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A Study on Physico Chemical Properties of the Soil in the Gautham Khani Open Cast Mine Kothagudem Coal Fields Region, Telangana

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Abstract

The soil quality refers to a broad range of physical, chemical, and biological characteristics that maintain environmental quality, productivity, and microbial proliferation, the soil samples are collected from Gautham Khani Open Cast Mine it was located in Goutampur Village, Chunchupalli Madal, Badradri Kothagudem District in Telanagan State. The texture of the soil sample, physical properties like bulk density, porosity, water holding capacity as well as chemical properties like pH, electrical conductivity, organic carbon and macronutrients like N, P, K are analysed in the soil samples, As a result, the study analyzed soil samples and observed that study area soils need the restoration to improve the soil quality In order to evaluate the condition of the soil in coal mining sites for reclamation methods.

Keywords:* *Soil quality, physic chemical, Texture, Macronutrients, Mining, Coal fields

I. INTRODUCTION

Soil influences vegetation development supported by microbial growth and mineralization, decomposition of organic matter (De deyn *et al.*, 2004; Kardol *et al.*, 2006), and thereby undergoing paedogenesis leading to soil fertility and quality. According to Doran et al. (1996) and Karlen et al. (1997), the soil quality refers to a broad range of physical, chemical, and biological characteristics that maintain environmental quality, productivity, and microbial proliferation. Evaluation of physico-chemical indices has the potential to serve as sensitive and early indicators of both ecosystem recovery and soil quality (Mummey et al., 2002; Xia and Cai, 2002; Maharana and Patel, 2013). The primary environmental implications of mining are reduced biotic diversity, altered ecosystem structure and function, and altered soil stratification; these changes ultimately impact trophic interactions, water and nutrient dynamics (Ghose 2004). Coal mining can be responsible for soil and water contamination, ecological deterioration, and human health risks (Bhuiyan et al., 2010, Ward et al., 2011, Fdez Ortiz et al., 2017, Zerizghi et al., 2022), mining wastage disrupts the soil fertility components, altering water quality and affecting vegetation leading to destruction of vast amounts of land. These operations convert fertile land into wasteland and pollute land, air and water. Presently, 119 abandoned coal mines exist in about 2.13 million hectares of coal reserves in In-dia. Land degradation due to coal mining operations is reported to be at the rate of 4 ha per million tonne of coal production. At this rate, coal mining operations alone would continue to render more than 1400 ha unproductive every year (CMPDI 2012). An indicator of environmental pollution is the quality of the soil. The area's water quality, soil structure, and nutrient availability are all impacted by soil contamination. This has a variety of knock-on effects on the growth of flora and wildlife. The disposal of industrial, mining, and residential solid wastes are the main causes of soil pollution (Singh and Singh 2004). While coal mining is necessary for a nation's economy to flourish, it also degrades the environment (Prathap et al, 2016). Degradation of soil fertility due to nutrient depletion, mostly from erosion and/or crop removal, is one of the problems facing agricultural systems. According to Van Veen and Kuikman (1990), the main element governing microbially mediated processes of organic matter decomposition in terrestrial ecosystems is the soil structure. Assessments by Ladd et al. (1976) and Van Veen et al. (1985) indicate that soil texture is the primary feature of the soil that affects the variability in carbon (C) and nitrogen (N) turnover. The most noteworthy distinctions between sandy and clay soils are these. The organic matter content and texture of the soil are factors that affect its fertility, resilience, and texture (Ajayi, 2017). When contrasting soils with consistent textures with those with medium and coarse textures, one of the key elements influencing crop yield regulation is soil fertility. In the context of sustainable agricultural production, soil characterisation is crucial for assessing the fertility state of a certain area or region's soils. The response (production) efficiency of chemical fertilizer nutrients in intensive agriculture has drastically decreased in recent years due to imbalanced and insufficient fertilizer use combined with low efficiency of other inputs (Meena et al., 2006). The physical-chemical characteristics of soil, such as pH, electrical conductivity, organic carbon, and calcium carbonate, have a significant role in determining the availability of vital nutrients for crop growth. By managing these characteristics well, soil can provide an increased amount of vital nutrients.

II. MATERIALS AND METHODS

Study area

As per the topo sheets No. 65-C/11, the Gautham Khani Open Cast Mine was located in Goutampur Village, Chunchupalli Madal, Badradri Kothagudem District in Telanagan State. The latitude range for the mine was $17^0$26'18.09" to $17^0$28'11.27". The maximum depth of the quarry is 240 meters below the bottom seam, with an excavation area of roughly 363.90 hectares on the surface. The Gauthamkhani Open Cast Mine is located around 12 kilometres from Kothagudem Town by road and is a component of the Kothagudem Coal Fields in the Kothagudem Region. The block lies between $17^0$26'18.09" and $17^0$28'11.27" in North Latitude and $80^0$37'32.7" and $80^0$40'2.12" in East Longitude. The Bolligutta hill is next to the project. Topography ranges in elevation from 154.1 m above mean sea level to 186.83 m above mean sea level.

Methodology

Soil samples

Soil samples were collected at five sampling stations within the study area (Table.1). Samples were taken at depths of 15 cm using an auger, the quadrant technique is used by dividing a mixed sample into four parts, separating the two opposing parts, remixing the remaining two parts, and repeating this process until the desired sample size is achieved and passed through 2 mm sieve. It was done. Samples were collected in polythene bags and labelled with collection location, date (and time). Only 0.5 kg of the sample was taken for soil analysis (Babu et al., 2023).

Examination of Physico-Chemical Factors in soil samples

`Physical properties like bulk density, particle density, pore space, and water holding capacity were used in the study of the soil samples, as well as chemical properties like pH, electrical conductivity, organic carbon (Mishra 1968), and macronutrients like N, P, K. (Jackson 1973). The textural class of the soil was ascertained using a hydrometer (Bouyoucos, 1927). Muthuval et al. (1992) employed the graduated measuring cylinder method to compute the water holding capacity (Mishra 1968), bulk density, and particle density. A digital pH metre was used to determine pH following the creation of a 1:2.5 soil-water suspension (Jackson, 1973). Electrical conductivity was estimated using digital conductivity meters. The fraction of organic carbon was determined by wet oxidation. Available phosphorus was measured using Bray's extraction method. Available potassium was measured using neutral normal ammonium acetate extraction followed by the flame photometric method, available nitrogen was estimated using the alkaline potassium permanganate method using the Kjeldahl apparatus.

The texture of the soil sample was determined by feeling or rubbing it between the thumb and fingers (Ghose et al., 1983). Mastery is quickly gained through a combination of trial and error and comparison with samples from the same textural class. Numerous physico-chemical characteristics, such as pH, porosity, density, phosphorus, nitrogen, potassium, etc., were investigated using accepted analytical methods (Jaiswal, 2004; Gupta, 2004). In addition, the organic carbon content of the soil was determined through the application of the Walkley-Black Method (Walkley and Black, 1934).

III. RESULTS AND DISCUSSION

The distribution of grain sizes is crucial to the establishment of the overburden dump materials in plants. It is crucial to the preservation of the overburden dump materials' bulk density. in five samples Thippanpalli Village (65.50%), Pengadapa (65.50%), GKOCP (33.44 %), Sitampeta (53.44 %), Penuballi (43.44%) (Table-2 & Fig-1), it indicates sand percentage was high indicating poor quality for plant growth Sand fraction in waste materials is caused by sandstone breaking down. Because there are more sand particles in the overburden samples, water can infiltrate the dump materials through a process known as infiltration (Ghose, 2004). While silt is easily removed and transported, its size is in between that of sand and clay. Clay distribution is Thippanpalli Village (25.76**%),** Pengadapa (30.56**%),** GKOCP (46.56 %), Sitampeta (12.56%), Penuballi (32.56%), the silt distribution is Thippanpalli Village (8.74**%),** Pengadapa (3.94**%),** GKOCP (20.0 %), Sitampeta (34%), Penuballi (24%) (Table-2 & Fig-1) a smaller percentage of clay materials include a large number of microspores, which allow water to enter the dump materials extremely slowly. According to Han et al. (2010), soil that has more than 50% stoniness should be classified as poor quality. The clay percentage is high in sample site 3 where the silt and clay percentage is slightly low due to that bulk density is moderate by the influence of the water holding capacity and porosity of the soils. The water holding capacity and porosity parentages are varies in the study area Thippanpalli Village (45.30%, 50.49%), Pengadapa (43.00%, 55.47%), GKOCP (35.00%, 39.89%), Sitampeta (50.00%, 60.43%), Penuballi (46.00%, 47.86%) indicated in table 2 & fig: 2.The bulk densities of the soil samples ranged from 0.94 to 1.18 gm/cc. The Sitampeta sample has the lowest recorded bulk density of 0.94 gm/cc. The high level of organic materials found in the dump samples could be the cause of this (Leelavathi et al., 2009). Because it controls the amount of space, air, and water available to soil microbes, bulk density is important (Foissner, 1992). Because of the growth of soil micropore space, the decrease in bulk density can be understood as a decrease in soil compactness (Ohta and Effendi, 1992). Since the clay fraction ultimately determines the bulk density of the soil, a rise in clay fraction levels helps the soil's micro pore space to expand and lower bulk density, soil types and land use may have an impact on bulk density (Han et al., 2010).

More organic C can be stored in soils (Ajayi, 2017). Significant variations in the amount of organic carbon accumulated in recovered mine soil can arise from even minor variations in the percentage of clay (Chodak and Niklinska, 2012). Reduced rates of mineralization in the dump samples and the loss of organic carbon, which contains nitrogen and nitrogen-fixing microbes, were the reasons for the decreased total N values in the mining site (Rai et al., 2010).

The pH range from 7.1 to 7.8 it indicates the soils are neutral condition and slightly alkaline in nature but the soils are supported to the plantation and cultivation in the study area (Table-3). Electrical conductivity (EC) is a commonly used indicator of salinity in dump materials. It shows how well an aqueous solution can conduct an electric current. The chemistry of the dump materials is determined by the composition of the rocks; limestone, for instance, has a higher EC due to the dissolution of carbonate minerals in the dump particles. Saxena (1989) proposed that in mine soil, EC values less than 4 dS/m might be considered good for plant growth, EC values between 7 and 8 dS/m might be accepted as fair, and soil/spoil with an EC value of 8 dS/m should be considered of poor quality, the Electrical conductivity range from the 0.324 mmhos/cm to 0.378 mmhos/cm EC values are average in the study area, the sodium absorption ratio level are varies from 0.038 to 0.04 and the organic carbon percentage is in the 0.45 % to 0.65 % it is in medium level, and the Cation Exchange Capacity which was found to be in the range of 8.2 to 11.6 meq%. The soils required for reclamation by re vegetation to improve the organic content (Prathap et al, 2016). According to Ajayi (2017) organic carbon is a measure of the productivity of dump materials and the quantity of carbon that is broken down from plants and animals and deposited in soil. The lower values were caused by the lower amounts of salts found in the dump samples at Site V. According to Ghose et al. (1983), soil or waste quality that has an organic carbon content of more than 0.8% is considered good, while less than 0.4% is considered low quality.

The Nitrogen value range from 188 to 213 kg/ha- reflecting that the values are observed to be in better category. The minimum value was observed at Pengadapa and Penuballi, and the maximum value was observed at GKOCP. As per the table -4 The Phosphorus value ranged from 20 to 22 kg ha-1 indicating that the values are in medium category. The maximum value of 22 kg ha-1 was found at GKOCP and Penuballi, The normal value of phosphorus in the soil should be 22.5 to 56 kg ha-1 (Gupta et al., 2006), (Fig-3), the Potassium value ranged from 260 to 393 kg ha^{-1} indicating that values are observed to medium to high category, the maximum value was found at Thippanpalli and the minimum value was observed at Sitampeta. According to Gupta et al. (2006), the typical potassium content of alluvial soil ranges from 136 to 337.5 kg ha-1 (table4 & fig-3). In several projects within the research area, the potassium content rose from the uppermost layer to the lowermost area. An essential component of raising soil fertility is the amount of nitrogen that is accessible. Normal soil typically has an accessible nitrogen content of 272–544 kg ha-1 (Gupta et al., 2006), Maharashtra's soils ranged in potassium content from 318.0 to 616 kg ha-1. Waikar & Associates (2004), the lowest levels were discovered for exchangeable K content, total nitrogen, accessible phosphorus, and soil organic carbon (Makdoh and Kayang, 2015). Singh et al. (2004) provided similar results (Dadsena et al. 2021). These soils need to be fertilized immediately and need to be provided with sulfur. Patil & Associates (2000).

Table: 1. List of Soil Sampling Locations

S.No	Sample code	Latitude	Longitude
S-1	Thippanpalli Village	17°24'31.0"	80°38'25.1"
S-2	Pengadapa	17°27'50.0"	80°40'14.6"
S-3	GKOCP	17°27'32.6"	80°38'21.3"
S-4	Sitampeta	17°28'24.4"	80°35'52.0"
S-5	Penuballi	17°32'26.1"	80°39'14.7"

Table: 2. Physical Parameters of the soil samples

S.No	Sampling Stations	Particle Size Distribution			Water Holding Capacity	Porosity	Bulk Density
		Sand %	Silt %	Clay %	%	%	gm/cm^3
1	Thippanpalli Village	65.50	8.74	25.76	45.30	50.49	1.0
2	Pengadapa	65.50	3.94	30.56	46.00	55.47	1.18
3	GKOCP	33.44	20.0	46.56	35.00	39.89	1.13
4	Sitampeta	53.44	34	12.56	50.00	60.43	0.94
5	Penuballi	43.44	24	32.56	43.00	47.86	1.10

Figure: 1. Soil Particle Size Distribution

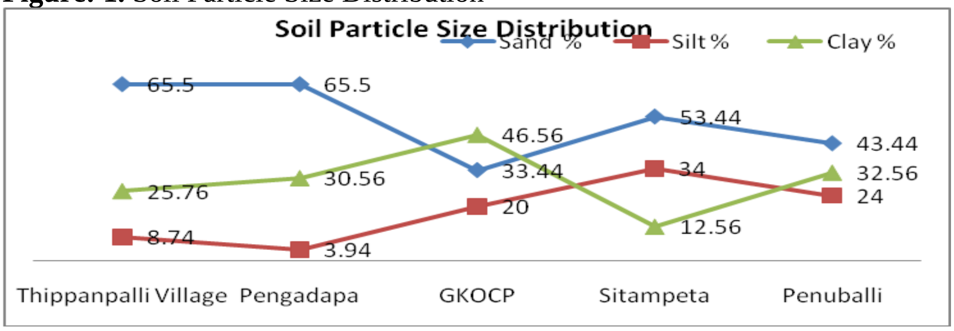


Figure:2. Soil porosity and Water holding capacity

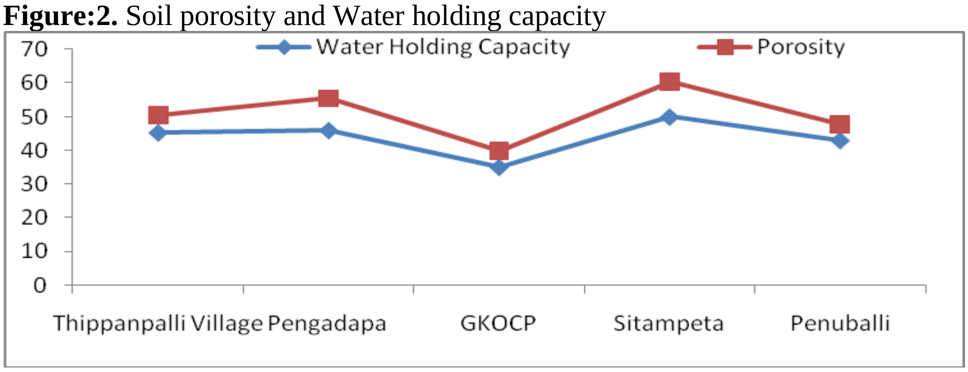


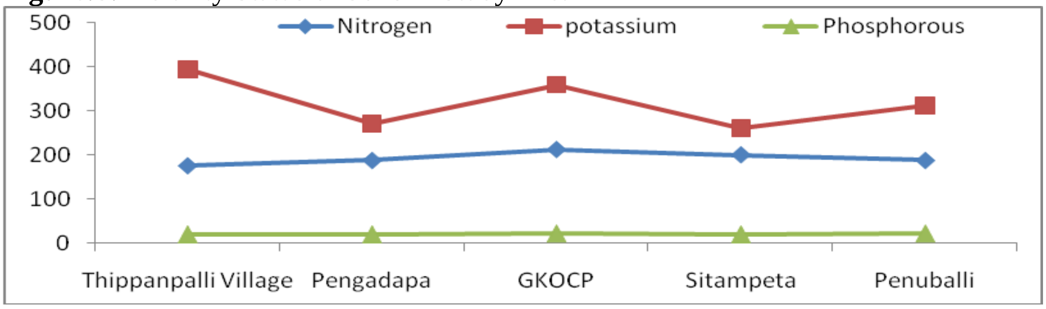
Table: 3. Chemical Characteristics of Soil Extract

S.No	Sampling Stations	pH	EC (mmhos/cm)	CEC (meq%)	SAR	Organic carbon %)
1	Thippanpalli Village	7.1	0.329	10.5	0.04	0.51
2	Pengadapa	7.5	0.324	8.2	0.04	0.45
3	GKOCP	7.8	0.378	11.6	0.04	0.65
4	Sitampeta	7.4	0.356	10	0.038	0.58
5	Penuballi	7.1	0.378	12	0.042	0.49

Table:4. Fertility Status of Soils in Study Area

S.No	Sampling Stations	Available Nitrogen (Kg/Ha)	Available Phosphorous (Kg/Ha)	Available potassium (Kg/Ha)
1	Thippanpalli Village	176	20	393
2	Pengadapa	188	20	271
3	GKOCP	213	22	358
4	Sitampeta	201	20	260
5	Penuballi	188	22	311
	Soil Limits	Better	Medium	Medium to high

Figure:3. Fertility Status of Soils in Study Area



IV. CONCLUSION

On the basis of physicochemical analysis of soils in the study area The following observations have been made based on physicochemical investigation of the soils in the coalfield study area: Continuous coal mining operations in the coalfields under consideration have been determined to constitute a serious hazard to many environmental components due to the massive volume of coal mining wastes they produce. The residues left over from coal mining seriously contaminate the quality of the soil and destroy the natural environment over time. In the coalfield study area sampling sites, the parameters of moisture content, bulk density, pH, and electrical conductivity were determined to be within a moderate range for plant growth. When compared to typical soils, the concentrations of organic carbon, available nitrogen, available phosphorus, and available potassium were found to be low in all of the soil samples. As a result, the study analyzed soil samples and observed that study area soils need the restoration to improve the soil quality In order to evaluate the condition of the soil in coal mining sites for reclamation methods, more extensive research over bigger areas in other parts of the state is needed.

Declaration

Ethics approval & consent to participate and for Publication::
Not Applicable.

Competing interest
The authors declared no competing interest.

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V. REFERENCE

1. De deyn, B., Raaijmakers, C.E., and Van derputten, W.H. (2004), Plant community development is affected by nutrients and soil biota. Journal of Ecology. Vol-92, pp- 824-834.
2. Kardol, P., Bezemer, T.M., and Van derputten, G.W.H. (2006). Temporal variation in plant-soil feedback controls succession. Ecology Letters, Vol- 9, pp-1080-1088.
3. Doran, J.W., Sarrantonio, M., and Liebig, M.A. (1996). Soil health and sustainability. Advances in Agronomy. Vol-56: 1-54.
4. Karlen, D.L., Mausbach, M.J., Doran, J.W., Cline, R.G., Harris, R.F., and Schuman, G.E. (1997). Soil quality: a concept, definition, and framework for evaluation. Soil Science Society of America Journal.Vol- 61: 4-10.
5. Mummey, D.L., Stahl, P.D., and Buyer, J.S. (2002), Microbial biomarkers as an indicator of ecosystem recovery following surface mine reclamation. Applied Soil Ecology. Vol-21: 251-259.
6. Xia, H.P., and Cai, X.A. 2002. Ecological restoration technologies for mined lands: a review. Chinese Journal of Applied Ecology. Vol-13: 1471-1477.
7. Maharana, J.K., and Patel, A.K.(2013), Physico-Chemical Characterization and Mine Soil Genesis in Age Series Coal Mine Overburden Spoil in Chrono sequence in a Dry Tropical, Journal of Phylogenetics & Evolutionary Biology, Vol- 1: 101.
8. Ghose M.K.,(2004), Effect of opencast mining on soil fertility, *J. Sci. Ind. Res.,Vol*- 63, pp**-** 1006–1009.
9. Bhuiyan, M.A.H.; Parvez, L.; Islam, M.A.; Dampare, S.B.; Suzuki, S. (2010), Heavy Metal Pollution of Coal Mine-Affected Agricultural Soils in the Northern Part of Bangladesh. J. Hazard Mater. Vol**-**173, 384–392.
10. Ward, C.R.; French, D.; Riley, K.; Stephenson, L.; Farrell, O.; Li, Z. (2011), Element Leachability from a Coal Stockpile and Associated Coastal Sand Deposits. Fuel Process. Technol, Vol- 92, 817–824.
11. Fdez-Ortiz de Vallejuelo, S.; Gredilla, A.; da Boit, K.; Teixeira, E.C.; Sampaio, C.H.; Madariaga, J.M.; Silva, L.F.O. (2017), Nano minerals and Potentially Hazardous Elements from Coal Cleaning Rejects of Abandoned Mines: Environmental Impact and Risk Assessment. Chemosphere, Vol-169, 725–733.
12. Zerizghi, T.; Guo, Q.; Tian, L.; Wei, R.; Zhao, C. (2022), An Integrated Approach to Quantify Ecological and Human Health Risks of Soil Heavy Metal Contamination around Coal Mining Area. Sci. Total Environ. Vol-814, 152653.
13. CMPDI, CMPDI survey report, Central Mine Planning & Design Institute, Ranchi, 2012
14. Singh V. and Singh T.N., (2004), Environmental impact due to surface mining in India, *Minetech*,Vol-25, pp-3-7.
15. Prathap A, Kujur V, Chakraborty S, Bhattacharya T. (2016), Assessment of soil characteristics in the vicinity of open cast coal mine and its suitability for vegetative reclamation in Charhi and Kuju of Jharkhand, India. J Environ Biol. Vol-37(4):523-8. PMID: 27498496.
16. Ghose, A.B., J.C. Bajaj, R. Hassan and D. Singh (1983), Soil and water testing methods: A laboratory manual. Indian Agricultural Research Institute, New Delhi, India. pp. 11-22.
17. Van Veen, J.A, Kuikman, P.J (1990). Soil Structural Aspects of Decomposition of Organic Matter by Micro-Organisms. Biogeochemistry, Vol-11, 213–233.
18. Ladd, J.N.; Amato, M.; Parsons, J.W. (1976), Studies on nitrogen immobilization and mineralization in calcarerous, soils-III. Concentration and distribution of nitrogen derived from the soil biomass. In Proceedings of the IAEA/FAO/SSF Symposium, Braunschweig, Germany, 6–10, pp. 301–310.
19. Van Veen, J.A.; Ladd, J.N.; Amato, M. (1985), Turnover of carbon and nitrogen through the microbial biomass in a sandy loam and a clay soil incubated with (14C (U)) glucose and [15N](NH_4) $2So_4$ under different moisture regimes. Soil Biol. Biochem., Vol-17, 747–756.
20. Ajayi, A. (2017), Biochar-Induced Changes in Soil Resilience: Effects of Soil Texture and Biochar Dosage. Pedosphere, Vol-27, 236–247.
21. Meena, H.B., R.P. Sharma, and U.S. Rawat (2006), Status of macro and micronutrients in some soils of Tonk district of Rajasthan. Journal of Indian Soc. Soil Sci. Vol-54(4): 508-512.
22. Babu K, Sudhakar G, Nirmala P. V. (2023), Heavy Metal Analysis in Agricultural Soils in Godavari River Basin of Rajahmundry Region, East Godavari District, Andhra Pradesh, India. Current Agricultural Research, Vol-11(2). pp-587-602.
23. Mishra, R. (1968). Ecology Work Book. Oxford IBH, New Delhi.
24. Jackson, M. L., Soil Chemical Analysis, Prentice Hall of India, New Delhi, 1973
25. George Bouyoucos (1927), Rapid Determination of the Moisture Content of Soils notes, Journal of the American Society of Agronomy, pp-197-198.

26. Muthuval P, Udaysoorian C, Natesan R, Ramaswami PP.(1992), Introduction to soil analysis. Coimbatore: Tamil Nadu Agricultural University-641002.
27. Jaiswal, P.C.: Soil, plant and water analysis. Kalyani Publishers, Ludhiana, India (2004)
28. Gupta, P.K. (2004), Methods in environmental analysis: Water, soil and water. Agrobios, Jodhpur, India (2004).
29. Walkley, A. and I.A. Black: Determination of organic carbon in soil. Soil, Vol-37, 29-38 (1934).
30. Han, W., Hu, J., Du, F., and Zhang, X. (2010). Estimating soil organic carbon storage and distribution in a catchment of loess plateau, China. Geoderma. Vol-154: 261-266.
31. Leelavathi G.P., Naidu M.V.S., Ramavatharam N. and Sagar G.K., (2009). Studies on genesis, classification and evaluation of soils for sustainable land use planning in Yerpedu mandal of Chittor District, Andhra Pradesh. India, Environment. Phylogenetics and Evolutionary Biology. Vol-1(1): 2-7.
32. Foissner, W. (1992). Comparative studies on the soil life in eco-farmed and conventionally farmed fields and grassland of Austria. Journal of Agriculture, Ecosystems and Environment, Elsevier Science Publishers, Amsterdam, the Netherlands. Vol-40: 207-218.
33. Ohta, S., and Effendi, S. (1992). Ultisol of lowland *Dipterocarp* forest in east Kalimantan, Indonesia. Journal of Soil Science and Plant Nutrition. Vol-38: 197-206.
34. Chodak, M., and Niklinska, M. (2012), Development of microbial biomass and enzyme activities in mine soils. Polish Journal of Environmental Studies. Vol-21(3), pp-569-577.
35. Rai A. K., Paul B. and Singh G., (2010). Assessment of Top Soil Quality In The Vicinity of Subsided Area in Jharia Coalfield, Dhanbad, Jharkhand, *Report and Opinion*, Vol-2(9), 1-6.
36. Saxena M.M., (1989). Environmental analysis: water, soil and air, Agro Botanical Publishers, Bikaner, Rajasthan, pp 121140.
37. Gupta, S., T. Mallick, J.K. Datta and R.N. Saha (2006). Impact of opencast mining on the Soil and plant communities of Sonepur-Bajari opencast coal mine area, West Bengal, India. Vista in Geology, Vol-5, 194-198.
38. Waikar, S.L., G.U. Malewar, and S.D. More, (2004),.Elemental composition of Humic and Fulvic acid in soils of Marathwada region of Maharashtra. J. Maharashtra Agric. Univ. Vol-29 (2): 127-129.
39. Makdoh K and Kayang H, (2015). Soil physico-chemical Properties in Coal mining areas of Khliehriat, East Jaintia Hills District, Meghalaya, India, H2International Research Journal of Environment Sciences, Vol. 4(10), pp-1-10.
40. Dadsena R, Senger A, Singh C, Pradhan AK, Rao IP, Sahu KK, Porte SS, Khalkho D, Sahu RK. (2021), Soil fertility status of available nitrogen in soil through soil fertility mapping using GPS and GIS techniques of Champa district of Chhattisgarh state. The Pharma Innovation Journal, SP-10(12): 1536-1538.
41. V.Singh A.Lehri N.Singh (2018), Assessment and comparison of phytoremediation potential of selected plant species against endosulfan, International Journal of Environmental Science and Technology, doi.org/10.1007/s13762-018-1880-y.
42. Patil, V.D., C.V. Mali, G.U Malewar and P. B. Chalwade (2000), State level seminar on “Soil Health Management for Sustainable Agriculture” Akola chapter of Indian Society of soil science Dept. ACSS. Dr. PDKV Akola.