Proceedings of the 24th Annual Convention and National Conference on Application of Clay and Allied Sciences in Agriculture, Environment and Industry

The 24th Annual Convention and National Conference on "Application of Clay and Allied Sciences in Agriculture, Environment and Industry" was organized by the Clay Minerals Society of India (CMSI), New Delhi in collaboration with ICAR-NBSS&LUP, Regional Centre, Kolkata and Anthropological Survey of India, Kolkata during September 22-23, 2022 in Kolkata. The convention organized the 8th Prof S.K. Mukherjee CMSI Foundation Lecture, two special sessions, three technical sessions, presentation by awardees, poster sessions and plenary session. A brief report of the Convention is presented hereunder.

Day 1: September 22, 2022 **Venue: Anthropological Survey of India, Salt Lake, Sector-V, Kolkata**

Inaugural session

8th Prof SK Mukherjee CMSI Foundation Lecture

Chairman: Dr. SC Datta, Former President, CMSI and Former Emeritus Scientist, ICAR-IARI, New Delhi

Speaker: Dr. Pankaj Srivastava, Professor, Department of Geology, University of Delhi

Topic: **Present is the key to the past: Soils to Paleosols and their implications for landscape stability (tectonism) and climate change based on micro-morphology and clay mineralogy**

Dr. Srivastava delivered his presentation in three geologic ages viz., Part-I on Modern soils of IGP landscape & climate change issues (10 ,000 years), Part-II on Paleosols, their pedogenesis & climate change overlapping (31-5.5 Million years) and Part-III on Paleocene-Eocene Thermal Maxima & Hyper thermals (56-53 million years). On formation of modern IGP soils, Dr. Srivastava depicted the fluvial sequence & its implications on landscape stability from prevailing climate to recent one. Five soil geomorphic surfaces from Q1G1 to Q1G5 have been recognized. The Pedofeatures of IGP soils are polygenetic in nature showing degradation of the earlier clay pedofeatures. The Paleopedology of fossil soils of Himalayan foreland has been illustrated in Part-II (31-5.56 Million year) based on study of oldest tropical weathering, diagenetic overlapping & paleopedogenesis in Trans Himalayas to Sub Himalayas. In lower 2.0 km depth Red Paleosols of slow agrading stages in stable landscape were recognized, whereas, in upper 1.1 km depth Yellow Paleosols of rapid aggrading stages were identified in Himalayan Fore land. The study showed diagenetic overlapping of fossil soils in Dharmasala. In Part-III

(56-53 Million years) evidence of abrupt chemical weathering during hyperthermals has been noted with marked alkali formation in soils of Barmer. Soil geomorphology, micromorphology and clay mineralogy are important indicators of Paleosol formation in all three geologic ages.

Special Session on "Soil carbon research in different agro-ecologies"

Convener: Dr. D.K. Pal, Former Head, Division of SRS, ICAR-NBSS&LUP, Nagpur
Co- Convener: Dr. T.J. Purakayastha, Principal Scientist, Division of SS&AC, ICAR-IARI, New Delhi
Panelists: Dr. D.K. Pal, Dr. T.J. Purakayastha and Dr. B.N. Ghosh
Rapporteur: Dr. S. Gupta Choudhury, Senior Scientist, ICAR-NBSS&LUP, Kolkata

A special session was held on "Soil Carbon Research in Different Agro- ecologies" in which the Convenor was Dr. D. K. Pal, Former Head, Division of SRS, ICAR- NBSS & LUP, Nagpur and the Co- convenor was Dr. T. J. Purakayastha, Principal Scientist, Division of SS&AC, ICAR- IARI, New Delhi. The three panelists were the Convenor & Co- convenor themselves as mentioned along with Dr. B. N. Ghosh, Principal Scientist, ICAR- NBSS & LUP, Regional Centre, Kolkata.

At the outset, the Convenor pointed out the present scenario of Soil Carbon Research in India and requested the other panelists to concentrate on the following points:

a. The way forward to maximize soil carbon content of Indian soils.
b. The conduits to overcome carbon saturation point.
c. The features of agricultural crop in climate change mitigation specially in arid and semi-arid zones and finally
d. The innovative management protocols to increase the Carbon- Sequestration based on the fundamental information.

Dr. B. N. Ghosh presented on "Recent Soil- Carbon research in India Battling climate" in which he reported that about 11% of world's land is suitable for crop growth and simultaneously land degradation is happening due to various reasons in 1.2 mha. So he wanted to search the scope to improve land degradation through Carbon- Sequestration measures. He also highlighted 4/1000 concept in the context of Indian Agricultural perspectives along with carbon emission/ Sequestration in different cropping system. He presented the scope of Conservation agricultural and agro- forestry system as a measure of restoration of degraded land with reference to Carbon- Sequestration potential. He depicted some database on Mal block of Jalpaiguri district, West Bengal in which he got 74% area comes under 4 per mile Sequestration zone, where as 26% area is yet to attain the 4per mile level.

Next, Dr. T. J. Purakayastha presented on "Soil Carbon research in different Agro-ecology". He presented the soil and SOC density maps in India in different agro- ecology. He also reviewed the SOC density and total SOC stock under different cropping system with variable soil types and agro- ecology. The zone wise SOC density as well as the challenges with BMP under different cropping system has been covered elaborately. He depicted the different controlling factors of Carbon- Sequestration like climate, edaphic factors, microbial, physical

protection, molecular structure of OM etc. for SOC-aggradation and/ or degradation. Finally, he concluded with some feature researchable issues of SOC-sequestration such as-

a. Clay mineralogy in different climate.
b. Soil texture.
c. Sensitivity of Soil Carbon under future scenario of climate change.
d. Litter chemistry.
e. Interaction of litter chemistry, priming effect and clay mineralogy.
f. Tillage effects etc.

Finally, the Convenor of the session, Dr. D. K. Pal present on "Soil Inorganic Carbon ($CaCO_3$, SIC) Carbon- Sequestration - a bane or a hidden treasure in soil ecosystem services". He enlightened us with the concept of SIC (geogenic or pedogenic) under different soil ecosystem services like IGP, S-S and RFS soils. He opined that, the SIC stock in the first 0-30 cm on depth is almost half of SOC stock, which suggest the enhancement of OC–concentration in rooting zone of shallow rooted crops preventing the formation of Pedogenic Carbonate. He said that, the formation of PC is a basic natural degradation process which exhibits the regressive pedogenesis by capturing atm.CO_2 and also immobilizes Carbon in unavailable forms in soil. A regressive pedogenesis poses a challenge to land resource managers the way to revive the required balance between exchangeable and water soluble Ca^{2+} ions in the soil systems to make calcareous sodic soils resilient OC poor sodic Vertisols (Haplusterts) rich in $CaCO_3$ show enough resilience under improved system as found in ICRISAT. He also depicted that the average grain yield of the improved management system over 30 years was 5 times higher than the traditional system along with higher OC Sequestration. Thus, he suggested an interesting area of soil research to realize the benefit of the presence of $CaCO_3$ as a hidden treasure and further as an ecosystem engineer during the reclamation of sodic soils. He postulated that, IGP sodic soils i.e., Natrustalfs after their reclamation by gypsum has been improved in terms of morphological, physical and chemical properties after reclamation by gypsum and are now have been reclassified and OC- rich normal Alfisols. In addition, growing of trees for 12 years is reclaimed IGP- sodic soils has improved their biological activities, which also resulted the $CaCO_3$ decrement in these zones.

Technical Session I: "Clay Mineralogy and Nano-science"

Chairman: Dr. S.C. Datta, Former ICAR-Emeritus Scientist, Division of SS&AC, ICAR-IARI, New Delhi
Co-Chairman: Dr. S.S. Mukhopadhyay, Former Professor, PAU, Ludhiana
Rapporteur: Dr. Debarup Das, Scientist, ICAR-IARI, New Delhi

The technical session I on "Clay Mineralogy and Nano-science" was chaired by Dr. S.C. Datta, Adjunct Faculty and Former Emeritus Scientist, ICAR-Indian Agricultural Research Institute, New Delhi.

The session started with a lead lecture by Dr. S.C. Datta on application of nano-clay in agriculture. The lecture covered the types of nano-clay polymer composites, their preparation techniques, and how they can be loaded with nutrients to form slow release nutrient delivery systems. The mechanisms of slow release of nutrients from these were also illustrated in detail. Further, preparation steps of nano-clay bio polymer composites or NCBPC were discussed. NCBPC has the same purpose but are more readily degradable than NCPC owing to the partial replacement of acrylic acid by starch. More research work is needed in this field to better utilize the nano-clays in different aspects of agriculture.

After the lead lecture, paper presentations were made based on the submitted abstracts. Out of five abstracts submitted, four were presented. One presentation was on the application of clay-polymer nano-composites as nutrient delivery system, one of the role of amorphous oxides and hydroxides and HIMs in organic C sequestration, one on the genesis of clay minerals in alluvial soils of Narmada river basin, and the last one on the changes in clay minerals due to potassium depletion.

Dr. Nintu Mandal from Bihar Agricultural University, Sabour presented a study assessing the effect of iron loaded NCPC on rice crop yield and iron uptake and compared it with a conventional fertilizer i.e., $FeSO_4$. A pot experiment with rice crop showed Fe-NCPC to be more efficient Fe carrier than $FeSO_4$ as with similar dose of Fe, both yield and Fe uptake were significantly higher with Fe-NCPC than FeSO4. They also found that 25% of recommended through Fe-NCPC can fetch yield equivalent to 100% of recommended Fe through $FeSO_4$.

Dr. Ranjan Paul from ICAR-National Bureau of Soil Survey and Land Use Planning, Nagpur presented a work on amorphous oxides, hydroxyl interlayered clay minerals and organic carbon sequestration in humid tropical Western Ghats soils of India. He and his co-workers carried out a systematic study to understand the role of amorphous oxides and HIMs in organic C sequestration. They showed that soil acidity due to profuse vegetation can cause breakdown of crystalline clay minerals, liberating amorphous metal oxides which are preferentially adsorbed in the interlayers of smectite and vermiculite to form HIMs. They also found that free amorphous metal oxides in the soil matrix are stabilized with soil organic matter. However, how to utilize this knowledge in modifying land management for better C sequestration and enhance organic C status in C-poor soils still needs to be thought-out.

Dr. R.P. Sharma from ICAR-NBSSLUP, Regional Centre, Udaipur, Rajasthan presented on the genesis of clay minerals in alluvial soils of Narmada River basin in West Coast of Gujarat. His presentation showed that both recent and old alluvial plains of Narmada River basin have smectite as the dominant mineral in clay as well as silt particles. These smectites were mainly inherited from basalts in the clay fraction of old alluvium but the same transformed from mica in recent epoch. Also, similar kind of minerals throughout the profiles suggested that the minerals were not formed during the post-deposition period of the soil formation, rather were inherited or altered from the parent material during transportation.

The last presentation of this session was by Subhadip Paul from ICAR-IARI, New Delhi. He showed the changes in clay minerals in five different soils due to K depletion. Irrespective

of soils, K depletion resulted in lowering of relative abundance of illite and illite/smectite interstratified minerals. Also, he showed that most of the 2:1 clay minerals have lost their interlayer K, resulting in noticeable changes in peak positions and areas in X-ray diffractograms of clay samples.

The session ended with remarks and vote of thanks from the Chairman.

Special Session on "Application of Clay Science in Industry and other niche areas"

Convener: Dr. S.K. Sanyal, Former Vice-Chancellor, BCKV, Mohanpur
Co- Convener: Dr. G. Goswami, Scientist F, TIFAC, DST, New Delhi
Panelists: Dr. G. Goswami, Dr. Soumitra Das and Dr. Shantanu Kar
Rapporteur: Dr. Prasenjit Ray, Scientist, ICAR-IARI, New Delhi

Dr. S.K. Sanyal, Former Vice-Chancellor, BCKV, Mohanpur was the Convener of the session. The Panelists were Dr. G. Goswami, Scientist F, TIFAC, DST, New Delhi; Dr. Soumitra Das, Director (India), International Zinc Association (IZA), New Delhi and Dr. Shantanu Kar, Senior Manager, Coromandel International Limited, Secunderabad. Dr. Prasenjit Ray, Scientist, Division of Soil Science and Agricultural Chemistry, ICAR-IARI, New Delhi was the Rapporteur of the session. The session commenced with the presentation of Dr. Shantanu Kar on the topic "Use of Clay for Slow-release Fertilizer". In his presentation, Dr. Kar highlighted about different commercial clay-based fertilizer products of the Coromandel International Limited. He mentioned about the 'SulphoZinc' product, where bentonite clay has been used as the binding agent for the slow-release of nutrient elements, i.e., S (65%) and Zn (18%). He also informed to the House about the 'Bentonite Sulphur' product containing 90% S in elemental form, with 10% bentonite clay. In his presentation, he also highlighted about the use of high surface area alumina as soil conditioner. According to the results of field trials conducted by Dr. Kar and his group, the yield of maize and wheat could be increased by 2-7% using the alumina. The speaker also informed that the Coromandel International Limited is in strong collaboration with the Division of Soil Science and Agricultural Chemistry (SS&AC), ICAR-IARI, New Delhi and the industry is currently conducting sponsored field trials with the help of SS&AC using the nano-clay polymer composite (NCPC) loaded with Zn and P. He drew attention on the aspects of the limitation pertaining to the nutrient loading capacity of the NCPC and the scope of using natural zeolite in the product.

Dr. Soumitra Das in his presentation highlighted that nanotechnology offers advantage in terms of efficacy of nano scale formulation. In his presentation, he informed that the liquid formulation of the IFFCO nano-urea (4% N) would help in reducing the consumption of urea by applying 2-sprays of nano-N (nano urea @ 2-4

ml per litre). He also informed that the field trials with nano urea are being conducted at the research stations and farmer's field across the country. He highlighted that the Government of India has approved the use of nano-urea in agriculture, whereas nano-Zn and nano-Cu are kept on hold. Besides, the Government is emphasizing on nano-DAP.

Dr. G. Goswami in his presentation on "Application of Clay Science in Industry and other Niche Areas- Fundamental to Application" highlighted the applications of clays in different industries, namely construction, steelmaking, wine and beer, pharmaceutical, textile and paper, and energy sector. Besides, he emphasized that special approach is required to exploit the full potential of clay minerals as adsorbent, catalysts, and biomaterials. Clay-based nanomaterials may be exploited in the energy sector for green environment and environmental remediation. He also emphasized that more focus is to be given on application-oriented research using clays and clay minerals.

Annual General Body Meeting

The Annual General Body Meeting was held on September 22, 2022 at the Conference venue. The Secretary of CMSI presented the accomplishments of the society during the last year. The Treasurer of the society gave a deliberation on the account statement of the society, which was approved by the members of the society. It was unanimously decided in the AGM that the 25th Convention of the society would be held in Delhi.

Day 2: September 23, 2022 **Venue: ICAR-National Bureau of Soil Survey and Land Use Planning (ICAR-NBSS & LUP) Regional Centre, Kolkata**

Presentations by Awardees- Young Scientist Award and Best Ph.D./ M.Sc. Student Travel Grant Award

Chairman: Dr. S.P. Datta, Professor, Division of SS&AC, ICAR-IARI, New Delhi
Rapporteur: Dr. S.K. Reza, Senior Scientist, ICAR-NBSS&LUP, Kolkata

Chairman of this session welcome to the all delegates of the 24th Annual Convention and National Conference on Application of Clay and allied science in agriculture, environment and industry who joined offline and online. Ms. Kavita P. Jadhav Ph.D. student from ICAR-IARI, New Delhi received the Best Ph.D. Student Travel Grant Award for her work on "Soil organic matter stability by clay humus-complexes in diverse soil orders under continuous paddy cultivation".

Mr. Goutam Parida (Best M.Sc. Student Travel Grant Awardee) from ICAR-IARI, New Delhi presented on soil characterization and organic dynamics in different land-use systems.

He has taken 6 land use system and studied soil profiles up to 150 cm depth and characterized the soil for pH, BD, organic carbon, TOC and calculated the SOC stocks. It was observed that rice-fallow and sugarcane-based system had less SOC and forest had highest.

Dr. Raj Mukhopadhyay (Young Scientist Awardee) from ICAR-CSSRI, Karnal presented on Engineered clay minerals for remediation of soil pollutants. He used both inorganic and organic modifiers and observed that both can adsorbed more pollutants as compared to the natural clay.

Technical Session-II: "Application of clays and clay minerals in various fields"

Chairman: Dr. Nayan Ahmed, Head, Division of SS&AC, ICAR-IARI, New Delhi
Co-Chairman: Dr. P. Tiwari, Head, Division of SRS, ICAR-NBSS&LUP, Nagpur
Rapporteur: Dr. D. Vasu, Scientist, ICAR-NBSS&LUP, Nagpur

Technical session II on "Application of Clays and Clay minerals in various fields" was chaired by Dr. Nayan Ahmed, Head Division of SS & AC, IARI and co-chaired by Dr. P. Tiwari, Principal Scientist, Division of SRS, ICAR-NBSS & LUP, Nagpur.

In the session two lead lectures were delivered. The first one on "Application of clay minerals in remediation of metal (loids) in polluted soil and water" was delivered by Dr. S.P Datta, Professor, Division of SS & AC, ICAR-IARI, New Delhi. Dr. Datta outlined the role of clay minerals in origin of life as they act as polymerization templates. He presented that >230 million people in 108 countries are affected by arsenic pollution, mainly arising from geogenic origin. The Cr pollution due to anthropogenic origin and Cd pollution due to fanning industries are also serious issues. Further, diseases like Itai-Itai, hyper- keratosis, Nerve disorders and sclerosis in humans are caused by heavy metal toxicity.

Dr. Datta presented evidence for the role of clay-based adsorbents in removing heavy metals from soil and water. Particularly, the effect of modification of clay on heavy metal adsorption and removal was highlighted. He also discussed the factors affecting adsorption of heavy metals by clay minerals. Dr. Datta concluded the lecture by stating that the feasibility of the large-scale application of clay materials for remediation of agricultural land and irrigation water need to be worked out. The chairman and the house appreciated the lecture.

The second lecture was delivered by Dr. Binoy Sarkar, Research Fellow, University of South Australia on "Designer clay composite materials for emerging environmental contaminants clean-up". Dr. Sarkar discussed about nano-clay technologies, clay-nano carbon composite, clay-biochar composite, magnetic-clay bio polymers, clay- bacteria composite, contamination treatment by clay minerals, polygorslaite-clay nano composite. The key PFAS removal mechanisms highlighted are electrostatic interaction, ligand exchange and hydrophobic interaction. He indicated that clay-biochar composite, which can be prepared from low cost raw material, has advantages such as increase in porosity, mechanical stability, CEC, oxygen function groups and enhances the interactions. Dr. Sarkar concluded that clay-

carbon composite have the potential to become next generation contaminant removal materials. The chairman and the house appreciated the lecture.

A total of 13 oral presentations were delivered by the researchers.

Dr. Raj Mukhopadhyay from ICAR-Central Soil Salinity Research Institute has presented a paper on engineered clay minerals for remediation of per- and polyfluoroalkyl substances in contaminated water and showed that clay-biochar composites and clay-anchored nano-catalysts and micro-organisms hold potential to further improve PFAS remediation via enhanced adsorption-transformation mechanisms.

Dr. Suman Manna from ICAR-Central Institute of Fisheries Education, Kolkata Centre, has presented a paper on bentonite and rice husk ash (RHA) reinforced polymeric adsorbents for treatment of waste water in sewage fed aquaculture and showed that total ammonia and hardness load was significantly reduced in the treated water after adsorption.

Dr. Vaidya P. H. from Vasantrao Naik Marathwada Krishi Vidyapeeth presented a paper on mineralogy of soils of Marathwada region Maharashtra and showed that presence of biotite in silt fraction and its absence in total clay fraction indicated depletion of biotite during natural weathering.

Dr. Anjali M. C. from University of Agriculture and Horticultural Sciences presented a paper on soil mineralogy of Kavalur sub-watershed (4D4A2P) of Koppal district, north Karnataka and showed that in most of the black soil pedons, smectite content increased while kaolin and quartz content decreased with soil depth.

Neepa Dey from Institute of Agricultural Science, University of Calcutta presented a paper on charge developed in soil mainly by organic matter, clay component and composition of clay and showed that soil charge formation is regulated by the amount of organic matter, nature and amount of clay component, concentration of sesquioxide and allophen.

Dr. Rajib Lochan Goswamee from CSIR-NEIST presented a paper on the mineralogical and physico-chemical characterizations of a Girujan clay deposit from Nagaland, India and showed that stacked layers with nano-pores in the basal planes is causing the high water inter-activity of clay.

Dr. S. Gupta Choudhury from ICAR-NBSS and LUP, Regional Centre, Kolkata has presented a paper on identification and characterization of Indo-Gangetic alluvial soils with *vertic* properties and showed that presence of chlorite and smectites with other mixed layer minerals in these types of soils make it qualified under fine to clayey over fine-silty, mixed, hyperthermic, Vertic Endoaquepts with phase variations at 1:10000 scale map.

Dr. K. Karthikeyan from ICAR-NBSS and LUP has presented a paper on diverse implications of Palygorskitein use and management of agricultural crops in Indian Vertisols and showed that presence of exchangeable Mg^{2+} is known to decrease aggregate stability and to enhance the dispersivity of soil clay fractions.

Dr. Debarup Das from ICAR-IARI, New Delhi has presented a paper on changes in extractable potassium in soils due to potassium depletion and showed that NaTPB-1 h method is superior to NH_4OAc in terms of monitoring the soil-K status under exhaustive K-depletion.

Dr. S. Hota from ICAR-NBSS and LUP, Regional Centre, Jorhat, Assam has presented a paper on investigation of pedogenesis through clay mineralogy of the lower Brahmaputra valley of Assam at foothills of Meghalaya plateau and showed that on the side slope of the inselbergs, with similar parent mineralogy and less intense weathering, soils were classified into *Typic Hapludalfs*, indicated higher proportion of the 2:1 clay mineral.

Dr. Jaymeet Solanki from Krantiguru Shyamji Ktushna Varma Kachchh University has presented a paper on geochemistry, mineralogy, and genesis of kaolin deposits of Kachchh, Western India and its diverse industrial application and showed that kaolin could be potentially used in ceramics, cosmetics, rubber, plastic, paints, and paper industries.

Dr. P. Tiwary from ICAR-NBSS and LUP has presented a paper on influence of soil types and cropping systems on active and passive pools of soil organic carbon and suggested that the land use and or cropping systems have significant role in storing active pool of soil organic carbon.

Dr. D. Vasu from ICAR-NBSS and LUP has presented a paper on modelling the effect of climatic variables and land use changes on soil organic carbon in coastal soils and showed that land use significantly improved the soil organic carbon content in the coastal soils of Gujarat.

Poster presentation

A poster session was organized where 21 posters were presented by researchers from different parts of India. The posters were evaluated by an evaluation committee, who recommended the following candidates for the Best Poster Presentation Awards:

First: Dr. Priya Gurav, Scientist, ICAR-IISS, Bhopal, Madhya Pradesh (Title of the paper presented: Estimation of layer charge by using clay CEC in shrink-swell soils of India authored by Priya P. Gurav and S.K. Ray)

Second: Dr. Shayani Khan, Sr. Geologist, Geological Survey of India, Kolkata, West Bengal (Title of the paper presented: Mineral Resource Assessment from Sediment and Soil Geochemical Study- An Example from the Kanker Granites, Bastar Craton, India authored by Sayani Khan, Sanjukta Mahanta, Sneha Bhaumik and Priyanka Jha).

Third: Md. Basit Raza, Ph.D. Scholar, Division of Soil Science and Agricultural Chemistry, ICAR-IARI, New Delhi (Title of the paper presented: Performance of bentonite supported nano scale zero valent iron for remediation of arsenic contaminated water authored by Md. Basit Raza, Siba P. Datta, Mandira Barman, Debasis Golui, Prasenjit Ray).

Technical Session-III: "Soil Resources, Soil Health and Environment Quality"

Chairman: Dr. B.P. Bhaskar, Director, ICAR-NBSS & LUP, Nagpur

Co-Chairman: Dr. S. Mukhopadhyay, IACR- NBSS&LUP, Regional Centre, Kolkata

Rapporteur: Dr. K. Karthikeyan, Senior Scientist, ICAR-NBSS&LUP, Nagpur

The session was chaired by Dr. B.P. Bhaskar, Director, ICAR- NBSS&LUP, Nagpur and co-chaired by Dr. S. Mukhopadhyay, Pr. Scientist, ICAR- NBSS&LUP, Kolkata. Dr. K. Kartikeyan was the rapporteur of the session. The session was commenced with lead lecture by Dr. D.K. Pal, Former Pr. Scientist & Ex Head, Div. of SRS, ICAR- NBSS&LUP, Nagpur and Visiting Scientist, ICRISAT, Hyderabad. A total of 26 oral presentations has been delivered. Dr. D.K. Pal delivered the lead lecture on the topic "A mechanistic review: pedogenic processes derived plant available water capacity for rain fed deep rooted corps in Indian Vertisols- A pragmatic method". In his lead lecture, Dr. Pal briefly illustrated that PAWC as a unique biophysical property which can act as a guiding principle for the deep-rooted corps in semi-arid tropic areas of Indian Vertisols and can be applied as a useful parameter for further refinement of agro-ecological sub-regions in SAT Vertisols.

A total of 26 oral presentations were delivered by the scientists. Characterization of soils of Rajmahal trap has been described by Dr. T Chattopadhyay. Formation of Vertisols (Typic Haplusterts) and vertic intergrades (Vertic Haplustepts) were reported to be formed in undulating plains of Rajmahal trap with COLE value ranging from 0.09 to 0.12. Dr. B.N. Ghosh explained optimum soil organic carbon estimation in terrain region of West Bengal. He showed that 25.8% areas of the Mal block of Jalpaiguri district in different land use could not sequester @ 4 per thousand under present land use, soil and input management practices indicating prioritization of conservation agriculture. This study implies to address the saturation deficit of SOC for soil and C input management for increased carbon sequestration to combat climate resilient agriculture.

Impact on traditional land use management on soil quality of NER of India has been exhibited by Dr. S.K. Reza. In this endeavor, PCA with multiple correlation analysis showed that organic carbon (OC), sand, clay, available P and available S emerged as the MDS for soil quality indicators. Results indicated that jhum cultivation had a significantly lower SQI compared to other land-uses for all soil depths. The low values of SQI in the jhum land may be due to the non-scientific methods adopted in jhuming that caused a decline in soil quality indicators lower than even agriculture.

Dr. S. Bandyopadhyay explained assessment of soil quality index in a topo sequence of A&N Islands towards climate resilient land use plan. PCA analysis based minimum data sets (MDS) for surface soils were selected as CEC/ Clay, Silt/ Clay, Available N, Available P and SOC, whereas, Fine Sand/ Coarse Sand, CEC, Weathering Index (IW) and ratio of Exch. Ca^{2+}/ Mg^{2+} were the MDS for sub surface soils. SQI values were used to prioritize soil series in different topographical locations based on their scoring and also for suitability for crops to address best possible agricultural land use options by adapting the adverse and fragile climatic environment in the Islands. Chitrakut and Kalipur Series (coastal plains) had lower SQI and were restricted to limited number of crops. These soils may be protected by high density mangrove plantation, agro-forestry with beetle nut and coconut and land shaping techniques like raised bedded farming system for Rabi crops as promising soil conservation measures.

Soil organic carbon pool under major cropping system of Purna valley, Maharashtra has been emphasized by Dr. R.K. Naitam. The soybean-chickpea cropping system registers the

highest SOC stock in the first 30 cm soil depth and a higher percentage increase in SOC stock found in green gram-pigeon pea cropping system.

Dr. Prasenjit Ray delivered lecture on assessment of suitability of different extractants for predicting available micro-nutrients in acid soils of North East India. the study indicated that the solubility-free ion activity model as a function of pH, organic carbon and extractable micronutrients was also effective in predicting the availability of micronutrients in the studied acid soils. Such results indicate the need of revisiting the methods for assessing the availability of micronutrients in acid soils.

Stability of carbon in rice based and non-rice based cropping systems of IGP has been explained by Dr. Ruma Das. The C stability was decreased from surface to sub-surface layer of soils. The clay mineralogy and silt content played significant role on C stability and its mineralization in soils. The variation of cropping system significantly influences the stabilization mechanisms of C in soil.

Dr. Abir Dey discussed possible effect of phosphate released from crop residues and fertilizers on soil aggregates fractions and its stability under maize-wheat cropping system. The results showed that P fertilization did not showed any significant effect on soil aggregation, however the retention of crop residues improved the percentage of macro-aggregates and consequently reducing the micro-aggregate size fractions.

Ms. Deepasree presented the experimental results about soil aggregation, soil carbon fractions and soil aggregate associated carbon under different perennial horticultural crops. A decrease in the aggregate associated carbon content with decrease in the aggregate size fraction was observed in all the orchards. Among the orchards, macro-aggregate associated carbon was found to be highest in guava orchard followed by Bael, while carbon associated with micro-aggregate and silt+ clay was highest in Bael.

Smart delivery of nitrate and synthetic auxin in nitrogen use efficiency in upland rice has been explained by Dr. D. Chatterjee. The study revealed that smart delivery of nitrate and synthetic auxin can be more promising as a fertilizer source than delivery without auxin for upland rice.

SQI under mango growing belts of South Karnataka has been illustrated by Dr. Kaushik Saha. Nagamangala in the central dry zone (CDZ) had significant constraints regarding soil depth and inherent soil quality for growing deep-rooted mango cultivars. The relationship between yield and soil quality suggests that NLSF is preferable to LSF and weighted index was determined to be more practical Over additive index, particular to these red ferruginous soils in semi-arid climate zones.

Dr. Sanjib Kar explained assessment of potassium tool by Q/I ratio in rice growing soils of India. The changes of Q/I parameters are associated with the contents of clay, organic matter and clay mineralogy of the soil. High exchangeable cation in soil matrix and higher cation exchange capacity (CEC) favours labile K, specific K and specific K sites. Equilibrium activity ratio of potassium increases with decreasing free energy change as well as increasing CEC and exchangeable cations.

Dr. KK. Maurya explained soil quality assessment under different land uses in North East India. He depicted that Soil organic carbon (SOC) was observed to be most influencing soil quality indicator under studied land uses and on an average OC contributed 47 and 40% in SQIw in 0-20 and 0-70 cm depths, respectively.

Mr. Amresh Chaudhary demonstrated the effects of long-term tillage, residue management and cropping systems on soil biological health of rainfed pearl millet-based cropping systems of North-western India. The results clearly indicated a better soil biological health under conservation agriculture compared with conventionally tilled soils under rain-fed conditions.

Micro morphological indicators of climate change and their implication in BSR and IGP soils has been explained by Dr. UK Maurya. He emphasized that vaious pedo-features provide evidence of active neo-tectonic / non-pedogenic stress during the pedogenesis. Impact has also been assessed in voids having different shape, size and arrangement in soil matrix in similar climate of BSR and IGP. Based on their position in soil matrix voids were categorised as inter-aggregate, intra-aggregate and trans-aggregate.

Dr. Somsubhra Chakraborty delivered lecture on Agriculture 5.0: Characterizing soils with AIML. The present framework consists of multiple proximal soil sensors, both optical and electrochemical, and AIML-based solutions. Since these traditional soil testing protocols were used to shape the understanding of soil systems, there is a scope for developing advanced analytical methods for a comprehensive understanding of the physical and chemical dynamics of the soil.

Debrup Ghosh explained impact of Silica rich crop residues in on phosphorus release in soils. He illustrated that the effect of the Si-rich crop residues on native-P release was noticeably higher in the alkaline alluvial soil than the other. Hence, the application of Si-rich crop residues could be an economic way to increase P availability in soils.

All the deliberations were discussed critically by the house for improvement. Dr. Pal stressed on evaluating suitable criteria for minimum data sets in assessment of soil quality index (SQI) in varying agro-ecology. The session was concluded with formal vote of thanks by the Co-Chairman.

Major Recommendations of the Conference:

- Soil micromorphology and clay mineralogy needs to be studied in detail in relation to paleopedology and geomorphology, for a better understanding of landscape stability
- Detailed studies need to be undertaken for the identification and assessment of different technologies for organic and inorganic carbon sequestration in soils varying in clay mineralogical makeup in the context of climate change
- More research work should be carried out on different aspects of nano-clays for multi-dimensional applications in the field of agriculture and allied sciences
- Research collaborations between fertilizer industries and academic institutes should be promoted for the development of novel and effective clay-based and(or) nano-fertilizer materials with high nutrient use efficiency.

- Development and evaluation of clay-based products should be carried out on a larger scale for the remediation of polluted soil and water.
- The clay mineralogical studies should be re-oriented towards maintenance and improvement of soil health for a sustainable future of Indian agriculture.

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