter 2(2) was soil biological health to address the role of soil biology under continued fertilizer use, key management steps for sustenance of productivity based on up-to-date research, and finally identifying a few missing links in research agenda to address soil biological properties. In this issue, having accepted the role of soil biology to maintain soil health, I would like to take the discussion forward towards gaps in our understanding of soil health or soil quality, and the dynamic monitoring needs to identify new microbial indicators with focus on their diversity.

Soil health is the result of continuous conservation and degradation processes and represents the continued capacity of soil to function as a vital living ecosystem. Although many indicators and indices of soil quality or soil health have been proposed, a globally acceptable and applicable definition and methodology of assessment of soil quality or soil health are still at large. Further, the existing knowledge provides a better understanding of the current capacity of a soil to function than of making predictions about capacity of the soil to continue to function under a range of stresses and disturbances. Another limitation of most of the available studies is that efforts have been made to measure soil characteristics in surface soil and not in the whole profile.

It is known that unique balance of chemical, physical and biological (including microbial) components should contribute to maintaining soil health. Evaluation of soil health therefore requires indicators of all these components, specifically the contributions of microorganisms and the pros and cons of using them as early warning indicators of environmental changes. Microorganisms appear to be excellent indicators of soil health because they respond quickly to changes in the soil ecosystem and have intimate relations with their surroundings due to their high surface to volume ratio. In some instances, changes in microbial populations or activity can precede detectable changes in soil physical and chemical properties, thereby providing an early sign of soil improvement or an early warning of soil degradation.

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According to Danish government strategy projected by NERI (Technical Report no. 388)further scientific knowledge should be developed through research activities included in the monitoring programme, and research on microbial biodiversity should be in focus. Implementation of new indicators is recommended as soon as these are applicable for soil monitoring purposes. These new indicator should be based on continuous development of microbial methods within the scientific community and will provide more precise, detailed and integrated results in order to give a dynamic up-to-date monitoring programme. Implementation is recommended in parallel with the existing measurements to assure the quality and comparability of the new indicators as the old indicators are phased out. The data sets of the new indicators can be used as the baseline for future monitoring activities.

H.S. Sen
President

EXECUTIVE COMMITTEE MEETING

Date: 09 September, 2016

Venue: ICAR-ATARI, Bhumi Vihar Complex, Block GB, Sector III, Kolkata

A combined Executive Committee (EC) meeting (members of the ECs for 2016-17 and 2015-2016) was held on 09 September, 2016 at 3=00 PM at the above venue.

The meeting was chaired by Dr. H.S. Sen, President of SFE. Resolutions taken/approved are as hereunder:

- EC meeting proceedings held on 30 March, 2016 at ICAR-ATARI, Kolkata was confirmed.
- Activities to be undertaken in coming months were enlisted which included one farmers' meet on soil health management in Gosaba, Sundarbans on 05.10.17 in collaboration with Sashya Shyamala KVK, one farmers' meet on "Judicious utilization of soil, water and fertilizers under changing climate and crop productivity strategies" in Burdwan on 03 November, 2016 in collaboration with KVK, Budbud and one farmers' meet on biofertilizer use & environment in collaboration with Vivekananda Women Welfare Society at Potashpur in December, 2016.
- Resolution was taken to organise a one day National Seminar on 'Maximizing fertilizer use efficiency and environmental health for posterity' at Narendrapur in collaboration with Sashya Shyamala KVK during March, 2017.
- Prof. B. Mandal, Secretary of the society presented salient report including membership status.
- Dr. D. Sarkar, Treasurer, presented the current financial status of the Society.
- Resolution was taken for regular updation and maintenance of Society's website and measures to be taken for improvement.
- The name of the newsletter was proposed to be changed from "SFE News" to "Fertilizer and Environment News" for increasing attraction to the contributors as well as readers and was accepted.
- Formation of an Editorial Board for the newsletter for its smooth publication.
- Preparing/finalization of the guidelines for selecting Fellows/Patrons of the society. The fellows will be recognized as "FSFE"
- Organizing one Foundation Lecture on the occasion of AGM to be held during March, 2017.

EXECUTIVE COMMITTEE MEETING

Date: 19 January, 2017

Venue: ICAR-ATARI, Bhumi Vihar Complex, Block GB, Sector III, Kolkata

A joint Executive Committee (EC) meeting (of the EC members for 2016-17 and previous EC) was held on 19 January, 2017 at 2=00 PM at the ICAR-ATARI, Bhumi Vihar Complex, Block GB, Sector III, Kolkata 700 097. Total of 10 members were present in this meeting. The meeting was chaired by Dr. H.S. Sen, President of SFE.

Agenda-wise resolutions taken/approved are as under,

- EC meeting proceedings held on 09 September, 2016 at ICAR-ATARI, Kolkatawas confirmed.
- Stock-taking of scheduled activities was briefed by Prof. B. Mandal, Secretary, SFE.
- Salient report including membership status was presented by the Secretary.
- Editorial Board for the news letter formed with following members,

  Chief Editor:

  Dr. D.K. Kundu, Principal Scientist and Head, Crop Production Division, CRIJAF, Kolkata

  Members:

  1. Dr. J.K. Saha, Principal Scientist and Head, Environmental Soil Science Division, IISS, Bhopal
  2. Dr. T.J. Purakayastha, Principal Scientist, Soil Science and Agricultural Chemistry Division, IARI, New Delhi
  3. Dr. U.K. Mandal, Principal Scientist, CSSRI, Canning Town
  4. Dr. N.C. Sahoo, Programme Coordinator, KVK, Ramakrishna Mission Vivekananda University, Narendrapur
  5. Dr. D. Ghorai, SMS and In-Charge, KVK Burdwan, Budbud

- Final resolution was taken to organise a one day National Seminar cum AGM at the Integrated Rural Development and Management Faculty Centre, Narendrapur in collaboration with Krishi Vigyan Kendra, Ramakrishna Mission Vivekananda University, Narendrapur on March 8, 2017. Possible collaboration was to be sought with WWF for which Dr. H.S. Sen would communicate Dr. A. Anurag Danda, WWF to confirm collaboration. Organising committee for the seminar will be

  Organising Secretary: Professor B. Mandal

  Members: Dr. N.C. Sahoo, Dr. F.H. Rahman, Dr. D. Ghorai, Dr. D. Sarkar and Dr. D.C. Nayek

- One Foundation lecture to be delivered by Dr. D.K. Das during the Seminar-cum-AGM.
- The issue of introducing endowment lectures from industries sector was discussed in order to raise the financial strength of the society, but the President advised to postpone it for some time, although he considered this to be very much important and therefore appropriate emphasis may be given in future.
- The DRAFT guidelines for selecting Fellows/Patrons of the society, prepared by Dr. H.S. Sen. Dr. Sen was passed to all members of the present and past EC for their necessary inputs.

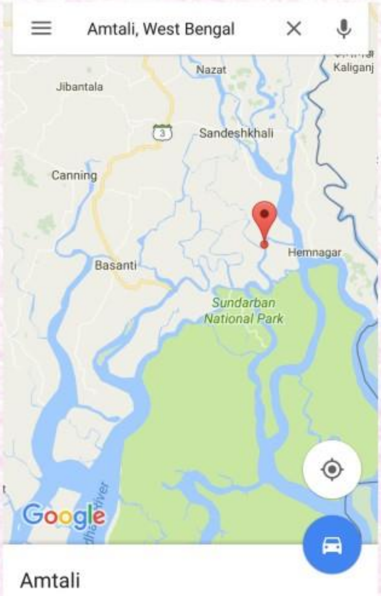
NEWS

One day awareness camp on soil health management

Date: 05.10.2016

Location: Amtali Island, Gosaba Block, Sundarbans

The principal livelihoods in the Sundarbans are agriculture and fishing. In so far as agriculture in the islands is concerned, there is one paradigm of discomfiture. It is soil health. Apart from the coastal environment, soil environment is in jeopardy - and so is agriculture in these islands. Besides increasing soil salinity, soil fertility is deteriorating courtesy of irrational and imbalanced fertilization and faulty management practices.



To stave off the ill effects and to continue with the agricultural livelihood of a major share of 5 million people those inhabit the Indian Sundarbans, there is a serious need to educate the farmers and make them aware of the future consequences. The Society for Fertilizers and Environment (SFE) felt the urgent need for the same and organised one mass awareness campaign to educate the farmers about deteriorating soil quality and the ways to attenuate those in collaboration with Sashya Shyamala Krishi Vigyan Kendra under Ramkrishana Mission Vivekanada University, Belur and Sunderban Dream, one NGO working actively deep into the area on 05.10.16 in Amtali Island of Gosaba (see location).

Some 300 farmers and farm women from nearby villages participated in the camp and interacted with the experts present, namely, Dr. H. S. Sen, President, SFE, Prof. Biswapati Mandal of BCKV and Secretary, SFE, Dr. F. H. Rahman, Pr. Scientist, -ATARI, Kolkata and Jt. Secretary, SFE, Dr. N. C. Sahoo, Sr. Scientist and Head, Sashya Shyamala KVK, Dr. D. Ghorai, SMS (Agril.), KVK Burdwan and Dr. Swagat Ghosh, SMS (Fisheries), Sashya Shyamala KVK.

The experts made pointed replies to the questions made by the participant farmers. However SFE deeply appreciated the interest shown by the farmers to participate in the discussion. The role played by Sundarbans Dream and particularly of Mr. Mustafa, their chief worker and his associates, for their dedicated involvement for improvement of the area and for organizing this programme was also very much appreciated. More detailed training-cum-awareness camp of the intending farmers will be held by SFE towards sustainability in production by improving soil health using as far as possible indigenous sources and adoption of integrated management practices.

NEWS

One day awareness camp on soil health management
Date: 03.11.2016
Location: Angikar Hall, Burdwan

The Society for Fertilizers and Environment (SFE) organised one mass awareness campaign and Farmer – Scientist interaction programme at Burdwan to educate the farmers about deteriorating soil quality and the ways to attenuate those in collaboration with Krishi Vigyan Kendra, Burdwan under ICAR - Central Research Institute for Jute and Allied Fibres (CRIJAF), Barrackpore.

Some 150 farmers and farm women across various parts of the district participated in the event held at Angikar Hall, Burdwan Zilla Parishad. Dignitaries, eminent personalities and resource persons present were as below,

1. Shri Debu Tudu, Zilla Sabhadhipati, Burdwan
2. Dr. H. S. Sen, Former Director, CRIJAF and President, SFE
3. Prof. Biswapati Mandal, Bidhan Chandra Krishi Viswavidyalaya (BCKV), Mohanpur, Kalyani
4. Dr. D. K. Kundu, Pr. Scientist and Head, Division of Crop Production, CRIJAF
5. Prof. Sanjay Kumar Dutta Ray, Associate Dean, BCKV, Burdwan Campus
6. Dr. F. H. Rahman, Pr. Scientist, ICAR-ATARI, Kolkata
7. Dr. Krishna Karmakar, Associate Prof., BCKV, Kalyani
8. Dr. Arup Chattopadhyay, Associate Prof., BCKV, Kalyani
9. Dr. Dibyendu Sarkar, Asst. Prof., BCKV, Kalyani
10. Dr. Dipankar Ghorai, SMS and In charge, KVK Burdwan
11. Dr. Golam Ziauddin, SMS (Fishery Sc.), KVK, Burdwan
12. Dr. Monica Suresh Singh, SMS (Ag. Extn), KVK, Burdwan

Prof. Biswapati Mandal, in his remarks, urged upon the farmers about importance of soil testing and generation of Soil Health Card therein for prescription based plant nutrition to maintain soil quality. Dr. H. S. Sen informed the gathering about the Society for Fertilizers and Environment and its activities in this regard. He pointed out to the fact that the acidity in soils of Burdwan is developing thereby hampering crop production, especially, in oilseeds and pulses. He stressed upon estimation of soil biological properties to get a rapid estimate of soil quality aggradations or degradations.

Next, Dr. S. K. Dutta Ray spoke on the emerging menace of soil nematodes hampering crop production and the remedies thereupon. Mr. J. Chatterjee, DDA, Burdwan, next, in his address spoke about various government initiatives in regard of soil health maintenance, crop insurance, water conservation, incorporation of legumes in cropping system and aromatic rice cultivation. Dr. D. K. Kundu focussed on changing climate and the need therein to adapt for sustainable production. Among other issues, he pointed out to the importance of nitrogen fixers in soil health and misuse of herbicides deteriorating soil health.

Shri Debu Tudu, Zilla Sabhadhipati and Chief Guest during the occasion urged upon agricultural education in the state and the government's initiatives in this regards. He stressed upon the farmers to follow improved and scientific cultivation techniques for sustainability of production in the long run.

Dr. F. H. Rahman spoke on importance of pulse cultivation and informed the gathering that the year 2016 being declared as the "International Year of Pulses". Dr. K. Karmakar, BCKV pointed to the menace of indiscriminate use of agro-chemicals in eradicating friendly pests and voiced his concern over the fact that climate change will only augment pest incidence and hence urged upon the farmers towards judicious application of agrochemicals.

Farmers- Scientists Interaction on Soil Health Management for Augmenting Productivity in Rice-Ground Cropping System in East Midnapore district of West Bengal

Date: 02.02.2017

Location: Potashpur, East Midnapore

The above interaction was held at the behest of Vivekananda Society for Social Welfare, Potashpur. The meeting was attended by the following:

- Dr.H.S.Sen President, SFE
- Dr.Biswapati Mandal, Secretary, SFE & Professor, BCKV
- Dr.F.H.Rahman, Joint Secretary, SFE & In-Charge/Principal Scientist, ICAR-ATARI.
- Dr. Krishna Karmakar, Professor, BCKV
- Dr. Arup Chattopadhyay, Professor, BCKV
- Dr. Subrata Dutta, Professor, BCKV
- Dr. Sudipta Mukherjee, Senior Sceintist & Head, KVK, Howrah
- Dr. Sudipta Banerjee, SMS, KVK, Howrah
- Mr. Subhas Hazra, Vivekananda Society for Social Welfare, Potashpur

The meeting, which was presided over by Dr. H.S. Sen, was well attended by more than 100 farmers and other enthusiastic personnel of Potashpur with a significant proportion of women participants amongst them.

The Chairman at the outset introduced the role of SFE to create awareness on maintaining soil health in the present day context to meet the growing hunger. He emphasized the need for organic manure and biofertiliser for maintaining soil health. Dr. Arup Chattopadhyay spoke on the need for increasing productivity of land by using improved vegetable crops. Dr. Karmakar spoke on use of improved technologies of pesticides and insecticides for assured productivity. Dr. Subrata Dutta spoke on the need for sustaining the higher soil organic C level in order to maintain improved soil health. He explained the approaches to be followed against attack of pathogens, namely (1) Seed treatments, (2) Soil organic C build-up say through *dhaincha* cultivation at regular intervals besides application of FYM, organic manures, biofertilisers (different strains are available) for protection against soil borne diseases requiring soil health to be restored/improved, (3) Adoption of virus-resistant varieties developed for different crops. He also explained the natural processes of direct absorption of atmospheric N to meet the nitrogen requirement partially.

Dr. Sudipta Mukherjee on behalf of KVK, Howrah apprised that out of 16 different technologies developed and applied at their Howrah unit many of them could be applied at East Midnapore. Copy of the bulletin developed for this purpose was handed over to the NGO at Potashpur for the benefit of the farmers. He however advocated immediate introduction of off-season cultivation of vegetable crops to meet higher price. He spoke on large number of soils analysed for soil health assessment at Howrah.

Dr. Sudipta Banerjee emphasized on developing the modus operandi for identify of actual problems on the one hand, and the need for formation of producers' organization for cultivation in groups to increase profitability of individuals, on the other.

Dr. Biswapati Mandal coordinated the next session on interaction in question-answer mode with the farmers and other enthusiastic persons. He invited various issues from the gathering attending the meeting. Following were addressed in the meeting :

- Method and feasibility of soil analyses and maintaining soil quality
- Increasing farmers income through efficient marketing
- Means for reducing indiscriminate use of pesticides in chilli, bhendi and other vegetables, and various insecticides
- Provision for Kisan credit card and Soil health card for the farming community

The NGO and the local seniors expressed great satisfaction for such interaction meeting which may be of very good use. They also felt that such meetings may be held more frequently and if possible at panchayat level.

Understanding soil microbiological processes for better fertilizer management

The dependency of food production on fertilizer will inevitably increase in future. This will lead to excessive accumulation of reactive nutrient elements in soil environment and will cause down scaling soil microbiological processes leading to sustenance of crop. Major beneficial functions of soil for providing sustenance to mankind are driven by soil biological processes. They are affected by different ways on application of fertilizers as discussed below:

Fertilizer use and C-cycle

Potentially, fertilizer N application affects SOM via three mechanisms:

(i) it may increase SOM by promoting plant growth and thereby increasing the amount of litter and root biomass added to soil compared with soil not receiving N (Fig 1),

(ii) it may retard the decomposition of lignocellulosic substrates in soil receiving N as lignin decomposing enzymes are sensitive to excessive mineral nitrogen. Similarly, cellulase enzyme is repressed by the low molecular weight end product of cellulose which is degraded faster under N-fertilization (Eiland *et al.,* 2001). Thus, humus synthesis is hampered.

(iii) it may accelerate SOM loss through decay or microbial transformation of litter (leaves, straw, manures, etc.) and indigenous forms of organic C already in the soil when the added organics get exhausted by huge decomposers proliferated by added organic matter and N-fertilizer.

β-glucosidase, the central to C-cycle, is inhibited by B, Zn, Fe, and Cu. Thus, it can be assumed that the entire C cycle would be affected. Indiscriminate use of micronutrient by the farmers may result in slower carbon transformation which, in turn, may cause slower release of other essential nutrients from organic matter in soil.

Fertilizer use and soil N cycle:

The most important biological processes involved in N cycling in agricultural soils are N-fixation, ammonification, nitrification and denitrification.

N-fixation process is suppressed in many bacterial species when an ample or excess supply of combined N is available after fertilization **(Table 1)**. In the presence of excess fixed N, nitrogenase enzyme is not synthesized (Yin *et al.,* 2015). In addition, the amount of fertilizer N influences the colonization and growth of diazotrophs on the root surfaces. In legume-rhizobia symbiosis, after fertilization, if nitrate concentration increases plant preferably want to utilize nitrate by passing symbiotic dinitrogen fixation since more energy is required to fix N_2 than to utilize No_3. However, inhibitory effect of fertilizer on N-fixation depends on the rate and nature of fertilizer used, nature of crop uptake, management options and efficient N-fixing microbial load existing in soil. Cereal based cropping systems through its leftover huge organic residues probably modified the availability of reactive nitrogen species and, thus, expression of *nif* gene was restored even under excessive chemical fertilizers. Moreover, cereals are highly responsive to applied nitrogen and mined huge nitrogen from soil leaving the soil N level below threshold for ecologically fit for N-fixers.

Ammonification: Proteases and/or peptidases involved in ammonification are highly sensitive to fertilizer ammonium. On application in soil, urea is hydrolysed to NH^{4+} by urease enzyme and thus, accumulates in soil, particularly in acid soil as nitrifiers is highly sensitive to acidity and fails to utilize NH^{4+} as their energy source. Thus, higher NH^{4+} concentration limits the protease as well as ureaseactivity.

Nitrification: Nitrifying bacteria exhibit sensitivity to high concentration of free ammonia in soil. Excess free ammonia inhibits ammonium oxidation. As a result, plants loving nitrate as theirs nitrogen source suffer. On the other hand, due to poor oxidation, concentration of ammonia increases that may cause ammonia toxicity to plants. Zinc, among micronutrients, has been found to be inhibitory to soil nitrification. Blanket application of micronutrients by the farmers without soil testing may create imbalances of micronutrients in soil that may slower the rate of nitrification. This may hamper nitrogen nutrition to crop.

Fertilizer use and P-cycle in soil

In P-cycle in soil, two important processes *viz*. solubilization of insoluble inorganic phosphate and mineralization of organic phosphorus play critical role in respect of P nutrition to crop plants.

P-solubilization: Solubilization process becomes slow or completely stops as concentration of soluble P increases above certain levels in soil after application of phosphatic fertilizer **(Table 1)**.The mineral phosphate solubilization trait of the phosphate solubilizers is repressed by higher concentration of soluble P which hinders the expression of gene responsible for organic acid production and /or gene expression is affected by the presence of soluble phosphate due to feedback regulation.

P-mineralization: Soluble mineral phosphate has negative effect on P-mineralization by acid and alkaline phosphatase in soil **(Fig 1)**. Increased nitrogen resulted in decreased activity of alkaline phosphatse. Lower alkaline phosphatase activity under over fertilization, particularly of nitrogen, is due to acidification of soil as phosphatases are sensitive to pH changes.

Micronutrients, particularly, Zn at the concentration up to 400 mg Zn kg^{-1}soil markedly reduced phosphate solubilization and acid phosphatase activity. These might be due to the loss of capacity to synthesize phosphatase enzyme. Zinc is now widely used by the farmers without soil testing on *adhoc* basis. Such indiscrimination in zinc use may retard the natural processes of P solubilization and mineralization.

Fertilizer use and S-cycle in soil

Sulfur mineralization: Aryl sulfatase acts on esters of sulfur to releases SO_4^{2-} in the S cycle. This enzyme is very sensitive to fertilizer mediated stress (excessive SO_4^{2-}) in soil and thus, sulfur mineralization is altered **(Fig 1)**. As reported, nitrogen fertilizer at the dose of 135 $kgha^{-1}$ caused a decrease in aryl sulfatase activity soil while a lower dose of 45 kg ha^{-1} secured the highest activity. The use of high concentration of soluble S hinders arylsulfatase activity by repressing the gene responsible for the enzyme synthesis. Micronutrient, especially B, is a very effective inhibitor of aryl sulfatase followed by Cu and Fe. The inorganic elements bind with the –SH group of an enzyme and altering the shape of the enzyme and activity. Thus, the entire S cycle would be slowed (Tabatabai and Bremner, 1970).

Fertilizer use, plant disease and soil defense system

Proper nutrition is the first line of defense. Current imbalance in fertilizer application shifts the classical NPK ratio of 4: 2: 1 abnormally to 61.7:19.2:1 in Punjab, 61.4:18.7:1 in Haryana, 44.9:16.5:1 in Rajasthan and 25.2:8.8:1 in UP. In most of the cases, propensity of farmer towards nitrogenous fertilizers leads to improper potassium utilization that causes failure to maintain NH_4/NO_3 ratio in plant cytosol. Thus, crop becomes vulnerable to diseases and pest attack. Fertilizer application may alter the soil environment, consequently of diseases incidence. High NH_4/NO_3 ratio favours *Fusarium* wilt severity. While higher NO_3 content reduces *Fusarium* wilt (Huber and Watson, 1997). Thus, it may be concluded that speediness of nitrification regulates the preponderance of pathogens in the expense of oxidation of NH_4 to NO_3.

Natural disease suppressiveness executed by Plant Growth Promoting Rhizobacteria (PGPR) and Arbuscular Mycorrhizal Fungi (AMF) gets setback on application Fe containing micro fertilizers and P fertilization, respectively, due to inhibition of siderophore mediating Fe capturing and failure of AMF establishment.

Fertilizer induced shift in keystone microbial species richness seriously damages the soil intrinsic property of system induced resistance. Thus, functions that ensure soil defence against pathogens retard. System thus, becomes vulnerable to diseases and pest attack. Fertilizer induced acidification enhances the incidence of fungal pathogens and associated disease. Potato growing tract of Bengal recently experiences with low pH largely due to indiscriminate use of chemical fertilizer. Outburst of potato blight caused by *Phythophthora infestans* in almost every year may, thus, be a chronic problem in this region.

Fertilizer use and soil ecosystem stability

Ecosystem stability to different stresses is basically restored by soil microbial diversity and their functional integrity. Due to its exposure to repeated fertilization over the period, diversity and consequently, ecosystem services and goods offered by microbes are at stake. Thus, the capacity of adaptation, in terms of resistance and resilience, of indigenous microbial community to environmental stresses are seriously damaged as evidenced by Indo Gangetic Plains (IGP).At the same time, this region is highly vulnerable to climate aberration due to abiotic stresses. Poor soil health under constant excessive fertilization over the period impacted with climate change may reduce the wheat yield in India in the range of 6 to 23% by 2050 and 15 to 25% by 2080 (Kumar *et al.*, 2014) and consequently of nutritional and social insecurity. One of the major factors of such yield reduction may be due to poor resistance capacity of soil to abiotic stresses **(Table1)** and/or its recovery as newly constituted microbial communities under over fertilization not metabolically superior to elaborate requisite enzymes to recovery the stress originating from chemical fertilizers.

Conclusion

Fertilizers are essential but costly input in agriculture for food production. To reduce cost, naturally occurring soil nutrient reserves suppressed by chemical fertilizers are to be explored by perpetuating microbiological processes. It is true that chemical fertilizers in excess retard the microbiological processes participating in different nutrient cycles. But it is not so critical as most effects are localized, soil specific, short lasting and faded due to crop removal, microbial metabolism, leaching, volatilization and fixation. Sometime fertilizers favour microbiological processes. But sensitivity of different processes to a critical concentration of certain nutrients and shifts in microbial communities under field condition is still pending. So, research priority should be directed to work out appropriate concentration of N, P and certain micronutrients essentially regulate the basic soil microbiological processes in field level.

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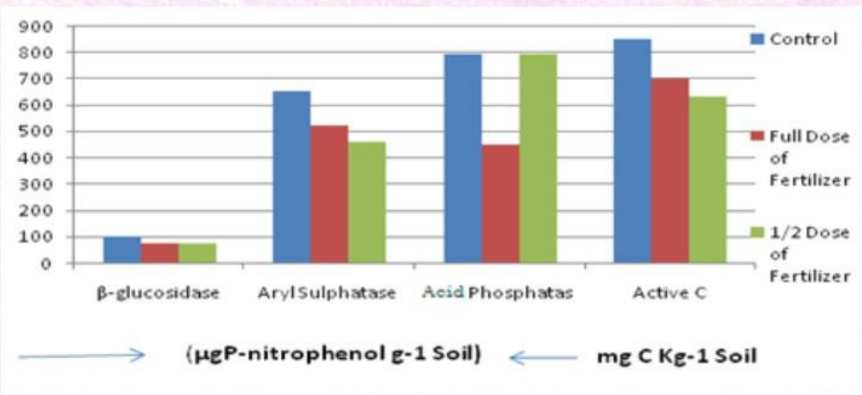

Fig. 1. Effect of chemical fertilizer on soil enzyme activities and active carbon content in soil (After Angima *et al.*, 2011)

Table 1. Impact of long-term nutrient management practices on some microbiological attributes of soil subject to over fertilization (Chanu, 2017)

Management options	*NFC (mg of N_2 fixed /g soil/g sucrose consumed)	*PSC (mg P solubilized/g soil/ g sucrose consumed)	CDC (mg/100mg/ 21 days)	Resistance of *NF to over fertilization	Resistance of *PS to over fertilization	Resistance of *CD to over fertilization
14 years Conventional farming (N:P:K- 125:28:62 ; STCR based nutrient targeting 45 q rice/ha)- T1	9.99	0.90	5.41	0.64	0.82	0.85
T1 subject to Over fertilization (N:P:K-375:84:186 ;3 times more nutrient than conventional)- T2	5.45	0.79	4.09	0.55	0.82	0.44
14 years INM (½ N&P +K of T1+ 2.4t GM/ha +4.0 kg /ha each of Azospirillum + PSB) subject to Over fertilization (N:P:K-375:84:186)- T3	11.65	0.93	9.50	0.68	0.86	0.76

NFC-N-fixing capacity, PSC-P-solubilizing capacity, CDC-Cellulose decomposing capacity, NF-N-fixation, PS-P-solubilization, CD-Cellulose decomposition

NiharenduSaha
Associate Professor
Directorate of Research,
Bidhan Chandra Krishi Viswavidyalaya, Kalyani-741235
*Corresponding author's email: nihar_bckv@rediffmail.com

Snippets: Global Soil Health Workshops

International Conference on Clean Water, Air and Soil

CleanWAS is the conference organized every year since 2012 under The International Water, Air and Soil Conservation society (INWASCON) with joint supports from Universiti Kebangsaan Malaysia, Nankai University, Mahidol University, China University of Geosciences, Chulalongkorn University, Universiti kebangsaan Malaysia and Chiang Mai University. The former conference of CleanWAS, attracted about 100 attendees from all of the world.

Date: August 25 -27
Place: Bangkok, Thailand
Event URL: http://www.cleanwas.org

National Conference on Cover Crops and Soil Health: Harvesting the Potential

Curious about the growing interest in cover crops, no-till, and soil health? Join the conversation on December 7-8, 2017, and hear from farmers and conservationists as they discuss what works and how it can work for you.

Date: December 7 - 8
Place: Indianapolis, IN, USA
Event URL: http://www.swcs.org/index.cfm/6404/81176/national_cover_crops_conference

ARTICLE

Biological attributes of soils under rice-based cropping system with organic and inorganic sources of nutrients

Soil health is assessed integrating physical, chemical and biological attributes of soils. These attributes might be changed under the influence of various management practices and cropping systems and as such aggrade or degrade health of soil. During the last decade, research on soil health has been intensified and popularized by a few groups of researchers in the country (Mandal *et al.*, 2005; Sharma *et al.*, 2005; Masto *et al.*, 2007; Bhaduri and Purakayastha, 2014; Basak *et al.*, 2015) through development of good protocols for assessment, identification of key indicators, their threshold values for different soils, and selection of management practices, cropping systems, land uses etc. that maintain a good health. Again, a few of them worked on rice-based cropping system, a system altogether different from others. Globally, the area of paddy (*Oryza sativa* L.) production has increased from 148 Mha in 2002 to 164 Mha in 2011. Food and nutritional security in Asian countries depend largely upon paddy, because it is the source of 15% of protein and 21% of energy intake for the population. However, productivity of rice in lowland cultivated areas is low because of declining soil nutritional security, degradation of soil structure, and unreliable water resources, lack of resources and widespread poverty. Management practices such as excessive and repeated tillage, pudding, maintaining flooded water regime on lowland paddy soils affect soil properties differently from management practices used in other agricultural systems. Intensity of cultural practices and waterlogging can lead to breakdown of stable soil structure and disturbance to habitat of soil biota (Biswas *et al.*, 2017).

Soil biological attributes

Soil biological attributes such as soil microbial biomass C, and N; mineralizable C, and N; soil enzymes and soil microbial diversity playthe major role in upkeeping all the main ecosystem services of rice-based cropping systems. Soil microbial biomass represents the living component of organic matter in soils, excluding animals and plant roots. Although microbial biomass usually makes up less than 5% of the soil organic matter, it carries out many critical functions in the soil ecosystem, such as, act as both source and sink for nutrients and participates in the C, N, P and S transformations. Nitrogen mineralisation in soils plays an important role in N nutrition of wetland rice because half to two-thirds of total N taken up by rice crops, even in N-fertilised paddies, comes from the soil N pool. It also helps to predict system yield and N extraction from soils and assess environmental pollution risk. Soil enzymes are extracellular and have the ability to degrade complex organic compounds into small utilizable molecules for microbial assimilation. Soil enzymes activities also describe organic matter decomposition, C-release and sequestration, nutrient cycling, and microbial activity. Further, such enzyme activities use as discriminatory indicators for a wide range of soil management practices.

Impact of long-term management practices on soil biological attributes

Integrated nutrient management through NPK + organic treatments (farm yard manure, FYM; paddy straw, PS and green manure, GM) significantly increased organic C and microbial biomass C **(Table 1)**. Integrated treatments, NPK + FYM/ + PS and /GM maintained 2.20, 2.33 and 2.2% of soil organic carbon in the form of mineralizable C (C_{min})which are higher compared to control and NPK treatments. Integrated nutrient management has potential to supply nitrogen in adequate level compared to NPK. However, among the integrated supplementation, PS did not increase the mineralizable N (N_{min}), while incorporation of green manure supplied good amount of N to crops. Both dehydrogenase and fluorescein diacetate hydrolyzing activity (DHA and FDHA) was significantly higher for NPK + FYM as compared to NPK + GM/PS. Other extra cellular soil enzymes *viz*., urease, β-glucosidase, aryl sulphatase, acid and alkaline phosphatase activity were higher for NPK + organic treated plots compared to NPK only.

Table 1.Biological and metabolic activities of soils with integrated nutrient supply systems under rice-wheat croppingsystem for 24 years (Basak *et al.*, 2016a)

Soil attributes	Fallow	Control	NPK	NPK+ FYM	NPK + PS	NPK + GM	$LSD_{0.05}$
Organic carbon, g kg^{-1}	9.9^{b}	8.2^{d}	9.3^{c}	10.9^{a}	9.9^{b}	10.2^{b}	0.38
Microbial biomass C, C in µg C g^{-1}	583.0^{d}	417.3^{e}	637.4^{c}	759.3^{a}	763.5^{a}	711.9^{b}	14.5
Mineralizable C, C in µg C g^{-1} d^{-1}	6.99^{c}	7.28^{c}	7.43^{c}	11.63^{a}	9.84^{b}	10.75^{ab}	1.04
Mineralizable N, µg NH_4-N $g^{-1}d^{-1}$	1.63^{bc}	1.38^{c}	1.94^{bc}	2.59^{a}	2.05^{ab}	2.19^{ab}	0.61
Dehydrogenase activity, µg TPF g^{-1}soil $24h^{-1}$	58.0^{c}	57.9^{c}	58.7^{c}	96.7^{a}	83.4^{b}	82.3^{b}	9.7
Fluorescein diacetatehydrolyzing activity, µg fluorescein g^{-1}soil h^{-1}	72.7^{c}	71.5^{c}	81.7^{b}	101.3^{a}	94.3^{a}	97.5^{a}	7.9
Urease activity, µg NH_4-N g^{-1} soil 2 h^{-1}	45.0^{c}	54.8^{bc}	62.6^{b}	78.6^{a}	63.9^{b}	64.5^{b}	11.2
β-glucosidase activity,µg *p*-nitrophenol g^{-1}soil h^{-1}	64.0^{c}	72.1^{bc}	80.4^{b}	106.1^{a}	100.0^{a}	99.7^{a}	10.1
Acid phosphatase activity,µg *p*-nitrophenol g^{-1}soil h^{-1}	140.1^{cd}	133.2^{d}	156.0^{ab}	168.1^{a}	152.3^{bc}	157.4^{ab}	14.1
Alkaline phosphatase activity,µg *p*-nitrophenol g^{-1}soil h^{-1}	129.3^{d}	252.1^{c}	276.9^{b}	307.5^{a}	286.3^{b}	312.6^{a}	19.6
Aryl sulphatase activity,µg *p*-nitrophenol g^{-1}soil h^{-1}	88.3^{c}	113.8^{b}	121.2^{b}	146.2^{a}	144.1^{a}	125.8^{b}	12.6

[Numbers followed by different uppercase letters are significantly different at $P \leq 0.05$ by Duncan's multiple-range test]

Biological attributes of soils from farmers' fields

Soil respiration or C mineralisation is an index of total soil biological activity including soil microorganisms, macro-fauna and plant roots. It reflects the overall activity or energy spent by the indigenous soil microbial pool. Measurement of C mineralisation yields an index of total carbon availability. So, mineralisable C is one of the most important parameters to monitor the microbial mediated processes like decomposition of organic matter in soil. The distribution of C mineralization at different days among the soils for different cropping systems showed that soils with farm yard manure (FYM) amended had higher C mineralization compared to only inorganic NPK supplied (Basak *et al.*, 2016b) **(Fig 1)**.

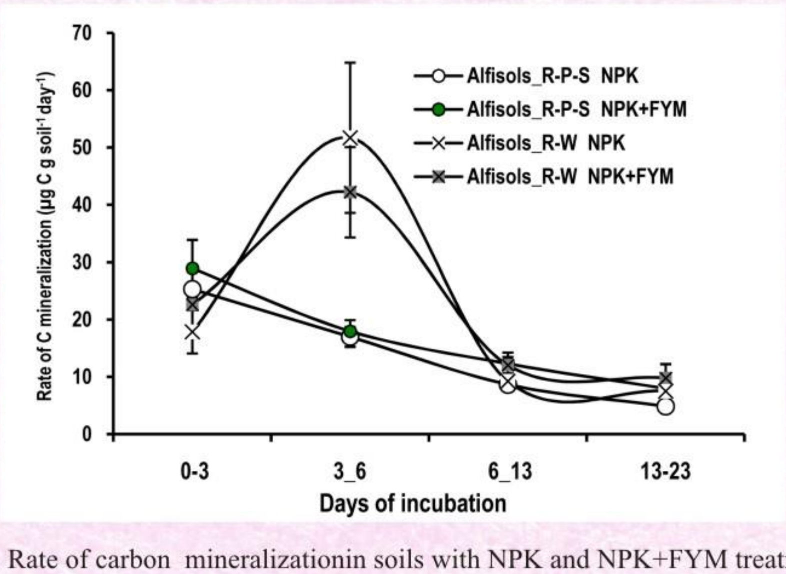

Fig 1. Rate of carbon mineralizationin soils with NPK and NPK+FYM treatments

We developed a minimum data set for assessing quality of soils belonging to three Soil Orders (*Inceptisols, Entisols* and *Alfisols*) with rice–potato–sesame cropping systems using statistical and mathematical models and 27 physical, chemical and biological attributes.Our observation showed that biological and chemical attributes were most sensitive for indicating the differences in soil quality and have a strong influence on system yield, whereas soil physical attributes largely (clay, bulk density, aggregate stability, hydraulic conductivity, total water stable aggregates) varied but did not predict system yield (Basak *et al.*,, 2015) **(Table 2)**. Among the soil attributes dehydrogenase activity for *Inceptisols*, organic C for *Entisols* and N_{min} and very labile C for *Alfisols* were screened as key indicators for assessment of soil quality under a rice-based cropping system (rice-potato-sesame).

Table 2.Selected soil quality indicators through statistical methodology

Soil order	Selected soil quality indicators	Per cent explained of total data set; and total number of attributes assessed
Inceptisols	Dehydrogenase activity (DHA), available K, exchange capacity and pH_{Ca}	87% and 27for Principle component analysis (PCA); Discriminate analysis (DA) explained the ~91% described data set of PCA
Entisols	Organic C, pH_{Ca}, bulk density, nitrogen mineralisation and β-glucosidase activity	85% and 27for PCA; 92% described data set of PCA
Alfisols	DHA, very labile C, nitrogen mineralisation and microbial biomass C	83% and 27for PCA; 99% described data set of PCA

Conclusion

Soil degradation of cultivated land is a major threat to agricultural sustainability and environmental quality in India. Assessment of soil health-fitness for use and identification of key master indicators for such assessment are the key options for curbing such degradation. These selected key indicators are unique and process based for each soil type and cropping system and be used for upkeeping health of soils under the study.

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NirmalenduBasak[1,3*], SunandaBiswas[2,3] and GoraChandHazra[3]

[1]ICAR-Central Soil Salinity Research Institute, Karnal, Haryana; [2]ICAR-Indian Agricultural Research Institute, New Delhi; [3]Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal;

[*]E-mail ID of the Corresponding Author: nirmalendu.basak@icar.gov.in

ARTICLE

Long term effect of fertilization on soil microorganisms

Soil is living because below our feet there is an immensely complex web of life that includes the smallest bacteria and fungi to burrowing mammals. Soil microorganisms perform a wide range of functions: they decompose organic matter, release nutrients into plant-available forms and degrade toxic residues; they also form symbiotic associations with plant roots, act as antagonists to pathogens, influence the weathering and solubilisation of minerals and contribute to soil structure and aggregation. Microbes require carbon, nutrients for their body building purpose and mineral fertilizer provides nutrients like nitrate, ammonium, phosphate, calcium, potassium, sulphur for their growth and reproduction. Mineral fertilizers especially nitrogen (N), phosphorus (P) and potassium (K), not only serve to maintain or improve crop yields, but their application also directly or indirectly induces changes in soil chemical, physical and biological properties. These changes, in the long-term, are believed to have significant influences on the quality and productive capacity of the soil. Long-term fertilization trials allow us to observe the effects of repeated additions of mineral or organic or combined application of fertilizer on soil microorganisms.

Direct effects of mineral fertilizers on soil microorganisms

The application of urea and ammonium fertilizers can lead to very high local concentrations of ammoniacal N. Ammonium is the preferred nitrogen source for most bacteria and fungi. However, when applied at high rates, urea and ammonium fertilizers can inhibit soil microorganisms due to toxicity of ammonia, increases in pH and increases in ionic strength (Geisseler *et al.*, 2014). Such high concentrations can strongly inhibit or even kill fungi and bacteria. The harsh conditions created by these fertilizers are generally spatially limited because the zone of high pH and ammoniacal N concentration created by fertilization do not extend beyond 6 cm of a large granule of urea. In addition to being spatially limited, the concentration of ammoniacal N decreases within a few days or weeks in aerated soil due to nitrification and plant uptake (Geisseler *et al.,* 2014). Even though long-term studies have shown that ammonium concentration may be higher in fertilized than unfertilized soils, concentrations at most times and in most locations are likely far below the level toxic to microorganisms. Despite the development of localized conditions hostile to soil biology following application of urea and ammonium fertilizers, short-term effects of fertilizer applications on soil microbial communities as a whole have been found to be minimal. Soil microorganisms either recover quickly from potentially harmful effects of urea and ammonium fertilizers or that susceptible species are rapidly replaced by more tolerant ones, leading to no major differences in biomass or activity at the community level in the long term.

Indirect effects of mineral fertilizers on soil microorganisms

There are strong indirect effects of fertilizers on soil microbial communities due to increased total organic carbon content and lower pH. Several long-term studies found that fertilization led to changes in soil microbial community composition (Kirchmann *et al.*, 2013). A few studies, on the other hand, were found no or only small effects of mineral fertilization on soil microbial community composition (Börjesson *et al.*, 2012). The response of specific microbial groups to the long-term application of mineral fertilizers varies considerably. In general, fungi have been found to benefit more from mineral N fertilization even when soil pH was little affected, decrease relative proportion of Gram-negative bacteria compared to in the unfertilized control, while the relative abundance of Gram-positive bacteria tended to increase. The microbial community responds to mineral fertilizer is influenced by environmental and management related factors and may also differ between the bulk soil and rhizosphere soil.

Long term effect of fertilization on soil microbial activities

Meta-analysis of 64 long term fertility trials all over the world showed that the addition of mineral fertilization significantly increased total organic C content compared to the unfertilized control by an average of 12.8% and microbial biomass C by 15.1% (Geisseler *et al.*, 2014). Ladha *et al.,* (2011) analyzed data from 104 long-term trials in agricultural systems throughout the world ranging in duration from 6 to 158 years. They found that the average total organic C content in these studies decreased over time; however, the decrease was less pronounced in plots that received mineral N compared to the unfertilized control. Irrespective of nutrient combination, long-term application of chemical fertilizer resulted in an increase in population of bacteria, fungi and actinomycetes **(Table 1)** (Wanjari *et al.*, 2013). Imbalanced use of nutrients say N alone had negative effect on population of these organisms when compared with balanced treatment but superior to control. Incorporation of biomass in larger quantity through root and stubble added to soil as a result of higher productivity in plots receiving balanced nutrient application favoured microbial population. Nutrient management also has consequence on the enzymatic activities. Evolution of CO_2-C with proportional presence of soil microbial biomass carbon (SMBC) in larger quantity supports the higher microbial population on balanced application of nutrients. Detection of greater amount of dehydrogenase activity (DHA) further supports the findings, as DHA activity gives an overall indication about the biological health of soil.

Table 1: Impact of long term fertilization on soil biological properties (Wanjari et al., 2013)

Treatment	CO_2 evolution (mg 100 g^{-1})	SMBC (mg kg^{-1})	DHA (µg TPF g^{-1} 24 h^{-1})	Bacteria (×10^7 cfu g^{-1} soil)	Fungi (×10^4 cfu g^{-1} soil)	Actinomycetes (×10^6 cfu g^{-1} soil)
Control	22.00	137.81	32.62	6.25	4.50	5.00
100% N	26.07	180.17	36.28	8.75	6.25	5.75
100% NP	28.32	204.39	39.57	13.00	8.25	8.75
50% NPK	27.35	197.49	37.60	9.50	7.25	6.00
100% NPK	31.62	216.39	41.19	15.50	11.25	11.75
150% NPK	40.42	239.79	46.10	22.75	13.25	13.5
100% NPK (S free)	29.42	206.40	41.16	14.75	12.00	10.5
100% NPK+Zn @ 2.5 kg ha-1	32.72	218.70	42.28	17.75	11.50	12.00
100% NPK+ FYM @ 10 t ha-1	41.52	249.01	47.70	30.50	15.50	16.25
CD (p=0.05)	2.10	14.88	2.20	2.05	1.94	1.74

Long term effect of fertilization on microbial community structure and diversity

Long-term organic and mineral fertilization had significant impacts on the soil microbial community structure and diversity. Francioli *et al.*, 2016 studied the effects of different fertilization regimes (no fertilization (NF), mineral fertilization (NPK), farm yard manure fertilization (FYM), and combined farmyard manure and mineral fertilization (FYM+NPK) on the community structure and diversity of the soil microorganisms under 115 years old long term fertilizer experiments in Germany. Pyrosequencing data analysis revealed that there were significant differences between the structures of bacterial and fungal soil communities associated to each fertilization regime. Bacterial diversity and richness were significantly higher ($p < 0.05$) in soil fertilized with farm yard manure (FYM and FYM+NPK) compared to the NF and NPK soils, while no significant differences were observed for fungal diversity (Shannon index) and richness (observed richness) among the four treatments **(Fig. 1)**. Organic fertilization increased bacterial diversity, and stimulated microbial groups (Firmicutes, Proteobacteria, and Zygomycota) that are known to prefer nutrient-rich environments, and that are involved in the degradation of complex organic compounds. In contrast, soils not receiving manure harbored distinct microbial communities enriched in oligotrophic organisms adapted to nutrient-limited environments, as Acidobacteria (Francioli *et al.*, 2016). The fertilization regime also affected the relative abundances of plant beneficial and detrimental microbial taxa, which may influence productivity and stability of the agroecosystem.

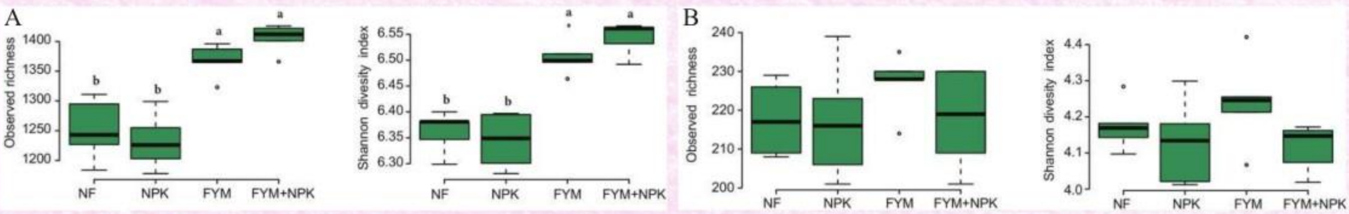

Fig.1. Box plots of the observed richness and Shannon's diversity index of (A) bacterial and (B) fungal community in the four soils studied. Different letters indicate significant differences based on Tukey's HSD test $p < 0.05$ (Francioli *et al.*, 2016).

Conclusions

Long-term fertilization of agricultural soil results in increased microbial biomass C content, which is likely caused by associated increases in total organic C content due to higher crop productivity. Long-term fertilizer experiments also proved that balance nutrient application is valuable with respect to growth of soil microorganism and their development. Application of recommended dose of NPK and in combination with FYM or other organics has further improved the richness of soil microbial populations in terms of their count and enzymatic activity. Fertilization with organic manure, which has a more diverse composition in terms of macro- and micro- nutrients than the mineral fertilizers, was responsible for the strong enhancement in soil microbial community and diversity. Genomics approaches that can differentiate changes within specific groups need to be used to identify and interpret phylogenetic and functional changes of microbial communities with long-term fertilizer induced changes.

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SunandaBiswas
Division of Soil Science and Agricultural Chemistry,
ICAR-IARI, New Delhi-110012
Email: sunandabiswas13@gmail.com

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Contact:
Prof. Biswapati Mandal,
mandalbiswapati@rediffmail.com,
Ph. No. 9433533598
Dr. H. S. Sen, Email: hssen.india@gmail.com,
hssen2000@hotmail.com, Ph. 9874189762

Designed & Printed at : NEW MODERN ART PRESS, Sadarghat, Old Market, Burdwan, PIN - 713103, West Bengal.
Email : nmap.bdn@gmail.com, Contact No. : 9434185400, 9332278830