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IMPACT OF SOIL MINING ON SOIL QUALITY IN BUNDELKHAND REGION, U.P., INDIA

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ABSTRACT

Soil Mining causes serious destruction of the surface morphology and soil structure of lands, and vegetation restoration on post-mining lands provides an effective way for soil and water conservation. Study area covers three districts of Bundelkhand region of Uttar Pradesh namely Banda, Chitrakoot and Hamirpur. To determine the impact of soil mining on soil properties in the Bundelkhand region, six land sites, including road construction, canal command area, bricks construction sites, were randomly selected. The total of 18 topsoil (0–15cm) samples and 18 de-surfaced soil (60-90cm) were collected from these six sites, and then soil properties (physical and chemical) were analyzed. The results showed that there was regime shift in most of the parameters excluding EC, available K and silt content after soil mining. The results of the study will facilitate further investigations on available micro-nutrients in subsurface soils after mining in such regions.

***Key words*: **Soil fertility, Environment, Surface soil, Construction

Introduction

The mining has not only played a significant role in economic transformation in resource-rich countries like Australia, Canada, the United States, and parts of Africa but in developing countries like India also (Worlanyo and Jiangfeng 2021). The biodiversity of any region poses serious and significant threats due to mining and however, it provides financial alternatives for livelihood of any country (Sonter *et al.*, 2018). The growth of the vegetation is rehabilitated for post-mining land reclamation through the topsoil, which is an essential component in abandoned mines. The physico-chemical properties and concentration of heavy metals in mined soil areas exceeds the permissible limit and that creates high pollution potential in ex-mining catchment (Saviour and Stalin, 2012). In spite of providing substantial industrial and economic benefits to the community, soil mining also decreases soil organic carbon (SOC) stocks with increased atmospheric carbon levels (Cetin *et al.*, 2023). Thus, mining land areas should be accurately determined with soil properties and treated in a timely way to prevent further degradation and contamination, and appropriate plant species can be selected for restoration of post-mining lands (Hu *et al.*, 2020).

Soil mining is the process of removal of soil where this practice is becoming an environmental issue as the demand for soil increases in the construction of expressway, canals, and bricks. In almost every region, soil mining and land degradation have been inseparably connected.

The Bundelkhand region is characterized by the omnipresence of shallow soils that rest directly on the bedrock. A large area of land (50-70%) in Bundelkhand upland and intermediate zone are not suitable for agriculture. Some of the peoples sell their fertile soil to the stakeholder of different companies for making expressway, canal and bricks. Farmers are making pond to save and conserve water for use in crops in the same or next season. Although, about 50-60% of the soils mined during the construction of ponds that are not surrounded by bunds but it's sold for human habitation. Lifeline Rivers *i.e.* Ken, Betwa and Yamuna of this region supply water for irrigation and other domestic uses. The government began the Ken-Betwa River Linking Project, connecting various districts in Madhya Pradesh and Uttar Pradesh. In order to shape the canal, topsoil is harvested from nearby agricultural areas and used in its construction.

Studies in clay mining regions of Bundelkhand have demonstrated that exceptional increment in the infrastructural needs of the region and the consequent increment in the clay extraction situations have prompted fast deterioration of the lands, which is altogether reflected in the declining agricultural profitability of the region. Brick making has become a whooping lucrative business in many districts such as Jhansi, Banda, Hamirpur, and Chhatarpur. The traditional practices of farming have been wiped out as a number of brick kilns were established in the farmland. This adversely affected the entire landscape causing irreversible damages to soil, hydrology and ecological balance. Many of the mined areas remain barren and reduce the extent of agriculture along with the emergence of serious problem of water scarcity. Keeping all these factors, the objectives of the present study are set to locate and collect the soil samples from the soil mining affected areas, and to investigate the changes in different soil properties after mining.

Material and Method

Study area

Bundelkhand region of central India is situated between longitude 78°20'N and 81°40'N and latitude 23°20'E and 26°20'E and altitude 80-137m covers parts of the states of Uttar Pradesh (in the north) and Madhya Pradesh (in the south). The study area covers three districts of Bundelkhand region namely Banda, Chitrakoot and Hamirpur for mining areas (Fig. 1). The climate is hot and arid, with a mean annual rainfall of 800-900 mm, mean annual temperature 25°C with an average 5-49°C. Region dominated with tropical dry deciduous forests, thorn forests, and scrub forests and the soil types are Black soil and red and yellow soil further sub grouped into Mar, Kabar, Paruwa and Rakar, locally called Bundelkhand soil. Soil mining of this area began in 2018, and the most prevalent mining technique changed from open-pit mining in 2024.

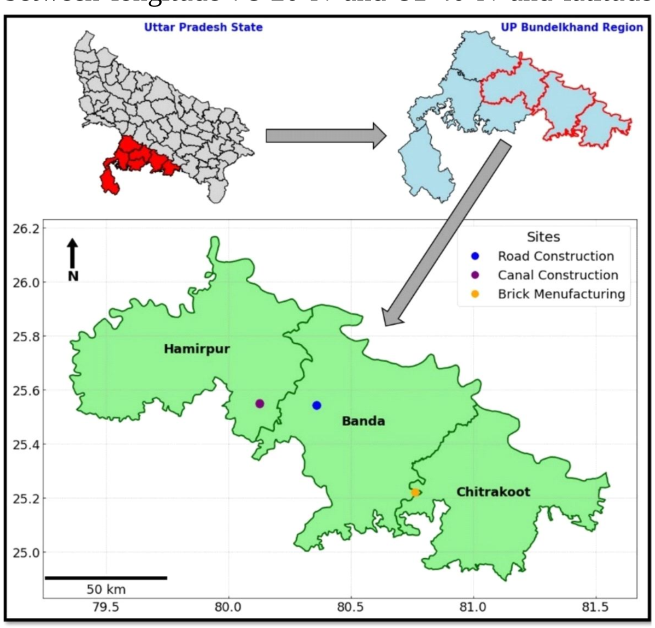

Fig. 1: Location of study area.

Soil sample collection

Based on a comprehensive survey, 18 topsoil samples (0-15 cm) and 18 de-surfaced soil samples (60-90cm) were collected across the study area in February 2024. The coordinates of the sampling points were recorded through Gobal Positioning System (GPS). Plant fragments and visible rock fragments larger than 2 mm were removed by hand. Soil samples were dried at room temperature for soil nutrient analysis.

Soil Chemical Analyses

Bulk density was determined by core sampler and Particle Density by Pycnometer (Piper, 1966), for pH and EC (electrical conductivity) (Jackson, 1973), soil organic carbon (SOC) (Walkley and Black, 1934), Available nitrogen by Subbiah and Asija, 1956, Available phosphorus by Olsen *et al.*, 1954, Available potassium and Sulphur by Hanway and Heidel, 1952. The micronutrients *i.e.*, Mn, Cu, Zn and Fe were determined by using DTPA method and available boron by using hot water (Lindsay and Norvell, 1978).

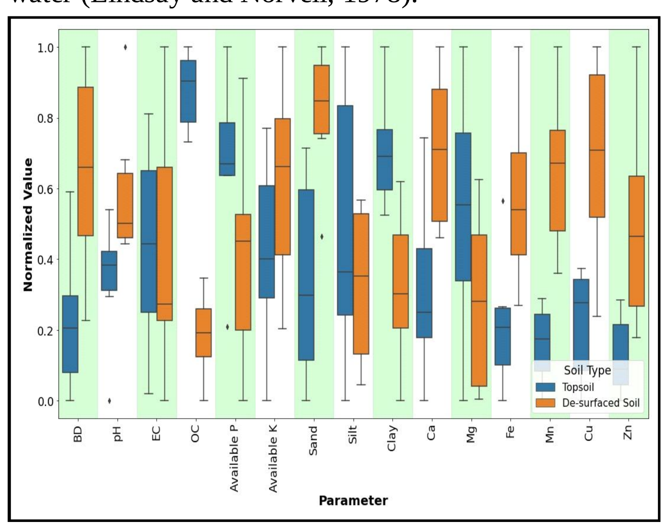

Fig. 2: Comparison of soil parameters (topsoil v/s De-surfaced soil) with normalized values.

Results and Discussion

The natural ecosystems and geological formations are extensively damaged by mining operations, which inevitably results in soil degradation. The study found that high pH, poor soil quality, and significant levels of trace metal pollution were characteristics of the soils from these regions. The regime shift is observed in the pH levels of topsoil and de-surface soil (Fig. 2).

Bulk density is a measure of physical property of the soil which shows the soil air and compaction of soil particles. Soil samples with the topsoil had an average value of 1.53g/cc and de-surfaced soil were 1.62g/cc results more compacted compared to surface soil. It might be due to using heavy equipment and poor organic matter content (Mishra *et al*., 2023). Soil pH moderates the availability of plant nutrients and trace metals mobilization during the restoration of mining sites (Feng, *et al.*, 2019). The pH of surface soil varies from 7.46 to 8.76 with an average of 8.28 while de-surfaced soil ranges from 8.53 to 9.87 with an average of 8.90. Therefore, the increase in pH may be caused by significant number of carbonates (Shrestha and Lal, 2011). EC was non-saline in nature, it ranges from 0.14 to 0.67 with average value of 0.37dS/m. The comparison of all parameters for topsoil and de-surfaced soil is depicted in Fig. 2.

The content of SOC decreased significantly in the de-surfaced soil. Removal of topsoil layers rich in organic matter, resulting in significant losses of soil organic carbon (SOC). Organic carbon is a major source of food for soil biodiversity. OC (%) in top soil samples ranges from 0.51 to 0.58 with an average of 0.55 while in de-surfaced soil samples ranges from 0.32 to 0.41 an average value of 0.37. Due to top soil harvesting, about 33% of organic carbon decreases compared to surface soil. The decreasing value of OC with soil depth might be the removal of topsoil containing rich biodiversity and vegetation (organic matter). The soil solution nutrient pool consists of nutrients that are dissolved in the water that occupies the pore space within soils (Hogberg, *et al.*, 2020). Phosphorus is available for plants in very narrow soil pH. In this study, available phosphorus was significantly decreased (about 14%) after disturbance with an average value change from 16.5 to 14.2 kg/ha. The increase in available potassium, sand, in de-surface soil compared with surface soil is about 16.5%, 12% respectively whereas, decrease in silt and clay are about 14% and 13% respectively. Naturally deposition of $CaCO_3$ in soil profile of this region is very common. In this study, Ca content increased by 30% in subsurface soil compared to topsoil samples. The concentration of Ca in the lower soil profile may be significantly impacted by high temperature and insufficient rainfall (Hu, *et al.*, 2020).

The micronutrients *i.e* Iron (Fe), Manganese (Mn), Copper (Cu) and Zinc (Zn) content significantly increased by 31.1%, 47.8%, 45.5%, 32.2%, respectively, in de-surfaced soil compared to topsoil. In the process of soil mining and beneficiation, the rocks and minerals are usually broken, so it is easy to change the trace metals form and release them into the surrounding environment (Tabelin, *et al.*, 2018).

Conclusions

The study determined the soil mining activities and its effects on soil quality. After mining, the bulk density and pH of de-surfaced soils significantly increases compared to top soil results reduction of soil productivity. The SOC and available phosphorus in soils under top soil was greater than harvested soil. The indiscriminate mining of top soil from agricultural lands for constructing roads has resulted in the deterioration of the physical and chemical properties of soil. It is clearly observed that there is a regime shift in most of the soil parameters excluding EC, available K and silt content after soil mining. As a solution suitable agro-forestry models must be adopted for rehabilitation and restoration of the soils in the affected areas. Further studies may also be conducted to continuously monitor the rehabilitation process of such soils.

Conflict of Interest

The authors declare that they have no conflict of interest. All the authors have read and agree on the present form of manuscript.

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