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Study of Physico-chemical Properties in Industrial Areas of Chambal Region Soil

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ABSTRACT

Background: Soil is a crucial and remarkable component of the terrestrial ecosystems. The objective of this study is to analyze macronutrients and micronutrients in order to understand the suitability of soil for cultivation of crops in the selected sites. In the present study the physicochemical analysis was carried out by analyzing the parameters *i.e.* pH, organic carbon and potassium *etc.*

Methods: Four soil samples were collected in 2017-2018 during the winter season at different locations in industrial areas of the Chambal region and compared with the standard value of soil quality. The micronutrients Fe, Cu, Mn and Zn were determined by using atomic absorption spectrophotometer.

Result: Organic carbon was observed in a range between 0.51 to 0.55%. The soil pH was observed neutral to slightly alkaline in nature (7.2-7.6). All the parameters were under the permissible limit of soil quality standard except the phosphorus which was found to be less than minimum requirement (<28 kg ha^{-1}). Pearson's correlation matrix result demonstrated that several physicochemical characteristics of soil were having a positive association, particularly soil pH, were correlated with EC and sand content. Organic matter and organic carbon had positive and significant correlation with nitrogen, phosphorus, potassium and iron. Organic matter and fertility of soil was significantly correlated. Therefore, the proper study of soil provided the information about its fertility and crop productivity.

Key words: Electrical conductivity, Organic matter, pH, Soil texture, Water holding capacity.

INTRODUCTION

Among the natural resources, soil is one of the foremost resources, which plays an important role in agriculture and living entities. Soil is maintained in all types of life in the terrestrial ecosystem. The soil is not an infinite resource and if it is managed indirectly its properties can be lost in a short period of time, with the limited regeneration opportunities (Nortcliff, 2002). From an agricultural point of view, the soil provides support to plants and acts as a reservoir of water and nutrients. Soils are characterized by using biological, chemical and physical properties. The physical properties of soil are the deciding parameter by which it can decide whether it is used for agricultural purposes and nonagricultural purposes. One of the important physical properties of soil is soil texture which relies on the amount of its sand, clay and silt particles. All vital components including soil nutrients, water and aeration mostly depend on it. The chemical properties of soil include the pH, organic carbon, organic matter, nitrogen (N), zinc (Zn) and potassium (K) *etc.* The chemical characteristics of soil depends on the soil physical characteristics. The amount of water that can be held by the soil depends partially on the size of the mineral particles (Sassenrath *et al*. 2018). Good agriculture requires sustainable soil resources, because soil can easily lose its quality within a short span of time for different reasons such as intensive cultivation, leaching and soil erosion (Kiflu and Beyene, 2013). Soil resources have also provided a great contribution in food and fiber production. Soil fertility is an important factor to determine the growth of the crop. It relies on the concentration of macronutrients and micronutrients, both macronutrients and micronutrients are important to maintain the soil fertility. This report highlights the physicochemical characteristics of soils and their importance. The physicochemical characteristics are important to maintain soil fertility and it is deciding parameters whether land is used for agriculture purposes or nonagricultural purposes. By this study we also know the ratio of nutrients (nitrogen, phosphorus and potassium) in soil and decide the amount of fertilization used or not, to enhance the crop yield.

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MATERIALS AND METHODS

Description of the study sites

The study sites were selected from Gwalior, Chambal region, Madhya Pradesh, India, located at Latitude 26°22′N and Longitude 78°18′E. It's above 197 meters (646 feet) from sea level. Gwalior district was spread across 5,214 km^2, the city of Gwalior covers 362 km^2 and falls in the Chambal region. Gwalior had sub-tropical climate regions. Four soil samples were collected in 2017-2018 during the winter season at different locations in industrial areas of the Chambal region. The map of the sampling area was displayed in Fig 1 and study sites were mentioned in Table 1.

Soil samples

Soil samples were collected from the depth of 4-6 inch by using soil augers. Samples were collected in triplicates into sterile plastic bags and transferred to the lab. Soil was air dried and the big lumps were broken down and other undesirable matters were removed. Soil was homogenized and passed through a 2 mm mesh screen. Various physico-chemical parameters were analyzed.

Analysis of soil physical and chemical properties

pH and electrical conductivity

20 gram soil was taken in a beaker, 50 ml of distilled water was added and kept this for shaking for an hour using a rotary shaker as described by (Tandon, 1993). After that filtered the soil suspension. The filtrate pH and electrical conductivity was determined by using digital pH meter (Systronics make, type 335) and conductivity meter (Systronics make, model 304).

Soil texture

50 gram of dried soil was taken into a baffled stirring cup, added half cup distilled water, added 10 ml of sodium hexametaphosphate solution and aggregated soil. Transferred the suspension to the settling cylinder. The settling rates of dispersed particles were measured by hydrometer (Jacob and Clarke 2002).

Water holding capacity

soil was determined by method suggested by (Harding and Ross 1964).

Organic carbon and organic matter

10 gram of soil was taken into ashing vessels and dried at 105°C for 4 hours. Now cooled the ashing vessel and weighed (W1). Then placed the vessels with soil into a muffle furnace at 400°C for 4 hours. Removed these vessels from the muffle furnace, cooled in a dry atmosphere and weighed (W2). Organic matter was calculated by formula:
Organic matter (%) = Organic carbon × 1.724.

Total nitrogen

was estimated by weighing 3 gram air dried soil samples into a digestion tube containing 8 gram of K_2SO_4 and 1gram of $CuSO_4$. Added conc. H_2SO_4 (20 ml). The mixture was maintained at about 420°C (for 1-2 h) until clear. Added 50 ml of water in a cooled digestion tube, made alkaline with NaOH and nitrogen distilled into 4% boric acid and titrated with 0.01 M HC1 using brómocresol green methyl red as an indicator.

Phosphorus and potassium

Phosphorus was estimated by the sodium bicarbonate extraction method suggested by Olsen *et al*. (1954). Analysis was done by using spectrophotometer (UV-Vis spectrophotometer, Perkin Elmer, Lambda 25). Potassium was measured by an ammonium extraction method and analysis was done by using a flame photometer (Pelican equipment, model Elite Ex).

Copper, iron, manganese and zinc

Copper, iron, manganese and zinc in soil samples were measured and digested using aqua regia (HCl: HNO_3 in ratio of 3:1) using a hot plate for heating. Digested extract analyzed for micronutrients (Zn, Fe, Cu and Mn) by flame atomic absorption spectrophotometer (GBC Scientific Equipment Ltd., Australia, Model NB14).

RESULTS AND DISCUSSION

Soil pH and electrical conductivity

The soil quality standard parameters are illustrated in Table 2. The pH of all study areas were found ranged in between 7.2 to 7.6 which indicate the slight alkalinity of soils. A pH range of 5.2 to 6.5 is rated by most nutritionists as ideal for the optimum growth of most plants because all essential elements are soluble and available within this range Brady (1974). It is estimated that the alkaline nature of the soil decreases the solubility of minerals and creates nutrient deficiency in the soil Iram and Khan (2018). Wagh *et al*. (2013e) and Patil *et al* (2003) also reported that in alkaline soil, minerals solubility decreased which led to nutrient deficiencies in the soils and in the deficiencies of iron, manganese, zinc, copper *etc*., plant growth was limited. Electrical conductivity was useful for the estimation of soluble salt concentrations. Soils with EC below 0.4mS/cm are considered marginally or non-saline Wagh *et al*. (2013e). Electrical conductivity was observed maximum in Morena (0.44±0.029 mS/cm) and minimum was observed in Banmore (0.31±0.022 mS/cm) (Table 3). The soils of all three sites (Banmore, Rairu and Malanpur) were found non saline

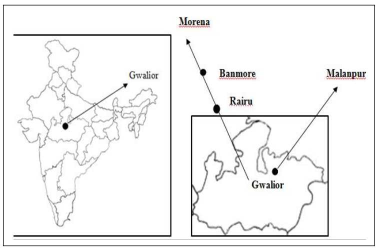

Fig 1: Location of study sites.

Table 1: List of the study sites.

Site no.	Name of the sites	Geographical condition	
		Latitude N	Longitude E
B-1	Banmore	26. 3553°	78.0947°
R-2	Rairu	26.3001°	78.1294°
M-3	Morena	26.4934°	77.9910°
M-4	Malanpur	26.3670°	78.2875°

except Morena sites. Pearson correlation coefficient and significance among soil physical and chemical properties are presented in Table 4. Several authors including Molin and Castro, (2008) and Chitranshi *et al*. (2018) had reported strong correlation between clay content and soil electrical conductivity. Similarly in this study soil pH was significant and positive correlated with electric conductivity, sand and silt value at (r=0.99), (r=0.34) and (r=.98) respectively, but it was negatively and insignificant value at (r=-0.02) correlated with the copper.

Soil texture

Soil texture directly or indirectly influences soil functions such as soil erosion, water availability Adhikari *et al*. (2009). The sandy soil can quickly be recharged but its holding capacity is not good. As texture becomes heavier, the wilting point increases because fine soils with narrow pore spacing hold water more tightly than soils with wide pore spacing. In this study soil texture of all sites was noted to have a higher proportion of sand. The texture of the soil is sandy loam. Proportion of sand ranged from 46.0 to 66.0%. The clay content ranged from 12.8±2.6 to 32.8±2.2%. Clay content was very low at just 12.8±2.6% in Morena site soil. Silt content was observed in a range of 21.21±2.1 to 21.24±2.4% in all four soil sites. Soil texture was displayed in table 3. Augustin and Cihacek (2016) found that sand was negatively correlated with organic carbon and silt was strongly correlated with organic carbon, which reflected greater water holding capacity, which in turn increased plant productivity and carbon sequestration in soil. Similarly, in this study the sand of soil was positively and significantly correlated with silt value at r=0.20 and negatively correlated with clay, organic matter and organic carbon. Silt had a negative correlation with water holding capacity, organic matter and organic carbon.

Table 2: Soil quality standard.

Parameter	Range
pH	Acidic<6.5
	Normal 6.5-7.0
	Slight alkaline 7.1-8.0
	Alkaline>8.2
Electrical conductivity	Normal<1
	Medium 1-3
	Harmful>3
Organic carbon (%)	Minimum<0.5
	Normal 0.5-0.75
	Maximum>0.75
Available phosphorus (kg/he)	Minimum<28
	Normal 28-56
	Maximum>56
Potassium (kg/he)	Minimum<140
	Normal 140-280
	Maximum>280
Copper (mg/kg)	Minimum<0.2
	Normal 0.2-0.4
	Maximum>0.4
Manganese (mg/kg)	Minimum<0.2
	Normal 5-10
	Maximum>10
Zinc (mg/kg)	Minimum<5
	Normal 0.5-1.0
	Maximum>1.0

Water holding capacity

Water holding capacity (WHC) was recorded lowest in Morena (37.2±2.1%) and highest in Rairu (62.1±3.8%). Water holding capacity had negative and significantly correlated with organ carbon, organic matter and silt (r=-0.18), (r=-0.18) and (r=-0.34) respectively, but it was positive and significantly correlated with sand and phosphorus values at (r=0.11) and (r=0.91) respectively.

Organic carbon and organic matter

Organic carbon and organic matter play an important role in soil. The organic carbon was observed highest in Banmore (0.55±0.09%) and lowest was observed in Morena (0.51±0.05%) and was under the normal range as the standard table of soil quality (Table 2 and Fig 2a). Organic carbon is an essential component of soil fertility as it add nutrients for plant growth by maintaining physical and biological health of the soil and also acts as a buffer against harmful substances. The organic matter provides a natural home for millions of bacteriological organisms which aid biological and chemical reactions required for sustaining plant life. It aids moisture retention in the soil, enhances soil aggregation, aeration, aids in reduction of soil erosion and increases nutrient holding capacity of soil. For many living entities the source of carbon is organic matter. Soil consists of various kinds of dead animal, live animal,

Table 3: Different parameter of soil samples.

Sites	pH	Electronic Conductivity (mS/cm)	Water holding capacity (%)	Organic carbon (%)	Organic matter (%)	Sand		
						Sand	Silt	Clay
B1	7.2±0.29	0.31±0.022	40.8±3.4	0.55±0.09	0.93±0.04	56±3.4	21.21±2.1	22.8±1.5
R2	7.3±0.31	0.35±0.032	62.1±3.8	0.52±0.08	0.88±0.06	62±4.1	21.22±1.8	16.8±2.1
M3	7.6±0.33	0.44±0.029	37.2±2.1	0.51±0.05	0.86±0.07	66±3.9	21.24±2.4	12.8±2.6
M4	7.4±0.32	0.39±0.035	43.5±3.0	0.54±0.08	0.91±0.05	46±3.8	21.23±2.1	32.8±2.2

Values represent the mean ± standard error (n=5).

Table 4: Pearson's correlation matrix of physico-chemical characteristics of soils.

	pH	EC	WHC	OC	OM	Sand	Silt	Clay	N	P	K	Zn	Fe	Mn	Cu
pH	1														
EC	0.992***	1													
WHC	-0.411	-0.364	1												
OC	-0.748***	-0.722***	-0.187**	1											
OM	-0.748***	-0.722***	-0.187	1	1										
Sand	0.348	0.252	0.118	-0.756***	-0.756****	1									
Silt	0.983***	0.998***	-0.342	-0.707***	-0.707***	0.208	1								
Clay	-0.348	-0.252	-0.118	0.756***	0.756***	-1	-0.208	1							
N	-0.723***	-0.7***	-0.235	0.999***	0.999***	-0.749***	-0.686***	0.749***	1						
P	-0.542**	-0.459*	0.92***	0.123	0.123	-0.281	-0.42	0.281	0.074	1					
K	-0.917***	-0.912***	0.707***	0.427	0.427	-0.067	-0.905***	0.067	0.39	0.715***	1				
Zn	0.186	0.074	-0.766***	0.033	0.033	0.408	0.023	-0.408	0.075	-0.898***	-0.341	1			
Fe	-0.051	0.078	0.357	0.191	0.191	-0.74***	0.135	0.74***	0.165	0.634**	0.026	-0.87***	1		
Mn	0.154	0.25	-0.349	0.412	0.412	-0.873***	0.291	0.873***	0.419	0.004	-0.41	-0.321	0.746***	1	
Cu	-0.023	-0.135	0.133	-0.433	-0.433	0.915***	-0.184	-0.915***	-0.429	-0.23	0.235	0.514	-0.868***	-0.974***	1

*Significant at P≤0.1; **significant at P≤0.05; ***significant at ≤0.01.

microorganisms and decay plant material. Those all were dependent on soil for nutrients and energy. Organic matter was observed from ranging 0.86±0.07 to 0.93±0.04% in all four soil sites. Very low organic matter was observed in Morena (0.86±0.07%) (Fig 2b). Babalola *et al*, (2021) also found low organic matter ranging from 1.52 to 1.79%. Pearson's correlation matrix confirmed there was a strongly positive relationship between soil nutrient and soil organic matter. This finding was in agreement with different individuals Tufa *et al*. (2019); Bezabih *et al*. (2016). Similarly in this study, organic matter and organic carbon had positive and significant correlation with nitrogen, phosphorus, potassium and iron. But it was positive and insignificant correlated with zinc. Organic matter and organic carbon was negative and significant with sand, silt and copper.

Total nitrogen

Soil total N was recorded in all sites ranging from 192.2 to 206.2 kg/ha and was under the normal range from soil quality standard (Table 2). Highest total N was observed in Banmore (206.2 kg/ha) and lowest was observed in Morena (192.2 kg/ha) (Fig 2c). Tufa *et al*. (2019) and Nweke and Nnabude, (2014) and Singh *et al*. (2009) reported that total N significantly positively correlated with phosphorus and organic carbon. Similarly, in this study total N had positive and significant correlation with phosphorus, potassium, zinc iron and manganese value at (r=0.07), (r=0.39), (r=0.07), (r=0.16) and (r=0.41) and negative correlated with copper (r=-0.42).

Phosphorus and potassium

Phosphorus was one of the important macronutrients required for the growth and metabolism of the plants. Application of phosphorus is necessary for maintaining a balance between the other plant nutrients and ensuring the normal growth of crops Wagh *et al*. (2013e). Phosphorus in soil varies from 11.8 to 13.9 kg/ha and is found to be below the minimum requirement (<28)(Fig 2d) as per the soil quality standard (Table 2). Phosphorus was positively and insignificantly correlated with manganese at (r=0.004) and it was negatively and significantly correlated with zinc and copper value at (r=-0.89) and (r=-0.22) respectively.

From the analyzed soil samples potassium ranges may vary from 249.7 to 275.5 kg/ha (Fig 2e), Potassium present in normal range in soil as per standard soil quality (Table 2). Dhakad *et al*. (2017) reported that potassium was significantly and positively correlated with EC (r=0.281) and clay (r=0.245) and non significantly correlated with organic carbon (r=0.167), whereas, negatively correlated with pH (r=-0.089), sand (r=-0.162) and silt (r=-0.033). Similarly in this study potassium was positively and significantly correlated with clay content (r=0.06) whereas negatively correlated with pH (r=-0.91), sand (r =-0.06) and silt (r=-0.905).

Copper, iron, manganese and zinc

Copper is one of the vital micronutrients for the plant. Copper was strongly bound to soils and immobile, hence the plant roots were in higher concentration of copper in comparison to other parts of the plant Wagh *et al.* (2013e). In the present study the concentration of copper in soil samples was found from 0.11 to 0.33 mg/kg (Fig 2f), in all sampling locations and was above (maximum level>0.4) as per soil quality standard (Table 2). Iron was one of the other crucial elements for the growth and development of plants. Iron required for oxidation and reduction of nitrates and sulphate, plant metabolism like protein formation, photosynthesis, electron transport and chlorophyll. Nasar *et al*, (2019) mentioned that iron (Fe) significantly improved the yield and quality of crops. The range of iron content in all tested soil sites were found from 4.2 to 4.4 mg/kg and And it was the under normal range of Fe (Fig 2g). Another micronutrients was manganese, it aids in the process of photosynthesis and protein synthesis and also plays an important role in formation of chlorophyll along with iron (Lindsay and Norwell, 1978). The amount of manganese available to the plant depends upon soil pH, the quantity of organic matter present and degree of aeration. In alkaline soil Mn deficiency may occur because it is less soluble at elevated pH level. Manganese content in the soil from the all four sites ranged from 1.1 to 2.1 mg/kg (Fig 2h). For the growth and development of plants zinc is an indispensable micronutrient. Zinc lacking plants are sensitive to various pathogenic fungal root diseases (Graham and Webb, 1991). Zinc concentration ranged from 0.6 to 0.7 mg/kg (Fig 2i) normal in quantity as per soil quality standard (Table 2). Niranjana *et al*, (2017) study also found the soils were comparatively low to high in iron and manganese contents and were low in copper and zinc contents. Zinc was positively and significantly correlated

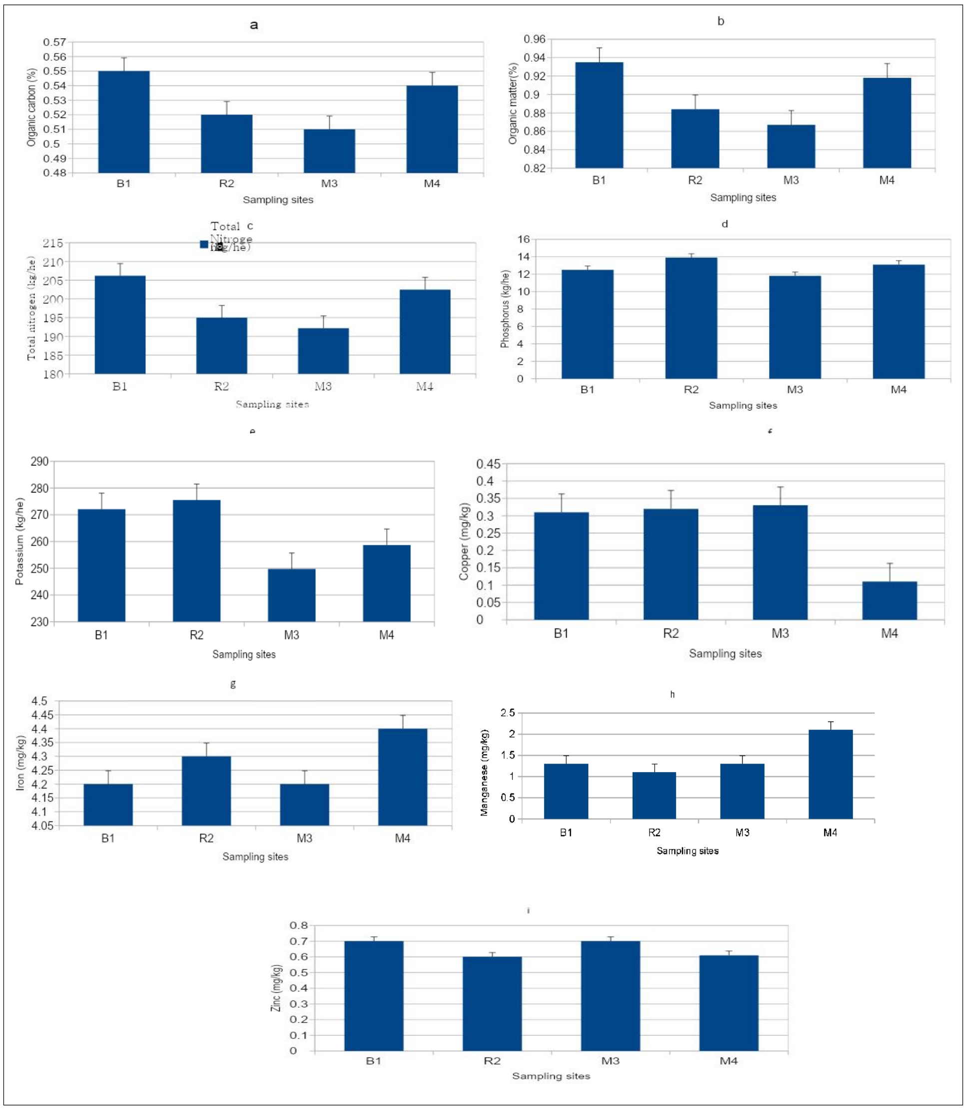

Fig 2: Various types of nutrient in Gwalior city soils. (a) Organic carbon (b) Organic matter (c) Total nitrogen (d) Phosphorus (e) Potassium (f) Copper (g) Iron (h) manganese (i) Zinc. Sampling sites B1 (Banmore), R2 (Rairu), M3 (Morena) and M4 (Malanpur). Error bars indicate means ±SE (n=5).

with copper (r=0.51) and negatively and significantly correlated with manganese and iron value (r=0.87) and (r=0.32) respectively. Copper was positively and significantly correlated with potassium (r=0.23) whereas negatively correlated with iron and phosphorus value at (r=-0.86) and (r=-0.22) respectively (Table 3). Iron was positively and significantly correlated with potassium, phosphorus and manganese values at (r=0.63), (r=0.02) and (r=0.74).

CONCLUSION

The physicochemical properties were analyzed in the soil samples of Chambal region, Gwalior. This study revealed that soil was neutral to slightly alkaline in nature. All the parameters were under the permissible limit of soil quality standard except the phosphorus found less than minimum requirement (<28 kg ha^{-1}). Correlation analysis was carried out among various parameters of soil quality. Organic matter and organic carbon had positive and significant correlations with nitrogen, phosphorus, potassium and iron. Organic matter and fertility of soil was significantly correlated. Monitoring the nutrients in the soils should be done periodically as it can be an efficient way to assess the quality of soil for improved crop yield and its aid to deciding the amount of fertilizers.

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Conflict of interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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