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Original Research Article

A Study on Some Important Soil Properties of Orchha Wildlife Sanctuary, Madhya Pradesh, India

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Abstract: Orchha Wildlife Sanctuary located in Niwari district of Madhya Pradesh remains unexplored and calls for recording of both soil and floristic data to ensure better management and conservation. It is important to study the soil because soil characteristics determine the plant diversity and forest productivity which provides food security to wildlife and influences environmental stability. In the present work, soil samples were collected from sites located within and around the sanctuary and were analysed for some important properties, micronutrients and macronutrients. The slightly acidic soils present in different locations in the sanctuary are predominated by sandy loam texture and reddish to red colour of soil. Soil organic carbon, nitrogen, phosphorus, potassium and sulphur were present in low range. Boron was found to be optimum, iron was present in marginal concentration, zinc was found to be deficient, copper in high concentration and manganese ranged from marginal to high. These results indicate that the low range of macronutrients and a few micronutrients can pertain to a low plant diversity in the sanctuary. The forest soils are neglected as they are self sustaining but some interventions like reforestation can be made to improve their productivity The preliminary knowledge of soil properties of this natural vegetation can be helpful in planning better productivity of the soil and consequently, it will indirectly improve the living conditions of the wildlife residing in it.The study of floristic and phytosociological studies are also complimented by soil studies.
Key words: Conservation, Forest, Macronutrients, Management, Micronutrients, Sanctuary, Soil

Introduction

Soil is composed of weathered minerals, organic matter, air and water. It is formed over time by the synergistic action of climate, organisms and relief features on the parent rock material. The vegetation in an area strongly influences the soil and vice versa. Distinction between forest physiognomies can be done on the basis of soil properties (Ruggiero *et al.*, 2002). The knowledge of soil physicochemical properties is an important prerequisite in biodiversity assessment of an area as it helps in correlating the prevailing soil conditions with the types of species present. A soil with the optimum range of macronutrients and micronutrients, would support a greater diversity of flora as compared to the soil which is low in nutrients.

Soil analysis becomes essential for the management and conservation of areas like national parks and wildlife sanctuaries which protect a variety of flora and fauna. India has a total of 903 protected areas comprising of 101 national parks, 553 wildlife sanctuaries, 86 conservation reserves and 163 community reserves (ENVIS, 2019). Physico-chemical soil analysis has been carried out in many wildlife sanctuaries like Laokhowa wildlife Sanctuary, Assam (Nath & Sarma, 2008), Askot wildlife sanctuary, Uttarakhand (Joshi *et al.*, 2013),

Hadagarh wildlife sanctuary, Odisha (Dhal *et al*., 2016) etc. showing the increasing importance of such studies.

Previously, a few soil properties under the canopy of some important tree species have been studied in the mixed dry deciduous forest of Orchha in the Bundelkhand region (Paul, 2018). In continuation to the above work, the current study is carried out to address the literature gap that remains in the soil study of the sanctuary. Hence, the present research aims to study the soil properties at various sites of the Orchha Wildlife Sanctuary, thus, giving a representative analysis of the soil present in this protected area.

Materials and methods

Orchha Wildlife Sanctuary is located in the Niwari district of the state of Madhya Pradesh in India (Fig. 1) . The Betwa river flows alongside it. It was established in the year 1994 and occupies a total area of 44.91 km^2 (ENVIS, 2019). The geographical position of the sanctuary is latitude 25^0 13´´ 45´N to 25^0 22´´ 30´N and longitude 78^0 33´´ 45´E to 78^0 40´´ 15´E. The sanctuary is comprised of Southern Tropical Dry Deciduous Forests and is dominated by trees like *Anogeissus pendula* Edgew. and *Tectona grandis* L.f. (Fig. 2).

The soil samples were collected in triplicates from each site during the months of December 2018 and February 2019 at a depth of 15 cm. The sites included were cultivated land (C), uncultivated land near river bank(UN), both located outside the sanctuary and various sites within the sanctuary (S1-138, S2-141, S3-152, S4 -162) (Fig. 3). The code S represents sample collection sites located within the sanctuary and the numbers 138, 141, 152 and 162 represent the respective regions

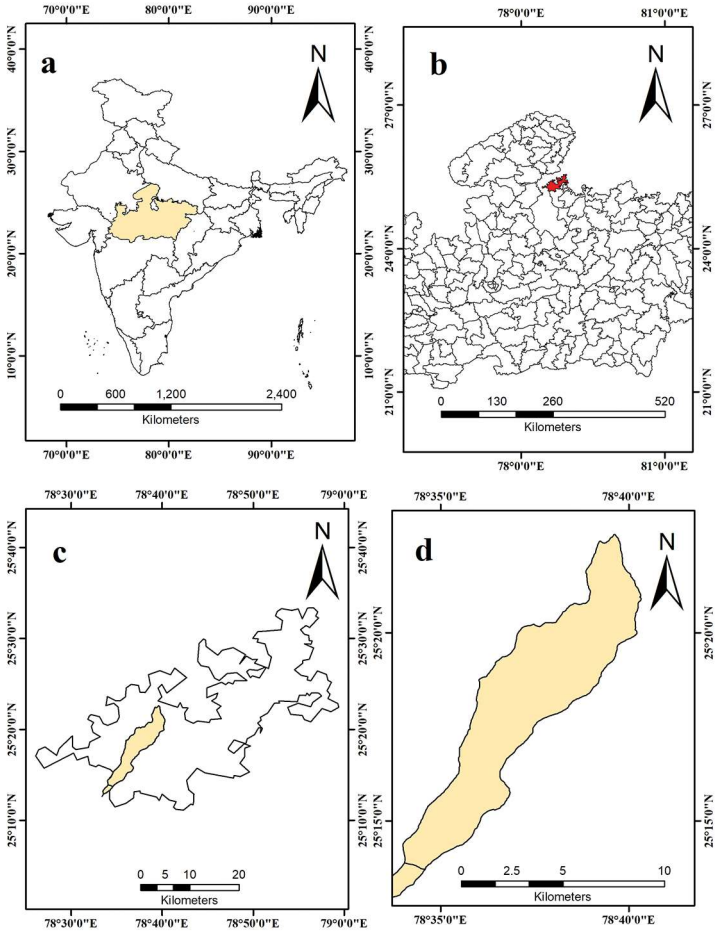


Fig. 1. Map of the study area: a) State of Madhya Pradesh located in Central India b) Niwari district in Madhya Pradesh c) Location of Orchha wildlife sanctuary in Niwari district d) Orchha Wildlife Sanctuary.

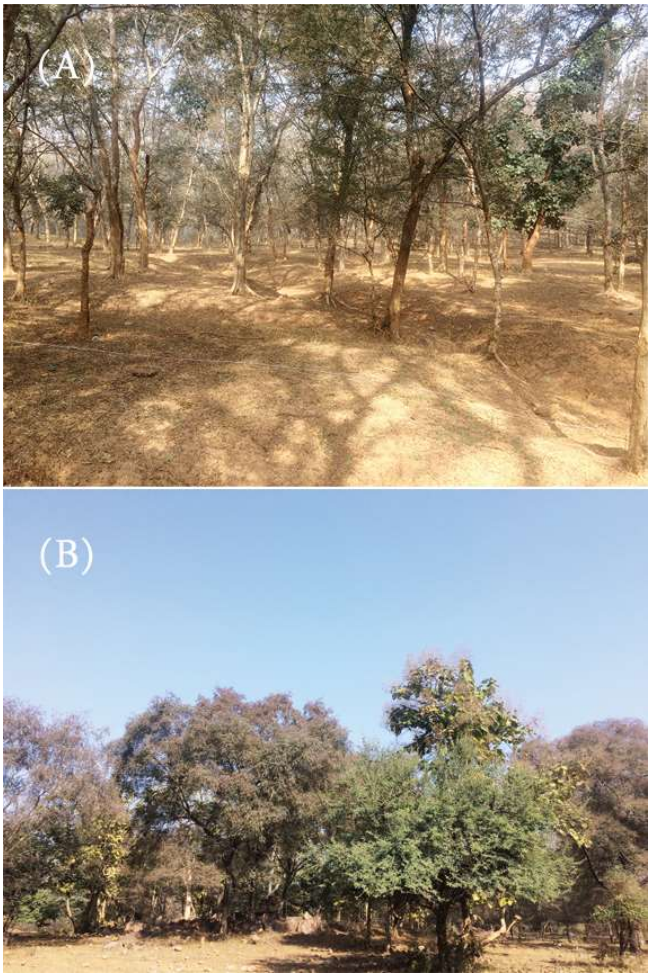


Fig. 2. Vegetation in the study area: a) *Anogeissus pendula* forest in Orchha Wildlife Sanctuary b) *Anogeissus pendula* and *Tectona grandis* are the dominant trees species of the sanctuary.

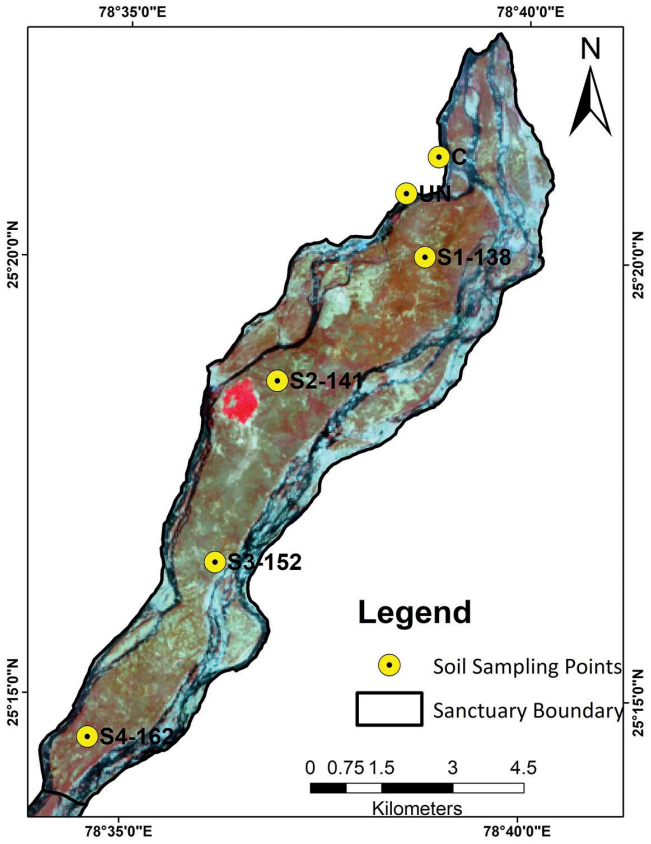


Fig. 3. GIS map of the study area showing locations of various soil sampling sites.

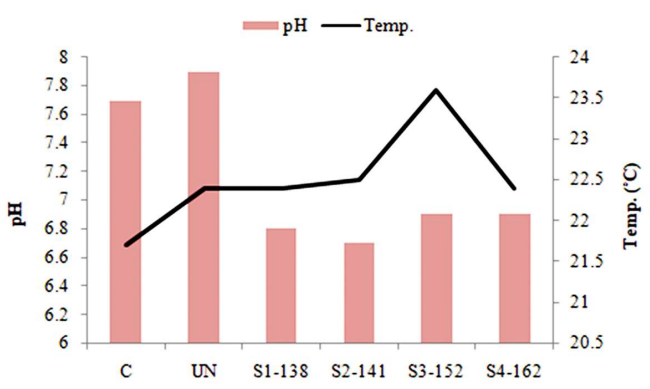
of the sanctuary numbered and demarcated by the forest department for ease of management. S1-138 is located at the entry point of the sanctuary from Orchha town, S2-141 in the middle of the sanctuary, S3-152 near the Jamni River while S4-162 is located near the confluence of Betwa and Jamni. After collection, soil was air dried and sieved through a 2 mm sieve for analysis.

Physical properties of soil like soil colour was determined by comparing with Munsell soil colour chart. The particle size distribution was studied with the help of pipette method (Kilmer & Alexander, 1949). Soil texture was found out using the NRCS soil texture calculator. Soil temperature was measured using a soil thermometer. Chemical properties like pH and electrical conductivity (EC) were estimated in 1:2.5 soil to water suspension using pH/conductivity meter (Jackson, 1973). Organic carbon (OC) was estimated by Walkley and Black method (Nelson & Sommers, 1982). Available nitrogen (N) was determined by modified alkaline permanganate method (Sahrawat & Burford, 1982). Available phosphorus (P) was determined using extraction with sodium bicarbonate (Olsen *et al.*, 1954). Available potassium (K) was estimated using flame photometry (Jackson, 1973). Available sulphur (S) was determined by turbidimetric method (Chesnin & Yien, 1950). Available Boron (B) was estimated using colorimetric determination (Hatcher & Wilcox, 1950). Available Zinc (Zn), Iron (Fe), Manganese (Mn) and Copper (Cu) were determined using Atomic Absorption Spectrophotometer (Lindsay & Norwell, 1978). The data was subsequently analysed and mean values as well as standard error were calculated.

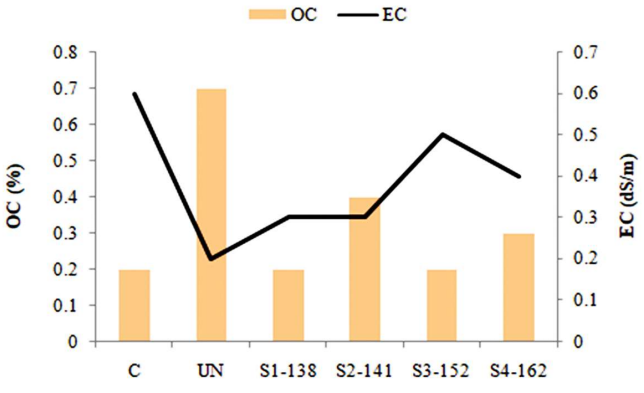
Table 1. Soil properties at various sites in Orchha Wildlife Sanctuary represented as mean value ± standard error.

	C	UN	S1-138	S2-141	S3-152	S4-162
pH	7.7 ± 0.06	7.9 ± 0.03	6.8 ± 0.06	6.7 ± 0.03	6.9 ± 0.03	6.9 ± 0.03
Temp. (°C)	21.7 ± 0.03	22.4 ± 0.06	22.4 ± 0.06	22.5 ± 0.03	23.6 ± 0.23	22.4 ± 0.03
EC (dS/m)	0.6 ± 0.03	0.2 ± 0.04	0.3 ± 0.03	0.3 ± 0.04	0.5 ± 0.03	0.4 ± 0.01
OC (%)	0.2 ± 0.03	0.7 ± 0.05	0.2 ± 0.01	0.4 ± 0.01	0.2 ± 0.01	0.3 ± 0.01
N (kg/ha)	104 ± 1.10	251 ± 1.37	104 ± 1.29	169 ± 1.28	119 ± 2.31	158 ± 1.88
P (kg/ha)	4.4 ± 0.07	4.3 ± 0.12	4.5 ± 0.06	4.6 ± 0.03	4.7 ± 0.07	4.5 ± 0.03
K(kg/ha)	45 ± 0.58	67 ± 0.64	36 ± 0.94	49 ± 0.77	58 ± 1.01	58 ± 1.10
S (kg/ha)	34 ± 1.07	28.2 ± 1.19	31.1 ± 0.78	34 ± 0.76	34 ± 0.55	33.1 ± 0.71
B (kg/ha)	1.8 ± 0.04	0.9 ± 0.03	1.1 ± 0.03	2.2 ± 0.03	0.7 ± 0.02	0.4 ± 0.03
Cu (kg/ha)	2.5 ± 0.06	3.4 ± 0.03	1.8 ± 0.01	2 ± 0.06	5.1 ± 0.06	5 ± 0.12
Fe (kg/ha)	9.6 ± 0.12	15.9 ± 0.61	19.9 ± 0.78	21.1 ± 1.13	14.3 ± 0.52	13.8 ± 0.25
Mn (kg/ha)	6.5 ± 0.06	6 ± 0.06	26.6 ± 0.43	25.1 ± 0.49	20.3 ± 0.15	38.3 ± 0.38
Zn (kg/ha)	0.7 ± 0.01	0.9 ± 0.03	1.3 ± 0.01	0.7 ± 0.02	0.7 ± 0.03	1.1 ± 0.09
Colour	LY Brown	Y Brown	R Yellow	Y Red	Y Red	R Brown
Texture	Loamy fine sand	Sandy loam	Fine sand	Sandy loam	Sandy loam	Silt loam

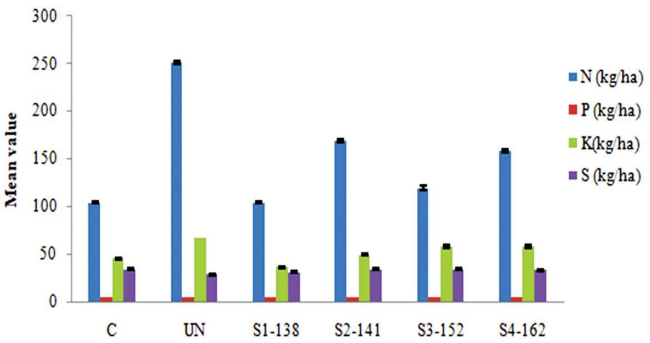
*EC- electrical conductivity, Temp- Temperature, OC- Organic carbon, LY- light yellowish, Y-yellowish, R- reddish.



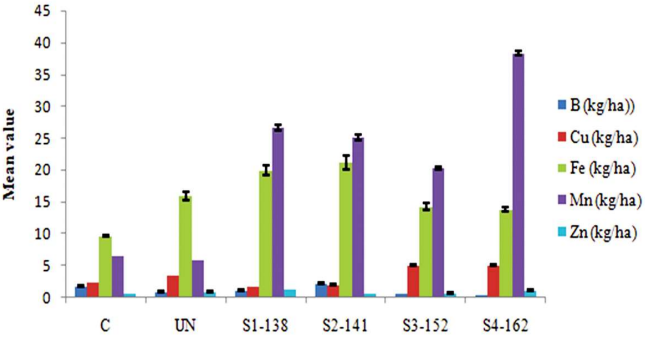
4. a. pH and temperature



4. b. Organic carbon (OC) and electrical conductivity (EC)



4. c. Macronutrients profile (N,P,K,S) at the sampled sites.



4. d. Micronutrients profile (B,Cu,Fe,Mn,Zn) at the sampled sites.

Fig. 4. Graphical representation of the soil properties studied for the sampled sites a) pH and temperature b) Organic carbon (OC) and electrical conductivity (EC) c) Macronutrients profile (N,P,K,S) at the sampled sites d) Micronutrients profile (B,Cu,Fe,Mn,Zn) at the sampled sites

Results

An examination of soil samples (Table 1) shows that the pH values range from 6.7– 6.9 in the sites within sanctuary (S1-138, S2-141,S3-152,S4-162) ,which is slightly acidic in nature. The cultivated (C) and uncultivated (UN) soil from a farm nearby the sanctuary and Betwa river bank have an alkaline pH of 7.7 and 7.9 respectively. Temperature values range from 21.7°C to 23.6°C, as measurement was done during winter. Figure 4a shows the range of pH and soil temperature in sites within and outside the sanctuary. The electrical conductivity values (Figure 4b) are found to be in a low range (0.2-0.6 dS/m) for all the sites. These values fall in the non-saline range, whereby, the salinity effects are negligible on plant growth.

A red/reddish colour was observed within soil sites of the sanctuary and light yellowish brown as well as yellowish brown colour in C and UN soil respectively. The soil has a sandy loamy texture in most of the sites, which provides good drainage. The site S1-138 is characterised by weathering rocks, hence, has a fine sand texture and S4-162 is located deeper inside the sanctuary, where sand percentage is lesser, hence, has a silt loam texture.

Organic carbon content is low in all the sites (Figure 4b) and ranges from 0.2 to 0.7 %. Figure 4c shows the macronutrients profile at various soil sampling sites. Nitrogen (104 to 251 kg/ha) is present in a low range. The maximum organic carbon and available nitrogen is present in site UN which is located on the river bank. Phosphorus (4.3 to 4.7 kg/ ha), Potassium (36 to 67 kg/ha) and Sulphur (28.2 to 34.0 kg/ ha) are present in a low range.

The micronutrients profile at the soil sampling sites is shown in Figure 4d. Micronutrients like Boron ranged from 0.4 to 2.2 kg/ha (optimum), Copper ranged from 1.8 to 5.1 kg/ha (high), Iron ranged from 9.6 to 21.1 kg/ha (marginal), Manganese ranged from 6.0 to 38.3 kg/ha (marginal to high) and Zinc ranged from 0.7 to 1.3 kg/ha (deficient).

Nutrient concentration in the soil is primarily influenced by vegetation, climate and rate of decomposition. The mixed deciduous forest as well as the warm and temperate climate of the region plays a major role in defining the soil characteristics.

Discussion

The analysis of various soil properties in Orchha wildlife sanctuary provides information about the type of soil present in the protected forest area. This study highlights the shortcomings in the soil properties which need to be further addressed by the forest management officials to increase the forest productivity and diversity which in turn could make it more habitable for wildlife. A distinction is observed between the sites in the soil pH. The sites within the sanctuary have a slightly acidic pH which can be attributed to parent rock material and the presence of deciduous tree species . Parent material that contributes bases back to the soil will maintain a moderate pH, while soils lacking a ready source of dissolvable nutrients are likely to be more acidic (Miller, 2016).

Most of the sites have a sandy loamy texture and red coloured soil. Red soil is the largest soil group of India, comprising several minor types, which originated due to weathering of ancient crystalline and metamorphic rocks (Siddiqui & Fatima, 2017).

Electrical conductivity values confirm the non-saline nature of soil in all the sampled sites. The organic carbon content is low in most of the sites. Site UN which is near the river bank has slightly high content of organic carbon. Soil organic carbon is dependent on various parameters like sand content, plant species, soil properties and land management. A negative correlation exists between sand content and water holding capacity while a positive correlation exists between soil organic matter and water holding capacity (Nath, 2014). Total soil organic content increases with precipitation and clay content and decreases with temperature (Jobbágy & Jackson, 2000).

Macronutrients like nitrogen, phosphorus and potassium are present in low range in all the sites (Sillanpä, 1982). Micronutrient critical range table has been compared with Wani et al., 2013. The optimal range of Boron is compared from Jokanovi, 2020. Some micronutrients like Zinc is present in a low range and Iron is present in marginal quantities. The reason could be because sandy loam soils and soils with less organic carbon content are deficient in zinc and calcareous as well as other alkaline soils show iron deficiency while iron

content also gets reduced in drought conditions (Shukla & Behera, 2017).

The deficiency in the various macronutrients and micronutrients needs to be addressed through prompt scientific interventions. An increase in the diversity of tree species through afforestation and development of pastures instead of plantation forests may aid in alleviating the problem of low organic carbon and nitrogen (Scott et al., 1999). The low range macronutrients and micronutrients can be added manually, in the form of fertilizers and green manure to ensure the optimum supply of nutrients. The improvement in soil health will result in better vegetation quality that would help sustain a larger variety of fauna.

Additionally, this study can be related with visual observation of the tree species present in the region which included *Anogeissus pendula* Edgew., *Tectona grandis* L.f., *Butea monosperma* (Lam.) Taub. and *Acacia leucophloea* (Roxb.)Willd. among others. The diversity of plant species present in the sanctuary is related to the soil characteristics. As the soil of Orchha wildlife sanctuary is low in many macronutrients and few micronutrients, it will also support a less diversity of flora. Hence, this account of soil parameters holds importance before conducting any floristic assessment and phytosociological study of the area.

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