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Characterization of Soil Quality Parameters of Balaghat and Malajkhand Blocks in Balaghat District of Madhya Pradesh, India

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ABSTRACT

The investigation was carried out at the laboratory of Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha; Mirzapur, during the year 2021-2022. This study's aim was to examine the different soil quality parameters and Nutrient index of the soil in the mining areas and normally cultivated areas in the Balaghat and Malajkhand blocks in the Balaghat district of Madhya Pradesh. With the help of GPS camera, 75 soil samples were taken from farmer fields in 9 villages at a depth of 0-15 cm. The soil samples from both sites were reported to be neutral to slightly alkaline in nature, with mean values of 7.59 and 7.57 for both mining and normal cultivated area, respectively. Electrical conductivity for both the sites was low with a mean value for mining area and normal cultivated area were 0.34 dSm^{-1} and 0.42 dSm^{-1}. High levels of organic carbon were found in the soil of both mine and non-mining areas, with mean values of 0.83% and 0.98 %, respectively. For all samples from both areas, the bulk and particle densities were within normal range, in mining area bulk density were observed high as compare to normal cultivated area and were observed to have the maximum pore space and water holding capacity. According to the nutrient index values of soil samples of Balaghat and Malajkhand blocks were found to be "Medium" for Phosphorous (1.80) and Potassium (1.99) and "Low" for Nitrogen (1.09) and Sulphur (1.12).

Key words: *Mining area, Cultivated area, Physico-chemical properties, Nutrient index.*

Introduction

A biologically active porous material called soil is found on the topmost layer of the Earth's crust and is formed by weathering processes under various influences. Soil quality is defined as "the capacity of a soil to function, within ecosystem and land use boundaries, to sustain productivity, maintain environment quality, and promote plant and animal health" (Doran and Parkin, 1994). The ability of a soil to support crop growth in an agricultural field depends on a number of soil properties, including physical, chemical and biological. Many of these characteristics may change by management, and soil quality can be enhanced in accordance with function.As the population of the nation grows, there is a constant pressure on the soil, which causes it to deteriorate and eventually become unsuitable for crop cultivation. Soil fertility must be preserved in order to feed the alarming population. Inclusion of a legume crop in acropping system can improve soil physical and chemical properties, particularly in predominantly rice cultivating areas (Kumar *et al*., 2020). A balanced application of organic and inorganic fertilizers could be beneficial to both soil nutrient availability, soil health and crop growth (Das *et al*., 2021).

Madhya Pradesh is a central Indian state with nearly 72 million people. The state is divided by the Narmada River, which runs east-west between the Vindhya and Satpura ranges; these ranges constitute the traditional northern and southern boundaries of India. Balaghat is a district in Madhya Pradesh. Its administrative headquarters are at the town of Balaghat. It occupies the south eastern portion of the Satpura Range and the upper valley of the Wainganga River. Malanjkhand also referred to as MCP (acronym for Malanjkhand Copper Project) is an open-pit copper mine in India, located near the town of Malanjkhand, 90 Kilometres (56 mi) northeast of Balaghat in Madhya Pradesh, at an altitude of 576 MRL. It falls in the tehsil of Birsa. Due to the mining area the physical and chemical condition were affected adversely. Different physico-chemical characteristics of the Balaghat and Malajkhand block'sMoil regionin Balaghat district of Madhya Pradesh has been determined by using standard methods.

Materials and Methods

The Study site

The geographical location of Balaghat is within 21.19' to 22.24' North latitude and 79.31 to 81.3' East longitude. The total area of Balaghat is 9245 sq. km. with total cultivated area 302500 ha. The average maximum temperature in May was approximately 43°C, and the average minimum in December was 8°C. Balaghat district receives 1294.5 mm of rainfall on average per year. Soil sampling was done from the two blocks namely, Balaghat and Malajkhand.

Soil sampling and analysis

GPS based 75 surface soil samples were collected randomly at a depth of 0-15 cm with the help of khurpi from different locations across both the blocks of Balaghat district. The soil samples were mixed thoroughly and about a half kilogram of composite samples was drawn from each site and kept into properly labeled sample bags. Soil samples were brought to the laboratory and air dried, crushed with wooden roller, sieved through 2 mm sieve and used for determination of various soil physico-chemical characteristics. The physical parameters include bulk density, particle density, water holding capacity, whereas chemical parameters include pH, Electrical conductivity, Organic Carbon, Macro-Nutrients (N, P, K, S).

Bulk density and Particle density were determined by pycnometer. Water holding capacity was determined by Keen's box (Piper, 1966). The pH was determined by pH meter (Chopra and Kanwar, 1982) after making 1:2.5 soil: water suspension. Electrical conductivity was determined by electrical conductivity meter (Sparks, 1996). Percent Organic Carbon was estimated by Wet Oxidation method (Walkley and Black, 1934). Available Nitrogen was estimated by Alkaline Potassium Permanganate method, using Kjeltech semi auto analyzer (Subbiah and Asija, 1956). Available phosphorus was determined by Spectrophotometric method as described by (Olsen *et al.,* 1954). Available Potassium was estimated by Neutral normal Ammonium Acetate extraction followed by Flame photometric method (Hanway and Heidal, 1952). Available Sulphurwas estimated by Turbidimetric method followed by Spectrophotometric analysis (Chesnin and Yien, 1951). The available major nutrient content and various physico-chemical characteristics of the soils were estimated for the correlation analysis of the data. The formula for the nutritional index (NI) and the division of nutrients into low (1.5), medium (1.5 to 2.5), and high (>2.5) categories as proposed by Parker *et al*. (1951).

Results and Discussion

The study revealed that the bulk density of the soil sample in the Balaghat and Malajkhand block of Balaghat district ranged from 1.27-1.48 g cm^{-3} for Mining area and 1.20-1.35 g cm^{-3} for normal cultivated area away from mines, with a mean of 1.38g cm^{-3} for mining area and 1.27g cm^{-3} for away from mining area. This implies that soils were permeable, well-aggregated, loose, and rich in organic matter. Patil and Chaturvedi (2012) observed similar outcomes in soil from the M.P. district of Jabalpur. Particle density varied from 1.53-2.58 g cm^{-3} for mining area and 1.73-2.81 g cm^{-3} for area away from mines, with the mean value of 2.09 g cm^{-3} for mining area and 1.98 g cm^{-3} for area away from the mines. The porosity of the sample in Balaghat and Malajkhand block ranged from 40.61-63.28 % with the mean value of 54.98% for mining area and for the normal cultivated area it ranged from 45.31-70.22% with the mean value 61.15%. Similar results were observed in the soil of Sarni, Betul M.P., as per Saxena *et al.* (2010) for both Particle density and Porosity. The Balaghat and Malajkhand blocks of the Balaghat district's cultivated soils and soil near mines had water holding capacities that ranged from 57.74 to 89.61% with mean value of 69.23 %and 46.52 to 82.98 % with the mean of 67.52 %, respectively. The pH of mining region and normal cultivated area, ranged from 6.9 to 8.3 and 7.1 to 8.2, respectively. With a mean value of 7.59 for mining and 7.58 for normally cultivated area, respectively. It was found that a majority of soil samples (48 %) were in the neutral reaction range and the remaining 52 % samples were in the slightly alkaline reaction range. Similar findings were recorded by Ahirwar *et al*. in 2021. The data revealed that the soil EC of the study regions as area near mines and cultivated area away from the mines was found to vary from 0.12-0.68 dSm^{-1} and 0.13-0.69 dSm^{-1} with a mean value of 0.34 dSm^{-1} and 0.42 dSm^{-1}, respectively. 100% of the samples were found low in EC which indicates that soils had low soluble salts and were suitable for cultivation of almost all crops. Similar results for different soils were also reported by Tomar (1968). Organic carbon content of the surface soil in the Balaghat and Malajkhand block of the Balaghat district ranged from 0.10-1.68 % in areas near mines and 0.18-2.33 % in cultivated areas away from mines, with a mean value of 0.83 % and 0.98 %, respectively. The range and mean values of different Chemical properties are given in Table 3. Greater soil organic carbon enhances water retention, and aeration while lowering erosion and nutrient leaching risks. Findings of Singh *et al.* (2014) and Y.li. *et al*. (2018) also support the findings of present study. Available nitrogen content ranged from 87.81-275.97 kg ha^{-1} for cultivated area near mines and 75.26-388.86 kg ha^{-1} in cultivated area away from mines with a mean value of 146.12 kg ha^{-1} for area near mines and 199.38 kg ha^{-1} in area away from mines. 68 samples (90.66%) of the samples were found to be low in Nitrogen and 7 samples (9.33%) were found to be medium in range according to the limits suggested by Ramamoorthy and Bajaj, 1969, Yadav *et al*. (2018) reported similar findings in the soils of Alirajpur district in M.P. Available phosphorous varied from 10.12-20.64 kg $ha^{-1}$for cultivated area near mines and 11.89-20.99 kg ha^{-1} in cultivated area away from mines with a mean value of 13.95 kg ha^{-1} for area near mines and 16.17 kg ha^{-1} in area away from mines. 15 samples (20%) were found to be low in phosphorous and 60 samples (80%) were found to be medium in range according to the limits suggested by Ramamoorthy and Bajaj, (1969). Soils rich in organic matter deliver organic phosphates to the plants. Similar results were reported by Singh *et.al*. (2014) in Chambal region of M.P.

Available potassium content varied from 112-306.88 kg ha^{-1} for cultivated area near mines and 166.88-378.56 kg ha^{-1} in cultivated area away from mines with a mean value of 204.17 kg ha^{-1} for area

Table 1. Nutrient Index values of Balaghat and Malajkhand blocks

S.No.	Available Nutrient	NIV	Category
1	Nitrogen	1.09	Low
2	Phosphorous	1.80	Medium
3	Potassium	1.99	Medium
4	Sulphur	1.12	Low

Table 2. Correlation between physico-chemical properties and available nutrients in soil of mining area of Balaghat and Malajkhand blocks

	N	P	K	S
pH	-0.099*	-0.148	-0.346	-0.216*
EC	-0.114	0.210	0.512	0.253
BD	0.148	0.194	-0.521**	-0.510
PD	0.078	0.034	-0.042	-0.172
WHC	-0.157	0.065	0.333	0.031*
OC	-0.153	-0.143	0.225	0.209

Table 3. Correlation between physico-chemical properties and available nutrients in soil of normal cultivated area of Balaghat and Malajkhand blocks

	N	P	K	S
pH	0.104	0.008	0.324	-0.126**
EC	0.662	0.535	0.714	0.543*
BD	0.367	0.091	0.165**	0.007
PD	0.011	-0.008	0.006	0.132
WHC	-0.058	-0.073	-0.121*	-0.016*
OC	-0.063	-0.392	-0.089	0.165

near mines and 267.92 kg ha^{-1} in area away from mines (Table 4 & 5). According to the standards given by Ramamoorthy and Bajaj (1969), 4 samples (5.33%) out of total sampleshad potassium concentration in the low range, 67 samples (89.33%) were in the medium range, and 4 samples (5.33%) were in the high range. The expanding clay mineral (Montmorillonite) of the research area is responsible for the medium to high potassium status of the soil. It tends to trap K inside the clay lattice and adsorb onto surface negative sites. Similar findings were reported by Wani *et al*. (2014) in the soils in Gwalior M.P. Sulphur content of the study area found tobe ranging from 1.11-9.36 mg kg^{-1} for cultivated area near mines and 2.51-13.43 mg kg^{-1} in cultivated area away from mineswith a mean value of 3.83mg kg^{-1} for area near mines and 8.34 mg kg^{-1} in area away from mines. Soil of both the blocks were found low in Sulphur content as 66 samples (88%) were found low in Sulphur content and 9 samples (12%) were found medium in Sulphur, according to the ideal range given by Ramamoorthy and Bajaj (1969). Tagore *et al.* (2014) reported a similar set of results in Indore, M.P.

Evaluation of Nutrient Index: It is required to obtain a single value for each and every nutrient in order to evaluate the soil fertility levels of one area to another area. Nitrogen, phosphorus, potassium, and Sulphur each had nutritional index values of 1.09, 1.8, 1.99, and 1.12, respectively, shown in Table 1. For the macronutrient in the soil of Madhya Pradesh's Jhabua district, Patidar *et al*. (2017) found comparable results based on soil nutrient index values. The Nutrient value index for soil of Balaghat and Malajkhand blocks was "Medium" for Phosphorous and Potassium and "Low" for Nitrogen and Sulphur, according to the range suggested by Parker *et al.* (1951).

Correlation

A correlation research for the mining area showed a poor correlation between pH and the soil's N, P, K, and S contents, as shown in Table 2. EC was negatively related with nitrogen and positively correlated with phosphorus, potash, and Sulphur. When compared to nitrogen and phosphorus, bulk density and particle density exhibited a positive correlation, while potash and Sulphur showed a negative correlation. Phosphorus, potash, and Sulphur all correlated positively with water holding capacity, but

Table 4. Statistical analysis of soils of Mining area:

Parameters	Mean	SD	Range	CV (%)
pH	7.59	0.36	6.9-8.3	4.76
EC dSm^{-1}	0.34	0.15	0.12-0.68	42.31
BD gcm^{-3}	1.38	0.06	1.27-1.48	4.60
PD gcm^{-3}	2.10	0.25	1.54-2.58	12.06
WHC (%)	67.52	7.94	46.52-82.98	11.75
OC (%)	0.83	0.40	0.10-1.68	48.18
N kg/ha	146.12	46.41	87.81-275.97	31.76
P kg/ha	13.95	2.37	10.12-20.64	17.00
P kg/ha	204.17	48.91	112-306.88	23.95
S mg/kg	3.83	2.10	1.11-9.36	54.74

Table 5. Statistical analysis of soil of Cultivated area:

Parameters	Mean	SD	Range	CV (%)
pH	7.58	0.29	7.1-8.2	3.79
EC dSm^{-1}	0.42	0.15	0.13-0.69	35.53
BD gcm^{-3}	1.27	0.04	1.20-1.35	3.19
PD gcm^{-3}	1.98	0.29	1.73-2.82	14.66
WHC (%)	69.23	6.91	57.74-89.61	9.98
OC (%)	0.98	0.56	0.18-2.33	57.59
N kg/ha	199.38	79.22	75.26-388.86	39.73
P kg/ha	16.17	2.69	11.89-20.99	16.62
P kg/ha	267.92	54.13	166.88-378.56	20.20
S mg/kg	8.34	2.60	2.51-13.43	31.14

nitrogen related negatively. Potash and Sulphur had a positive correlation with organic carbon, but nitrogen and phosphorus had anegative correlation. (Table 2).

In a normal agricultural area distant from mines, a correlation analysis showed that pH had a positive correlation with N, P, and K and negative correlation with S. Significant positive correlations between EC and BD with N, P, K, and S were found.Particle Density had a negative correlation with P and a positive correlation with N, K, and S. Nitrogen, phosphorus, potash, and Sulphur all showed negative correlation with water holding capacity. Organic carbon correlated positively with Sulphur and negatively with nitrogen, phosphorus, and potash, as shown in Table 3.

Conclusion

This analysis will assist in recommending farmers to apply the suitable and adequate doses of fertilizer in their agricultural fields in accordance with the requirements of the soil nutrients for improved yield. Results revealed that the soils in the Balaghat and Malajkhand blocks of the Balaghat district were categorized as neutral to alkaline in terms of soil reaction (pH), and all soils with soluble salt values that were less than 1dS m^{-1} were considered safe for the growth and development of plants. It was discovered that the level of organic carbon was medium to high. An analysis of 75 soil samples revealed low levels of available nitrogen, low to medium levels of phosphorus, medium levels of potassium, and low levels of Sulphur. In both areas, there was medium to high water holding capacity. Both bulk and particle densities were seen to be within normal limits. We found that the soil lacked in available phosphorus and nitrogen. As a result, these essential nutrients must be supplied in the right amounts by the use of fertilizer or organic manures.

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