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Comparative Evaluation of Soil Fertility Status in Mining and Non-Mining Areas of Bageshwar District, Uttarakhand (India)

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Abstract: This study focuses on assessing the deterioration of soil fertility caused by soapstone and magnesite mining in the Kumaun hilly regions of Bageshwar district, including Kanda, Dafaut, Kafligair, and Reema, in comparison with nearby non-mining areas. Important soil fertility parameters such as pH, organic carbon, macronutrients (K and P), and micronutrients (S, Fe, Cu, Mn, and Zn) were analyzed using standard analytical methods. The findings revealed a significant decline in essential soil fertility attributes in the mining-affected areas, indicating the adverse impact of mining activities on soil health and productivity.
Key words: Bageshwar**.** Macro and Micronutrients**.** Mining areas**.** Soil fertility

Introduction

The agricultural land is the source of livelihood for residing people in Bageshwar. Soil is the top layer of the Earth's crust that provides essential requirements for plant growth and ecosystem functions, naturally. The study area is susceptible to mining therefore keeping in view, the assessment of soil fertility status become necessary to predict the availability of nutrients for sustainable crop production and recommendation of fertilizers for specific crops according to regional conditions. Mining operations are focused in Kanda, Dafaut, Reema and Kafligair where extraction of minerals such as soapstone (talc) and magnesite has been carried out for decades. The mining activities across different parts of the country have serious effects on the cultivable land and the forest area soil (Guha 2014, Lad and Samant 2015). Mining leads to the removal of fertile top soil, producing ground instability, loss of forest and wildlife, loss of organic matter, soil erosion, degradation of agricultural lands and contamination of soil and water quality with heavy metals (Lamare and Singh 2014).Impacts of mining alters the physicochemical properties of soil, and disturb the local ecology. (Mohapatra and Goswami 2012) examined soil characteristics in opencast coal mining regions under different conditions, focusing on texture, organic carbon and nutrients and similarly (Ghose 2004) studied opencast mining activities and their impact on the physicochemical and microbiological properties of soil in Eastern Coalfields Limited. Several studies have been reported different issues caused by mining across different regions of India (Yaseen et al. 2012, Prathap et al. 2016, Masto et al.2015, Reza et al. 2015, Ramli et al. 2020). Khedkar et.al (2020) studied soil properties of agricultural land of Garud block in Bageshwar district. Physicochemical parameters of all blocks of Bageshwar in non-mining area have recently been analyzed in these laboratories (Majila and Shah 2024). Present study of comparative investigation of soil parameters (mining and non-mining areas) of Bageshwar district has not been done before in my knowledge.

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Material and methods

Study area and sample collection: Bageshwar district is located in the central region of Uttarakhand, India, at 29.49° N latitude and Himalayan 79.45° E longitude, with an elevation of 935 m above sea level (Fig 1). Soil samples were collected from the surface layer (0–15 cm depth) using a spade, and each sample was properly labeled. A total of four distinct mining and non-mining sites within Bageshwar district were selected for sampling to assess the influence of mining activities on soil fertility status. The soil type was sandy loam and grayish brown.

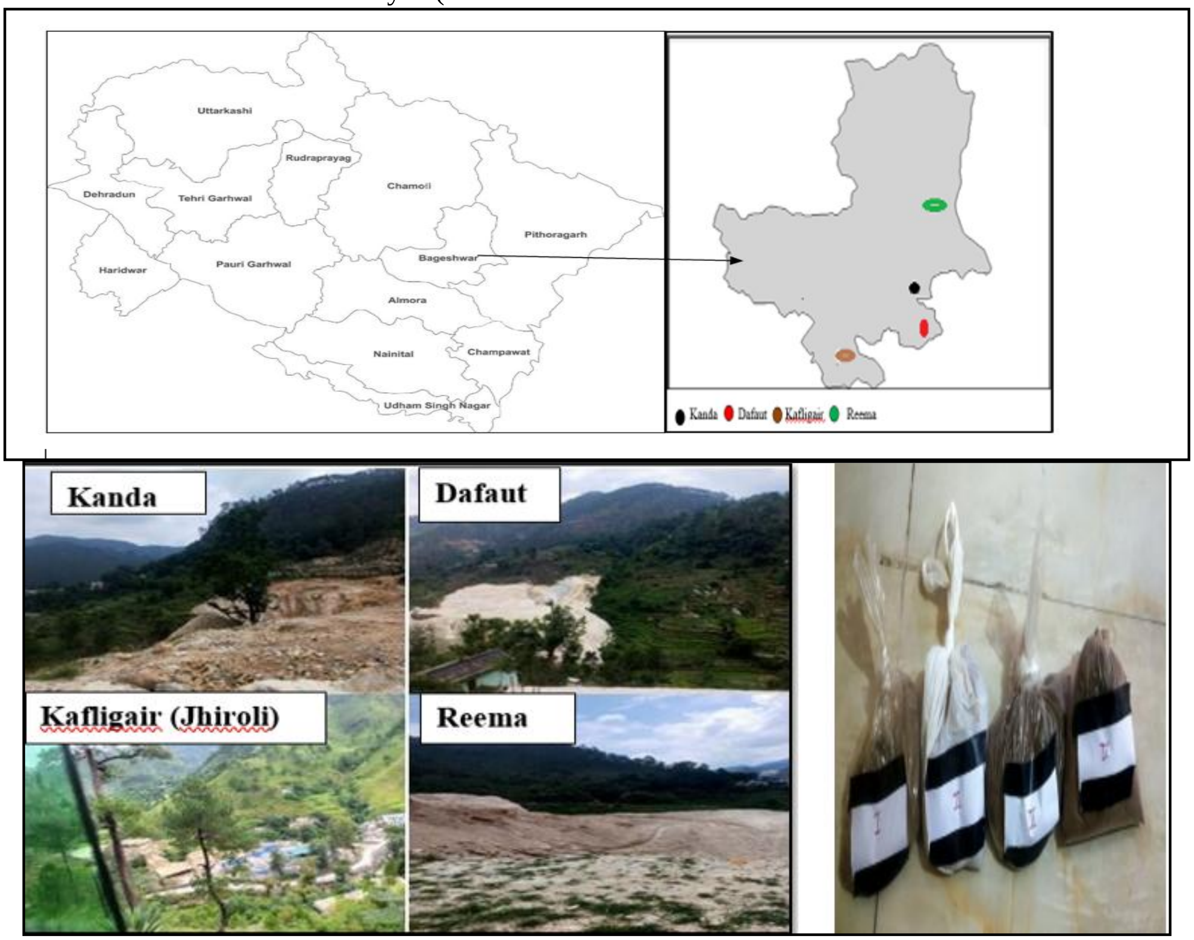

Fig.1: Sampling areas

Analysis of sample: The collected soil samples were air-dried in shade, crushed using a crusher, and passed through a standard sieve before analysis. The processed samples were then utilized to determine soil pH, organic carbon, macronutrients, and micronutrients using standard laboratory techniques. Soil pH was determined in a 1:2 soil-to-distilled water suspension using a glass electrode pH meter (Jackson 1973). Organic carbon was estimated by the titration method (Walkey and Black 1934). Available phosphorus was extracted using 0.002 N H_2SO_4 solution, followed by the addition of ammonium molybdate and 5 drops of stannous chloride solution (Truog 1930). Available potassium was determined by extracting the soil with ammonium acetate solution, treated with 40% ethyl alcohol and analyzed using a flame photometer (Metson 1956). Sulphur content was estimated by the turbidimetric method with UV spectrophotometer (Chesnin and Yein 1950). Micronutrients (Cu, Fe, Mn, and Zn) were extracted using DTPA solution and quantified

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through Atomic Absorption Spectroscopy (AAS) (Lindsay and Norvell 1978).

Result and Discussion

Soil parameters of non-mining and mining areas of Bageshwar district is presented in Table 1.

Table 1: Soil parameters of non-mining and mining areas of Bageshwar district

	Parameters									
Area		**pH**	**OC%**	**K (kg/h)**	**P (kg/h)**	**S (ppm)**	**Fe (ppm)**	**Cu (ppm)**	**Mn (ppm)**	**Zn (ppm)**
Kanda	**Non-mining**	7.58	2.11	347.20	22.51	12.47	20.00	2.62	7.18	2.60
	Mining	6.40	0.15	101.64	9.00	9.29	6.30	0.18	3.92	1.00
Dafaut	**Non-mining**	7.51	1.27	349.44	27.00	31.39	31.68	3.00	5.18	1.68
	Mining	6.60	0.40	109.76	9.45	10.44	5.10	0.12	3.16	0.10
Kafligair	**Non-mining**	7.72	1.79	373.20	18.00	16.20	30.02	3.28	6.52	5.91
	Mining	6.38	0.61	105.12	9.50	9.40	4.50	0.96	4.22	1.22
Reema	**Non-mining**	7.68	1.74	301.60	23.00	11.80	29.40	2.00	7.09	2.78
	Mining	6.51	0.30	76.16	9.20	8.26	4.00	1.02	4.08	0.46

Soil pH: Comparison of soil pH analysis of non-mining and mining areas showed a decrease of 1.18 in Kanda, 0.91 in Dafaut, 1.34 in Kafligair, and 1.17 in Reema. The decrease in soil pH is responsible for slightly acidic soil restricted root growth and reduces microbial activities (Fig 2).

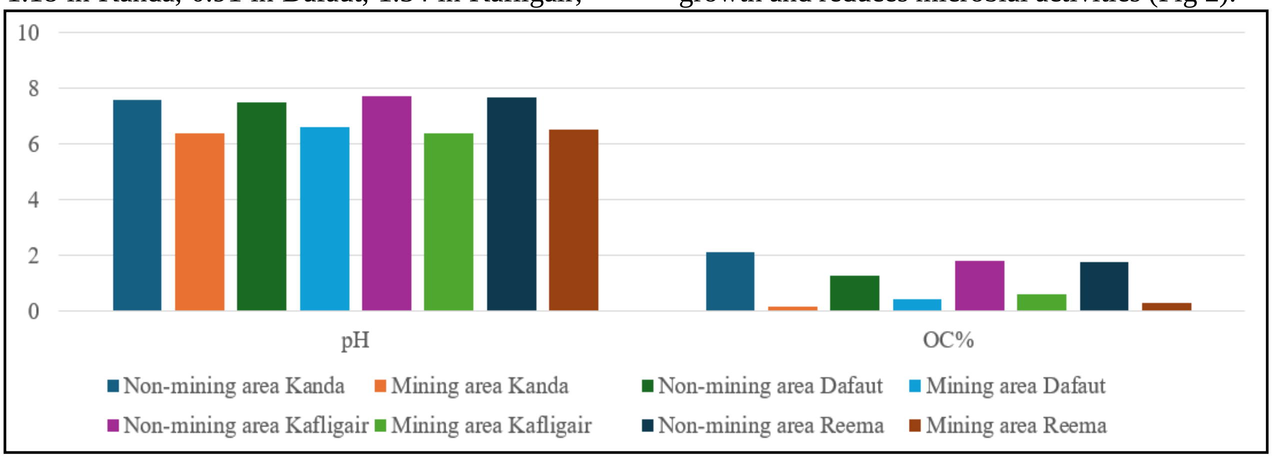

Fig. 2 Graphical representation of pH and OC%

Organic Matter Content (%): The organic carbon content is vital nutrient of soil for crop production. At Kanda, the decrease in organic carbon (OC%) was 1.96% while at Dafaut, Kafligair, and Reema the value declined by 0.87%, 1.18%, and 1.44% respectively. The findings indicated that the organic carbon percentage steadily decreased in the soil of mining areas, resulting low production of crop compared to non-mining areas. The deficiency of OC% deteriorates soil structure and lowers ability to hold nutrients and water (Fig 2).

Available Potassium (Kg/h): The assessment of available potassium was observed with much difference across the soil of the study area. The fall of 245.56 Kg/h in potassium content was recorded at Kanda, 239.68kg/h, Dafaut, 268.08kg/h, Kafligair, and 225.44 kg/h at Reema. The results showed that soils from mining areas were lower in potassium content,

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reflect negative impact on growth of the plant compared to non-mining areas soil (Fig 3).

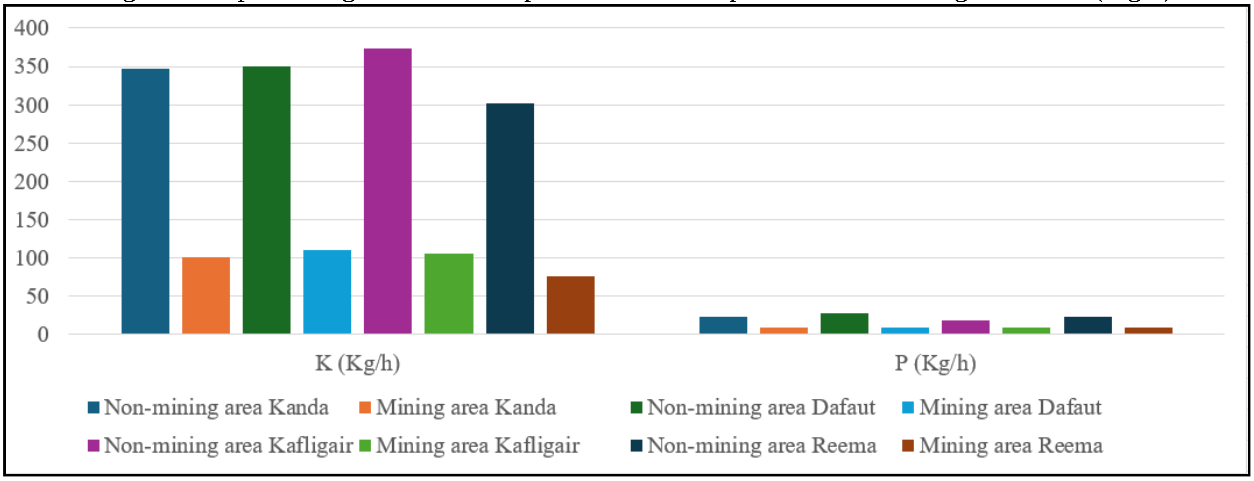

Fig. 3 Graphical representation of macronutrients

Available Phosphorous (Kg/h): The available phosphorus contents were calculated with noticeable differences between mining and non-mining areas. At Kanda, phosphorus was decreased by 13.51kg/h, Dafaut by 17.55 kg/h, Kafligair by 8.50kg/h and Reema by 13.8kg/h which results below by low limit for crop production. Phosphorous deficiency is responsible for to dark green to blue green colouration of folliege (Hassan et al. 2025).

Sulfur (ppm): The outcome revealed that presence of sulfur (S) declined by 3.18 ppm in Kanda, 20.95 ppm in Dafaut, 6.80 ppm in Kafligair and 3.54 ppm in Reema. The low range of sulphur was investigated for colour change from green to yellow (Narayan et al. 2022).

Iron (ppm): The study recorded a decrease in iron concentration by 13.7 ppm, 26.58 ppm, 25.52 ppm and 25.4 ppm at Kanda, Dafaut, Kafligari and Reema respectively. Iron deficiency leads to chlorosis in plants (López-Millán et al. 2013).

Copper (ppm): The micronutrient Cu is activator of enzymes for the growth of the plants. The declination of copper concentration by 2.43 ppm at Kanda, 2.88 ppm Dafaut, 2.32 ppm Kafligair and 0.98 ppm at Reema was observed. The values investigated were falls in medium to low range.

Manganese (ppm): The analysis exposed a reduction in manganese concentrations of 3.26 ppm at Kanda, 2.02 ppm at Dafaut, 2.30 ppm at Kafligari, and 3.01 ppm at Reema. An appreciable difference was observed in manganese content between non-mining and mining area soils. The low value of Mn affects flowering development of plant (Saini et al. 2022).

Zinc (ppm): Zinc is vital component for hormonal activities in plants facilitating the growth. The results indicated a slight decrease in zinc concentrations by 1.6 ppm at Kanda, 1.58 ppm at Dafaut but considerable difference of 4.69 ppm at Kafligair and 2.32 ppm at Reema. The Zinc deficiency decreases the enzyme activity in leaves and roots (Fig 4).

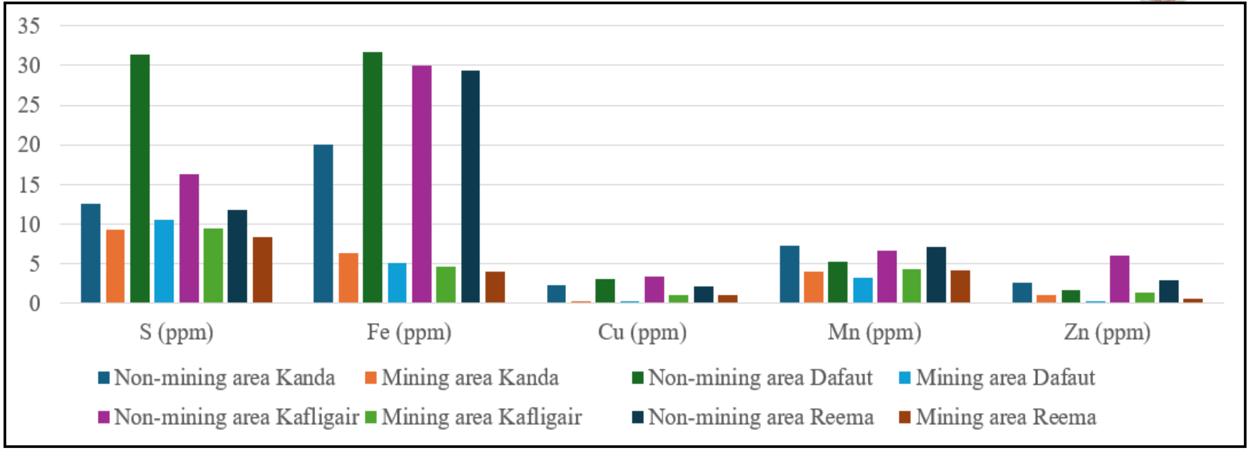

Fig. 4 Graphical representation of micronutrients

Conclusion

The significant decrease in soil fertility due to mining disturb every parameter necessary for soil health, leading to degraded quality, reduced productivity, and long-term challenges for maintaining sustainable crop production. Additionally, it weakens rural livelihoods, health, and the environment, triggers to issues like migration, landslide, floods, and earthquake. It is required to stop mining beyond rules and regulation scientifically and also there is need of making and implementing new strategies for maintaining the quality of the essential resource soil, for rural Himalayan area and conserving environmental sustainability.

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