

Perpendicular Distribution of Macro Nutrients and Micronutrients of Ghatpipariya Village of Dhanora Block in Seoni district, Madhya Pradesh, India

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Abstract: A study was undertaken to evaluate the nutrient fame of soils of Ghatpipariya in Seoni district, Madhya Pradesh, India during the year 2018-19. A total of 5 Series Soil samples were collected from different physiography-Soil relationship namely Plateau, Escarpment, Pediments and Alluvial Plain and analyzed for pH, electrical conductivity, organic carbon, available nitrogen, available P₂O₅ and available K₂O, and available micronutrients (Zn, Mn, Fe & Cu) using standard analytical methods. Based of fertility ratings, pH of soils was neutral to moderately alkaline. Electrical conductivity of all the soils ranged from 0.07 to 0.26 dSm⁻¹ which are within the acceptable limit and the soils have no salinity hazard at present. Organic carbon content in soils ranged from 0.17 to 1.92 per cent in different horizons . Soils of Ghatpipariya -2 series have high organic carbon content, whereas, soils of Ghatpipariya -4, Ghatpipariya -5 series have low organic carbon content. The calcium carbone varied from 1.45 to 5.3 %. Cation exchange capacity of soils range from 39.1 to 62.6 cmol(p⁺)kg⁻¹. Higher CEC values were observed in soils of Ghatpipariya -4 and Ghatpipariya -5. Based on the fertility parameters the soils are low in available N, low to very high in available P and medium to very high in available K. similarly available micronutrients *viz.* Fe, Mn and Cu were high in all the soils, while, deficiency of available Zn was observed in the soils of Ghatpipariya -1, Ghatpipariya -2, Ghatpipariya -3, Ghatpipariya -4 and Ghatpipariya -5. Based on soil characterization and fertility analysis the information generated will help in sustainable development and to enhance the crop productivity.

Keywords: Soil fertility, Macro-nutrients, Micro-nutrients, Ghatpipariya

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1. Introduction

Agriculture is the most important sector, accounting for around 15% of national GDP and so serving as the backbone of the Indian economy. For their daily lives, fifty percent of the Indian population is entirely or largely reliant on agriculture and related activities (Amutha, 2013). (Sharma et. al., 2013) Soil, land, and water are the three basic elements that are vital for human life and agricultural development to be sustainable ((Das et al., 2009), (Chakraborty et al 2009). To

maintain healthy food, water, and environment for the present and future, researchers, administrators, and farmers must manage (Zhuo, et.al., 2021). Soil and water resources in a sustainable manner (Das, 1998; Kanwar, 2000). Soil, as a fundamental component of the universe, plays a critical function not only in the production of food, fodder, and fibre, but also in the preservation of environmental quality. (Prava,et. al., 2019), (Xiang Yu et. al., 2020). For ages, Asian farmers have followed a cultural system that ensures a consistent output as well as the required degree of soil fertility. During the 1960s, India began cultivating high-yielding

cultivars and increasing the use of chemical fertilisers, insecticides, and herbicides, among other things, in order to make the country self-sufficient in food grain production. (Debroy et al., 2020)

Though increased output assured the country's food security, extensive cultivation of high yielding cultivars and fertiliser use resulted in a decline in the use of organic manures, crop residues, and nutritional imbalance in the soils. (Lisnawati Y and Siregar C.A. 2019) The primary cause of the shortage is a lack of secondary and micronutrients, whereas the secondary cause is soil conditions that limit nutrient availability (Sharma & Chaudhary, 2007). As a result, determining the soil fertility state is necessary for the long-term usage of land to boost crop yield. Farmers are now using more chemical fertilisers and herbicides in order to enhance yields, as well as implementing continuous cropping with no fallow periods (Kumar et al., 2021), (Zhang & Zhang, 2007). The loss of soil organic matter (SOM) and stored nutrients as a result of intensive agriculture has been directly linked to productivity decline (Juo & Manu, 1996).

Knowledge of vertical distribution of plant nutrients in soils is useful, as roots of most of the crops go beyond the surface layers and draw part of their nutrient requirement from the sub surface layers. (Ingle et al., 2018, 2019) Soil profile characteristics as conditioned by different processes and factors of soil formation have great influence on soil fertility and crop productivity. Detailed and scientific study of soil profiles is immensely essential for understanding the prevailing soil forming (soil genesis) factors and processes, without a knowledge of which soil characteristics cannot be clearly interpreted (Vedadri and Naidu, 2018), (Medhe et al., 2012). The crop productivity cannot be boosted further without

judicious use of macro and micro nutrient fertilizers to overcome the existing deficiencies. Hence, a clear cut understanding of vertical distribution of plant nutrients in soil is highly necessary to suggest appropriate fertilizer schedule for different crops to obtain optimum yield. Variations in physiography greatly influence the availability and distribution of plant nutrients, both in surface as well as subsurface soils (Dorji et al., 2014). (Ramamurthy et al., 2009), (Singh and Misra, 2012, Ingle et al., 2019 Kuchanwar et al., 2021, Kuchanwar et al., 2022).

The Seoni district of Madhya Pradesh is experiencing frequent erratic rainfall with continuous depletion of vegetative cover and increase in soil erosion with low crop productivity. The information on detailed characterization of soils, soil fertility, particularly, in soils of Ghatpipariya village of Seoni district of Madhya Pradesh. The information will be of immense use for maintain the soil health for sustained agricultural production. Therefore, the present investigation has been planned to characterize and fertility of soils of Ghatpipariya village in Seoni district of Madhya Pradesh for sustained agricultural production.

2. Materials and Methods

The Ghatpipariya villages on basaltic terrain, lies between 22° 32' 47" to 22° 34' 22" N latitudes and 79° 44' 51" to 79° 46' 49"E longitudes in Dhanora block, Seoni district, Madhya Pradesh and covers an area about 480 ha. The villages are was separated into five major Landform units *viz.* plateau (P), Alluvial Plain (A), escarpments (E), isolated mounds (M) and pediments (D). The particular area varies from 503 to 564 m above from MSL (mean

sea level) accompanying with very gently sloping (1-3%) to strongly sloping (15-25%) lands.

The area under the study has a very typical sub-tropical climate with an average rainfall of 1100 mm with dominant in ustic soil moisture regime and hyperthermic soil temperature regime. The vegetation in this area includes evergreen as well as deciduous plant species including khair (*Acacia catechu*), babul (*Acacia arabica*), shivan (*Gmelina arborea*), behra (*Terminalia bellirica*), tendu (*Diospyros melanoxylon*), palas (*Butea monosperma*), neem (*Azadirachta indica*) and teak (*Tectona grandis*), etc. While the herbaceous crops include kural (*Heteropogon contortus*), kundu (*Setaria pilosum*), and dub (*Imperata cylindrica*). The kharif crop was dominant in this observed area including the commercial crops of pigeon pea (*Cajanus cajan*), ground nut (*Arachis hypogea* L), maize (*Zea mays*) cotton (*Gossypium* spp.), and soybean (*Glycine max*), similarly the main rabi crops were chickpea (*Cicer arietinum*) and wheat (*Triticum* spp.). Mango (***Mangifera indica***) and Guava (*Psidium guajava*) were the foremost fruit crop in the Villages level.

A total of Five Profile samples were collected covering the area of 480 ha the soil samples were further processed for physico-chemical observation. To determine organic carbon, the soil sample was sieved through a hundred mesh sieve (0.5 mm) (Walkley and Black, 1934). Soil pH was measured with a 1:25 soil water ratio. Soil available nitrogen ($\text{KMnO}_4\text{-N}$), phosphorus (Olsen-P), and potassium ($\text{NH}_4\text{OAc-K}$) were assessed as per the methodology given by Subiah and Asija, Olsen et al. (1954) and 1 N ammonium acetate, respectively. To determine CEC for calcareous soil and Non-calcareous soil, 1N sodium acetate (pH 8.2) and 1N sodium acetate (pH 7.0) were used,

respectively, by saturating the soil overnight. While Available micronutrient cations (Fe, Mn, Cu, and Zn) were extracted by DTPA- CaCl_2 extractant at pH 7.3. (Lindsay and Norvell 1978).

3. Results and Discussion

3.1. Chemical properties of study area

The data pertaining Table 1 indicate that the soils of the Villages are neutral to moderately alkaline with pH values ranging from 6.5 to 7.9. Based on pH values, the soils of the area have been grouped as neutral. (Ghatpipariya -2, Ghatpipariya -3), slightly alkaline and (Ghatpipariya -1, Ghatpipariya -4 and Ghatpipariya -5), moderately alkaline. Higher pH value in soils may be due to basalt as parent material, which is alkaline in nature (Chinchmalatpure *et al.* 2000) higher content of calcium carbonate and accumulation of soluble salts due to washing from upper elevation (Arnold and Venkateshwarlu, 1982).

The EC of soils is generally low and ranges from 0.07 to 0.26dSm^{-1} which are within the acceptable limit and the soils have no salinity hazard at present. The low EC value were observed in this soil may be due to leaching of salt from the surface layer of soil. Organic carbon content in soils ranged from 0.17 to 1.92 per cent in different horizons. Soils of Ghatpipariya -2 have higher organic carbon content, whereas, soils of Ghatpipariya -4 and Ghatpipariya -5 have lower organic content. In general, the organic carbon content decreased gradually with increase in depth, which is mainly due to the accumulation of plant residues on the soil surface and less movement down the profile due to rapid rate of mineralization at higher temperature and adequate soil moisture level. Similar results were observed by Sarkar *et al.* (2001) Nayak *et al.* (2001) Rao *et al.* (2008) whereas the Calcium carbonate in the soils varied from

1.45 to 5.3 per cent (Table 1). The distribution of calcium carbonate in soil profile invariably shows an increasing pattern with increasing soil depth, which indicates the process of leaching down of calcium and subsequent precipitation at lower depth due to high pH level. The results are in a present with that Pal *et al.* (1999) and Challa *et al.* (2000).

While The dominance of calcium and magnesium content on the exchange complex was observed in the soils of the village. The exchangeable cations were found in the order $\text{Ca}^{2+} > \text{Mg}^{2+} > \text{Na}^{+} > \text{K}^{+}$ indicating the presence of calcium bearing minerals in parent rocks. Similar results were reported by Sarkar *et al.* (2001) and Maji *et al.* (2005).

The exchangeable calcium content of the soils ranges from 20 to 34.5 $\text{cmol}(\text{p}^{+})\text{kg}^{-1}$. The exchangeable calcium content was higher in soils of Ghatpipariya -4 and Ghatpipariya -5. Exchangeable magnesium content of the surface soils ranges from 16.8 to 21.5 $\text{cmol}(\text{p}^{+})\text{kg}^{-1}$. Exchangeable sodium ranges from 0.57 to 0.58 $\text{cmol}(\text{p})\text{kg}^{-1}$. Exchangeable potassium ranges from 0.15 to 0.21 $\text{cmol}(\text{p}^{+})\text{kg}^{-1}$. Accordingly Cation exchange capacity of soils range from 39.1 to 62.6 $\text{cmol}(\text{p}^{+})\text{kg}^{-1}$. Higher CEC was observed in soils of Ghatpipariya -4 and Ghatpipariya -5 compared to Ghatpipariya -1, Ghatpipariya -2 and Ghatpipariya -3. Pal and Deshpande (1987) stated that higher CEC values in black soils were due to smectite type of clay mineralogy.

3.2. Nutrient Status and Soil fertility

3.3. Available Macronutrient

Soil fertility status exhibit the status of different soil with regard to amount of nutrient essential for plant

growth. The data pertaining Table 1. The available soil nitrogen content of the surface soils ranges from 107 to 390 kg ha^{-1} and found low in soils of Ghatpipariya -1, Ghatpipariya -2 and Ghatpipariya -3 and medium in soils of Ghatpipariya -4 and Ghatpipariya -5. The available nitrogen was higher in surface soils as compared to subsoil layers. This might be due to the higher content of organic carbon in surface soils. Similar results were reported by Sharma and Bali (2000) and Todmal *et al.*, (2008).

The available phosphorus content of the surface soils varied from 7.9 to 34.3 kg ha^{-1} . indicate that soils of Ghatpipariya -1 is low, moderately high in soils of Ghatpipariya -2 and Ghatpipariya -5 and high in soils of Ghatpipariya -3 and Ghatpipariya -4. The phosphorus content is seen to be increasing with reduction in slope and elevation. Higher phosphorus content in soils of pediment and valley may be attributed to higher clay content in these soils and the declined trend of phosphorus with depth may due to higher fixation of available P by clay. Similar findings were reported by Todmal *et al.* (2008).

The available potassium content of the surface soils varied from 342.4 to 492.8 kg ha^{-1} . The soils of soils of Ghatpipariya -1, Ghatpipariya -2, Ghatpipariya -3, Ghatpipariya -4 and Ghatpipariya -5 are very high in available K. The potassium content also increased with the clay content. This may be attributed to the K-rich minerals occurring in the soil (Pal, 1985) and the relative immobility of this element on account of fixation by clay. Most of the surface soils had higher available potassium content which might be due to more intense weathering of potash bearing minerals, generation of leaf litter from different crops in cropping systems, release of labile K from organic residues, application of K fertilizers and

upward translocation of K from lower depth with capillary rise of ground water (Hirekurbar et al., 2000 and Patil et al., 2008).

3.4. Available Micronutrient

The data pertaining Table 1. The DTPA extractable Fe ranges from 11.1 to 33.6 mg kg⁻¹ and found to be much higher than the critical level of 4.5 mg kg⁻¹ (Lindsey and Norvell, 1978) in all the soils. The high Fe content was due to presence of mineral like feldspar, haematite, magnetite and limonite which together constitute bulk of rock in this soil Phiarande *et al.* (1996) and Abraham *et al.* (2011). The DTPA extractable Mn content varies from 10.1 to 43.1 mg kg⁻¹ and found to be much higher than the critical level of 3.0 mg kg⁻¹ (Takkar *et al.* 1989 in all the soils. Mn deficiency usually does not occur in black soils because a sizeable portion of Mn is bound with manganese oxide which may be readily available (Singh, 1988) Cu content of the soils varies from 2.3 to 6.4 mg kg⁻¹ and decreased with depth. The Cu content is higher than the critical value of 0.2 mg kg⁻¹ (Katyal and Randhawa, 1983) in all the soils. The copper content could be attributed to difference geology, physiography and degree of weathering in these soil similar result were observed in Kirmani *et al.* (2011). Zn content of the soils varies from 0.15 to 0.59 mg kg⁻¹. The soils of Ghatpipariya -1, Ghatpipariya -2, Ghatpipariya -3, Ghatpipariya -4 and Ghatpipariya -5 showed zinc deficiency against critical level of 0.6 mg kg⁻¹ (Katyal and Randhawa, 1983; Sharma *et al.* 1996) and need to be supplemented. The high deficiency status of Zn might be due to the formation of Zn-phosphates following large applications of P fertilizer as well as the formation of complexes between Zn and organic matter in soils with high pH and high organic matter content or because of large applications of organic manures and crop residues (Kavitha and Sujatha,

2015). Hence, their solubility and mobility may decrease resulting in reduced availability. According to Singh *et al.* (2016) zinc uptake by plants decreases with increased soil pH. Uptake of zinc also is adversely affected by high levels of available phosphorus in soils (Pulakeshi *et al.* 2012).

4. Conclusion

In the current study, the soil test report values are used to classify several significant soil features like village wise soil fertility indices of available Nitrogen (N), Available Phosphorus (P), Available Potassium (K), Organic Carbon (OC) along with Micronutrient like Fe, Mn, Zn, Cu as well as the parameter Soil Reaction (pH), CEC and CaCO₃. The classification and prediction of the village wise soil parameters aids in reducing wasteful expenditure on fertilizer inputs, increase profitability, save the time of chemical soil analysis experts, improves soil health and environmental quality.

Table 1 : Soil Chemical properties and available Macro and Micronutrient status of the study area.

Hori - zon	Depth	pH	EC	O.C	CaCO ₃	Exchangeable cations				Sum of cation s	CE C	Available nutrients						
						Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺			N	P	K	Fe	Mn	Cu	Zn
	(cm)	(1:2.5)	(dS m ⁻¹)	(%)	(%)	[cmol (p+) kg ⁻¹]						(kg ha ⁻¹)			(mg kg ⁻¹)			
Ghatpipariya - 1 Clayey, smectitic, hyperthermic Lithic Ustorthents																		
Ap	0-15	7.4	0.17	1.90	2.1	20.0	12.5	0.13	0.02	32.7	39.1	183	7.9	492.8	22.2	27.0	5.4	0.58
Ghatpipariya - 2 Fine, smectitic, hyperthermic Typic Haplustepts																		
A	0-17	6.5	0.08	1.92	2.2	25.4	21.0	0.20	0.01	46.6	49.5	156	26.8	342.4	28.6	43.1	6.4	0.54
Bw1	17-34	6.5	0.08	1.48	4.7	23.2	20.0	0.17	0.02	44.4	47.6	132	16.1	291.6	27.4	32.5	5.1	0.44
Bw2	34-51	6.7	0.07	1.42	5.3	21.7	18.3	0.14	0.02	40.2	45.1	107	11.3	223.4	23.8	27.5	3.2	0.27
Ghatpipariya - 3 Clayey, smectitic, hyperthermic Lithic Ustorthents																		

Ap	0-10	6.9	0.09	0.93	4.1	20.1	15.2	0.16	0.04	35.5	39.1	151	30.0	369.6	33.6	37.6	3.5	0.43
Ghatpipariya - 4 Fine, smectitic, hyperthermic (calcareous) Typic Haplusterts																		
Ap	0-18	7.6	0.20	0.64	2.2	25.1	16.8	0.57	0.15	42.6	45.2	390	34.3	368.8	19.4	31.1	4.5	0.39
Bw	18-38	7.7	0.17	0.61	2.8	31.1	19.7	0.46	0.18	51.4	53.4	350	26.4	346.4	18.7	28.5	4.2	0.31
Bss1	38-55	7.9	0.26	0.59	3.3	29.9	18.1	0.35	0.19	48.5	50.3	315	22.7	276.4	16.6	24.2	3.0	0.27
Bss2	55-75	7.3	0.23	0.47	5.2	30.2	18.8	0.39	0.16	49.6	51.4	270	17.7	223.1	15.4	21.5	2.7	0.21
Bss3	75-101	7.7	0.19	0.26	6.5	27.5	16.3	0.45	0.14	44.4	47.7	125	10.5	196.5	13.2	19.8	2.4	0.15
Ghatpipariya - 5 Very-fine, smectitic, hyperthermic (calcareous) Typic Haplusterts																		
Ap	0-18	6.5	0.10	0.72	1.45	31.5	21.5	0.58	0.21	53.8	57.4	384	23.3	362.8	29.7	34.1	4.7	0.59
Bw	18-42	7.8	0.07	0.62	2.20	34.5	22.3	0.47	0.15	57.4	62.6	362	21.5	340.6	25.9	29.5	4.3	0.52
Bss1	42-76	6.7	0.07	0.47	2.69	33.3	21.5	0.37	0.22	55.4	61.7	333	16.8	295.7	21.4	27.2	3.6	0.40
Bss2	76-102	7.5	0.14	0.32	3.48	32.6	22.7	0.32	0.25	55.9	59.3	274	14.8	272.9	18.5	19.8	3.1	0.31
Bss3	102-132	7.6	0.20	0.30	3.65	34.4	19.6	0.34	0.26	54.6	61.7	218	11.8	220.5	14.6	12.8	2.8	0.27
Bss4	132-150	7.6	0.08	0.17	4.25	27.5	15.4	0.38	0.26	43.5	48.8	125	8.2	152.7	11.1	10.1	2.3	0.18

References

- [1]. Amutha, D. 2013. Present Status of Indian Agriculture. Available at SSRN 2739231
- [2]. Challa, O., Bhaskar, B.P. Anantwar, S.G. and Gaikwad, M.S. 2000. Characterization and classification of some problematic Vertisols in semi-arid ecosystem of Maharashtra Plateau. *J. Indian Soc. Soil Sci.* 48 :139-145.
- [3]. Chakraborty, K., Joshi P.K. and Sarma, K.K. 2009. Land use/land cover dynamics in Umngot watershed of Meghalaya using Geospatial tools. *Journal of Indian Society of Remote Sensing*, 37 (1) : 99-106.
- [4]. Chinchmalatpure A.R., Brijlal R., Challa O., Sehgal J. 2000. Available micronutrient status of soils on different parent materials and landforms in a micro-watershed of Wunna catchment near Nagpur (Maharashtra). *Agropedology*. 2000; 10:53-58.
- [5]. Das, D.K., 1998. Remote sensing application in management of agricultural resources. *Research Highlights. Indian Agricultural Research Institute, New Delhi.* :1-103.
- [6]. Das, D. K., Bandyopadhyay, S., Chakraborty, D., and Srivastava, R. 2009 . Application of modern techniques in characterization and management of soil and water resources. *Journal of the Indian Society of Soil Science*, 57(4), 445-460.
- [7]. Debroy P., Jena R.K., Ray P., Bandyopadhyay S., Padua S., Singh., S.K. and. Ray S.K. 2020. Vertical distribution of cationic micronutrients across landscape positions on Meghalayan plateau in the North-Eastern Region of India. *Journal of Environmental Biology* 41(5):1089-1098.
- [8]. Dorji, T., Odeh, I.O.A., and Field, D.J. 2014. Vertical distribution of soil organic carbon density in relation to land use cover, altitude and slope aspect in the Eastern Himalayas, *Land* (3) :1232-1250.
- [9]. Hirekurbar, B.T., Satyanarayan, S. T., Manjunathaiyah, P.A. 2000. Forms of potassium and their distribution in soils under cotton based cropping system in Karnataka. *Journal of the Indian Society of Soil Science*, 48(3):604- 608.
- [10]. Ingle, S. N., Nagaraju, M. S. S. Sahu, Nisha Kumar, N. Tiwary, P, Srivastava, R. Sen, T. K. and Nasre, R. A. 2018 . Soil fertility status of macronutrients and micronutrients in Bareli watershed of Seoni district, Madhya Pradesh, India. *International Journal of Chemical Studies*, 6(4): 1950-1953.
- [11]. Ingle, S. N., Nagaraju, M.S.S. Sahu, N. Kumar, N. Twary, P. Srivastava, R. Sen, T. K. and Nasre, R. A. 2019 . Characterization, classification and evaluation of land resources for management of Bareli watershed in Seoni district, Madhya Pradesh using Remote Sensing and GIS. *Journal of Soil and Water Conservation*, 18(1): 1-10.
- [12]. Juo, A. S. & Manu, A. 1996 . Chemical dynamics in slash-and-burn agriculture. *Agriculture, Ecosystems & Environment*, 58(1), 49-60.
- [13]. Kanwar, J.S., 2000. Soil and Water resources management for sustainable agriculture – imperatives for India. In : *Development and conservation, Int. Conf. on Managing Natural Resources for Sustainable Agricultural Production in 21st Century.* Feb. 14- 18, New Delhi. : 17-37.
- [14]. Katyal, J.C. and Randhawa N.S. 1983. In: *Micronutrients. FAO fertilizer and plant nutrition bulletin*, Rome 5: 92 p.
- [15]. Kirmani, N.A., Sofi, J.A., bhat, M.A. Bangroo, S.A. Shabir Bhat A. 2011. Soil micronutrient status of district Budgam, *Research Journal of Agricultural Science*, 2(1):30-32.
- [16]. Kuchanwar, O. D., Gabhane, V. V. and Ingle, S. N. 2021. Remote sensing and GIS application for land resources appraisal of Ridhora watershed in Nagpur district, Maharashtra. *Journal of Soil and Water Conservation*, 20(2): 139-153.
- [17]. Kuchanwar, O. D., Gabhane, V. V. and Ingle, S. N. 2022. Vertical Distribution of Macro Nutrients and Micronutrients of Ridhora Watershed in Nagpur district, Maharashtra, India. *Biological Forum – An International Journal* 14(1): 1140-1145.

- [18]. Kumar, R., Singh, A. K. and Singh, A. K., 2021. Vertical Distribution of Soils Fertility of Sagarpali and Chitbadagaon Village of Ballia District, Uttar Pradesh, *Acta Scientific Agriculture* 5.5 : 69-74.
- [19]. Lindsay, W.L. Norwell, 1978. A. Development of DTPA soil test for Zn, Fe, Mn and Cu. *Society of American Journal*, 42:421-428.
- [20]. Lisnawati, Y., and Siregar, C.A., 2019. Vertical Distribution of Macro Nutrient on Drained Peat for *Acacia crassicarpa* plantations. *Earth and Environmental Science* 394 -012039
- [21]. Maji, A.K., Reddy, G.P. Obi Thayalan, S. and Walke, N.J. 2005. Characteristics and classification of landforms and soils over basaltic terrain in sub-humid tropics of central India. *Journal of the Indian Society of Soil Science*, 53(2) : 154-162.
- [22]. Medhe, S. R., Tankankhar, V.G., Salve, A.N., 2012. Correlation of chemical properties, secondary nutrients and micronutrient anions from the soils of Chakur Tahsil of Latur district, Maharashtra. *Journal of Trends in life sciences*, 1(2).
- [23]. Nayak, A.K. Sahu, G.C. Nanda S.S.K. 2001. Characterization and classification of soils of Central Research Station, Bhubaneswar. *Agropedology*. 12:1-8.
- [24]. Olsen, S.R., Cole, C.V., Watanabe, F.S., Dean, L.A., 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Department of Agriculture, Circular No 939, USA, 19p.
- [25]. Pal, D.K. and Deshpande, S.B. 1987. Characteristics and genesis of minerals in some benchmark Vertisols of Southern India. *Pedologie* 37 : 235-248.
- [26]. Pal, D.K., Dasog, G.S., Vadivelu, S., Ahuja, R.L., and Bhattacharyya, T. 1999. Secondary calcium carbonate in soils of arid and semi-arid regions of India. In *Global climate change and pedogenic carbonate* (Rattan Lal, John, M. Kimble, H. Eswaran and B.A. Stewart eds.), Lewis Publishers, New York.
- [27]. Patil, G.D., Khedkar, V.R., Tathe, A.S., Deshpande, A.N. 2008. Characterization and classification of soils of Agricultural College Farm, Pune. *Journal of Maharashtra Agricultural University*, 33(2):143-148.
- [28]. Pharande, A.L., Raskar, B.N., Nipunage M.V., 1996. Micronutrient status of important Vertisols and Alfisols soil series of Western Maharashtra. *Journal of Maharashtra Agricultural University*, 21(2):182-185
- [29]. Prava, K. D., Mishra, A. and Saren, S. 2019. Vertical distribution of available nutrients in an Eastern Indian Catena, *Annals of Plant and Soil Research* 21(4): 320-325.
- [30]. Pulakeshi H.B.P., Patil, P.L., Dasog, G.S., Radder, B.M., Mansur, C. P., 2012. Mapping nutrients status by geographic information system (GIS) in Mantagani village under northern transition zone of Karnataka. *Karnataka Journal of Agriculture Science*, 25(3):232-235.
- [31]. Rao, A.P.V., Prasad, M.V.S., Naidu N., Ramavatharam and G. Rama Rao., 2008. Characterization, classification and evaluation of soils on different landforms in Ramachandrapuram Mandal of Chittoor District in Andhra Pradesh for sustainable land use planning. *Journal of the Indian Society of Soil Science* , 56(1):23-33.
- [32]. Sarkar, D., Gangopadhyay S.K., and Velayutham, M. 2001. Soil toposequence relationship and classification in lower outlier of Chhotanagpur plateau. *Agropedology* 11 : 29-36.
- [33]. Sarkar D, Gangopadhyay SK, Velayutham M. 2001. Soil toposequence relationship and classification in lower outlier of Chhotanagpur plateau. *Agropedology*. 11:29-36.
- [34]. Sharma, M.P., and Bali, S.V., 2000. Long term effect of different cropping systems on physicochemical properties and soil fertility. *Journal of the Indian Society of Soil Science*, 18(1):183-185.
- [35]. Sharma, J.C., and Chaudhary, S.K. 2007. Vertical Distribution of Micronutrient Cations in Relation to Soil Characteristics in Lower Shiwalika of Solan District in North-West Himalayas. *Journal of the Indian Society of Soil Science*, 55, 40-44.
- [36]. Sharma R.P., Singh R. S., and Sharma S. S. 2013. Vertical Distribution of Plant Nutrients in Alluvial Soils of Aravalli Range and Optimization of Land Use. *International Journal of Pharmaceutical And Chemical Sciences*, . 2 (3)-1377-1389.

- [37]. Singh, S.S. Crop management under irrigated and rainfed conditions. Kalyani Publ. New Delhi, Ludhiana, 1988, 450.
- [38]. Singh, R. P., and Mishra, S. K. 2012. Available macro nutrients (N, P, K and S) in the soils of Chiraigaon block of district Varanasi (UP) in relation to soil characteristics. Indian Journal of Scientific Research, 97-101.
- [39]. Singh, G., Sharma, M., Manan, J., and Singh, G. 2016. Assessment of Soil Fertility Status under Different Cropping Sequences in District Kapurthala. Journal of Krishi Vigyan.; 5(1):1-9
- [40]. Subbaiah, B. V. and G. L. Asija, 1956. A rapid procedure for determination of available nitrogen in soils. Current Science, 25: 259-260.
- [41]. Takkar, P.N., Chhibba, I.M., Mehta, S.K., 1989. Twenty years of coordinated research on micronutrients in soil and plant. Bull. Indian Institute of Soil Science, Bhopal, 1-75.
- [42]. Todmal, S.M. Patil, B.P., Tamboli, B.D., 2008. Characterisation and classification of soils in Agriculture College Farm, Kolhapur. Journal of Maharashtra Agricultural University, 33(3):287- 291.
- [43]. Vedadri, U., and Naidu, M. 2018 . Characterisation, classification and evaluation of soils in semi-arid ecosystem of Chillakurmandal in SPSR Nellore district of Andhra Pradesh, Journal of the Indian Society of Soil Science, 66(1): 9-19.
- [44]. Walkley, A.; Black, I.A. 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Sci. 37, 29–38.
- [45]. Xiang Yu; Boyao Li; Tianyi Wang; Yan Liu; Chao Zhan; Buli Cui. 2020. The Horizontal and Vertical Distribution of Nutrients and the Potential Eutrophication Assessment in the Yellow River Estuary in Dry Season. Journal of Coastal Research 99 (SI): 208–213.
- [46]. Zhang, W. & Zhang, X. 2007. A forecast analysis on fertilizers consumption worldwide. Environmental Monitoring and Assessment, 133(1-3), 427-434.
- [47]. Zhuo, C., Sun, J., Ting ,G., Zhang, G., and Wei, Y. 2021. Nutrient ratios driven by vertical stratification regulate phytoplankton community structure in the oligotrophic western Pacific Ocean, Ocean Science., 17, 1775–1789.