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Degradation of the Soil Quality Parameters in the Industrial Regions of India

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ABSTRACT
The increasing demands of the growing population have triggered rapid industrial growth that disrupts natural resources. Soils surrounding such industrial areas are largely exposed to industrial sludge, effluents, and other wastes because the necessary effluent treatments and disposal strategies are largely missing. These wastes alter the quality parameters of the soil and make it unsuitable for public use. The objective of this research was to investigate the load of heavy metal and variability in other soil characteristics of industrially contaminated soil samples. To achieve the objective, four industrial regions were selected namely, Punjab (Ludhiana), Rajasthan (Sanganer and Bapi), and West Bengal (Kasba). These soil samples were investigated for the chemical values of arsenic (As), lead (Pb), calcium (Ca^{+2}), manganese (Mn), copper (Cu), phosphorus (P), sulphur (S), potassium (K), nickel (Ni), organic matter (OM), nitrogen (N), pH and electrical conductivity (EC). The soil tests revealed that As, Ni, Cu, Mn, and Pb were present in higher concentrations as compared to permissible & standard values by WHO and other municipal authorities. The soil quality parameters also differed greatly from the standard values. Overall, the study shows these sites are polluted and the soil samples are not suitable for domestic, irrigation, agricultural and other purposes.
***Keywords**: Soil quality, heavy metals, contaminated, physicochemical characteristics*

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INTRODUCTION

The physicochemical parameters of the soil are very important to meet the basic need of all organisms living on the earth including the entire microbial community living in the soil. The physical and chemical properties of soil are affected by heavy metal contamination, and these parameters help people to determine the productivity and nature of further use of soil. Heavy metals have the property of proliferating in biotic systems and subsequently polluting the food chain and persisting in the environment. ([1]). Heavy metal hazards are present in more than 40 countries worldwide, including the USA, Egypt, Prague, Bangladesh, Pakistan, Argentina, China, India, Canada, Chile, Myanmar, Brazil, etc. ([2],[3]). There are many anthropogenic and geogenic modes of heavy metal pollution, but the most common mode and occurrence are mining activities around the world ([4]). The industries like fertilizers, pesticides, textile, clothing , paints, pulp & paper, thermal power plants, steel mills, tanneries, and mining companies contributes to excess metal pollution ([5], [6], [7], [8], [9], [10], [11], [12]).Several authors have noted that repeated exposure to heavy metals can cause potentially fatal diseases such as various types of tumors, kidney lesions, breakdown or failure of the excretory &nervous systems, hypertension, kidney inflammation, airway obstruction, anuria, cardiovascular system dysfunction, osteoporosis, and many more ([13], [14], [15]). These metals accumulate and have toxic effects on the organs of the organism later stage in life ([16]). To solve this problem of heavy metal pollution, government organizations and various municipal authorities have established certain standard protocols and limits to indicate the pollution level of soil throughout the world. These include WHO (World Health Organization)([3]), BIS (Bureau of Indian Standards)([17]), ICMR (Indian Council of Medical Research)([18]), CPCB (Central Pollution Control Board([19]) etc. These institutions recommended desirable heavy metal concentrations and other physiochemical properties of soil to control pollution and improve the survival of organisms. In the present study the physiochemical properties and heavy metal toxicity were compared against these limits in soil samples to determine contamination levels. With continued urbanization and economic progress, our environment and the health of all organisms are threatened, so regular monitoring of extent of these pollutants and implementation of preventive measures should be adopted.

MATERIAL AND METHOD

Soil Sampling: The impacted soil was collected from four industrial regions of India for soil quality assessment from each site three random samples were taken from a depth of 10 to 20 cm in previously ethanol-cleaned polypropylene zipper lock bags and stored in refrigerator prior to analysis. The un-impacted underground soil from Rajasthan University campus used as control. The industrial soil was collected from three states of India namely, Punjab, Rajasthan and West Bengal. The table 1 provides the details of the study areas selected for soil sample collection.

Table 1:**Soil Sample Collection Sites with location**

S. No.	Soil sample Area	Longitude & Latitude	Symbol
1.	Ludhiana Industrial Area,(Punjab)	30˚.55' north latitude and 75˚.54'east longitude	L
2.	Sanganer Industrial Area (Rajasthan,Jaipur)	26˚.55' north latitude and 75˚.49' east longitude	J
3.	Kasba industrial area (West Bengal ,Kolkata)	22 ˚.57' north latitude and 88 ˚.36' east longitude	K
4.	Bapi Industrial area (Dausa,Rajasthan)	26 ˚.88' north latitude and 76˚.33' east longitude	B

2.Physicochemical characterization of soil samples: All soil samples were characterized for parameters like pH, electrical conductivity, organic matter,Moisture content, exchangeable calcium, manganese, phosphorus, Sulphur, nitrogen, and many other heavy metals such as Zinc(Zn), Arsenic(As), Copper(Cu), Lead(Pb), Manganese (Mn) and Nickel (Ni) content using standard methods([20,21]).

3. Statistical Analysis- Each analysis was run in triplicate to obtain the average value further the averaging of each parameter at one site is reported as Mean ±Standard Error.

RESULTS AND DISCUSSION

The variable physicochemical properties of the selected industrial soil samples are presented in figures 1 and 2. The parameter-wise results and discussion as given in the following text provide a wholesome idea about the state of soil degradation.

pH - The pH is a simple but very important estimate to observe the acidity, alkalinity, and neutrality of the soil. The pH greatly affects the availability of nutrients and the microbial population living in it ([22]). The pH of all the studied soil samples was in the range of 7.34-8.47, indicating slightly alkaline character (figure1 d). According to the WHO and ICMR guidelines, a pH between 6.5 and 8.5 is considered a suitable range for microbial growth. All the soil samples except the Kasba industrial area had pH in the above-mentioned range and were suitable for microbes. Only Kasba soil samples showed higher levels of alkalinity which might pose an inhibitory effect on normal soil microbiota,([23,24])have also reported slightly alkaline character of the industrial soil samples

Electrical conductivity (Micro mho/cm) - Electrical conductivity(EC) is a measure of levels of salts and ion transport in the soil solution ([25]). In all the studied soil samples, electrical conductivity was in the range of 242.38± 7.63 - 938.86±4.35 (micro mho/cm) with the mean electrical conductivity of all the soil samples being 518.26±16.7(micro mho/cm) (figure 1g).The highest electrical conductivity was found in sample 2 (Sanganer industrial area), which is well known for textile factories. In our earlier studies on soil of Sanganer textile area EC was in range of 0.356-2.58 mS([26]) , Similar results of high EC have been reported by([24])in Bhairavgarh, Ujjain dye industrial area.

Organic Carbon and Moisture Content (%) - Organic carbon(OC) increases nutrients, soil quality, structure, and water-holding capacity ([27, 28]). The OC content of the studied industrial soil samples ranged from 0.47±0.01% to 1.75±0.05% and had a low to medium organic carbon content with a mean value of OC as 1.10±0.31%. The highest moisture content among the industrial soil samples was recorded in the Sanganer sample at 25.96±0.77% (figure 1b) .The organic matter and moisture content were lower in the industrial soil samples compared to the uncontaminated soil samples (control) (figure 1c). These results also coincides with soil of Pune industrial area([29]) with less organic matter and lower moisture content in the soil samples.

Exchangeable Calcium (meq/100g)– Calcium is also an important nutrient needed for better microbial growth. The calcium content in industrial soil samples ranged from 2.5±0.10 meq/100g in Ludhiana, industrial area to a maximum of 8.63 ±0.18meq /100 g in Bapi, industrial area. Almost similar results were reported in the industrial zone of Maharashtra ,a state of India[30] (figure 1f).

Potassium (%)-The Potassium content of all the industrial soil samples was lowest in Ludhiana industrial area (1.69±0.07%) and highest in Sanganer industrial area (2.15±0.07%). TheBapi and Kasba (WB)industrial areas has intermediate levels of Potassium content in soil. The results showed a deficiency in nutrients and productivity of soil due to a potassium deficiency. Potassium deficiency was reported by([30])in Maharashtra industrial area (figure 1e).
Sulphur and Nitrogen content (%) – The content of Sulphur and Nitrogen provides the suitability of soil for plant growth as these are considered as limiting factors([31]).The mean Sulphur content of all the industrial soil samples was in the range of 0.04- 0.35 % . Low Sulphur content in the industrial area was also reported by ([32]) due to inclusion of other contaminants (figure 1h). The nitrogen % of the studied industrial soil was in the range of 0.36-1.04 % (figure 1a).Nitrogen deficiency was observed due to untreated heavy metal discharge in the industrial areas.

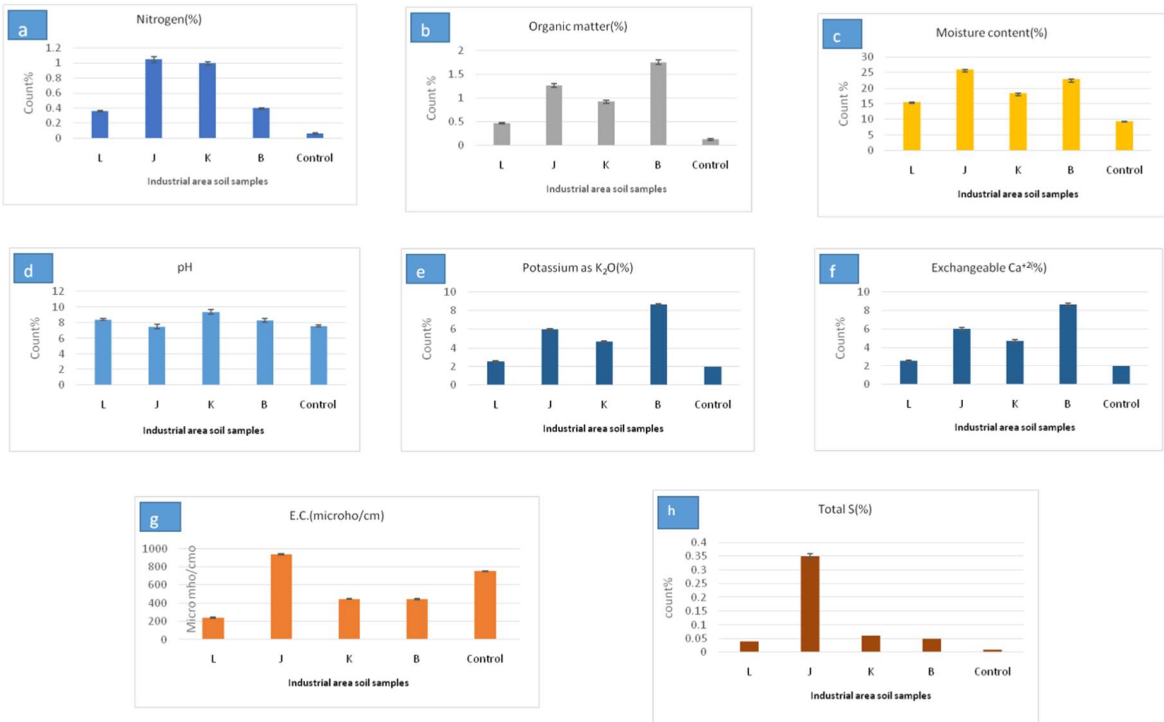

Figure 1: - Physiochemical characteristics of the studied soil samples(a)Nitrogen,(b) Organic matter, (c) Moisture content(d)pH(e) exchangeable calcium, (f) Potassium as K_2O (g)Electrical conductivity (h)Total Sulphur

Heavy metals estimation
Zinc(mg/Kg)- Sanganer and Bapi industrial area were found free from Zn contamination. Whereas, Ludhiana and Kasba industrial areas were found highly polluted with Zn with 216.29±9.86 mg/Kg and 55.48±3.10mg/Kg of soil.The WHO limits prescribed for Zn in the soil is 5mg/Kg (figure 2a).
Copper (mg/Kg) - According to WHO and ICMR, copper concentration of 1.5 mg/Kg and above is harmful to flora and fauna. All industrial soil samples were found heavily contaminated with copper as compared to the prescribed limits in the order Bapi>Ludhiana>Kasba>Sanganer(figure 2b).
Nickel (**mg/Kg**)- According to BIS (Bureau of Indian standards) the permissible limit for nickel in soil is 5mg/Kg. Nickel contamination in Ludhiana and Bapi was observed higher than Sanganer andKasba. All the studied soil samples had above permissible nickel contamination (figure 2c).
Arsenic (mg/Kg) - The highest arsenic concentration obtained was 964.25±12.51 mg/Kg in the Ludhiana industrial area. The mean arsenic concentration in all four soil samples was 648.57±209.68mg/Kg, Arsenic contamination in soil samples was found in the order of Ludhiana>Kasba>Sanganer>Bapi. As 0.50 mg/Kg is the limit of arsenic suggested by WHO. Hence industrial samples are heavily impacted by arsenic pollution as compared to any other heavy metal(figure 2d).
Lead (mg/Kg) –Highest lead contamination was found in the Sanganer industrial area (52.48±1.57mg/Kg). The permissible limit for Pb in soil is 0.50 mg/Kg as per WHO. All other industrial areas were also found polluted with lead in the sequence Bapi >Kasba >Ludhiana, see 2 (e).

Manganese(mg/Kg) - 5 mg/Kg is the recommended level of manganese in the soil suggested by the WHO. All the soil samples were found heavily contaminated with Manganese in the order Ludhiana >Bapi >Sanganer >Kasba . All the soil samples were contaminated with manganese and therefore unusable for agriculture and other purposes(figure 2 f).

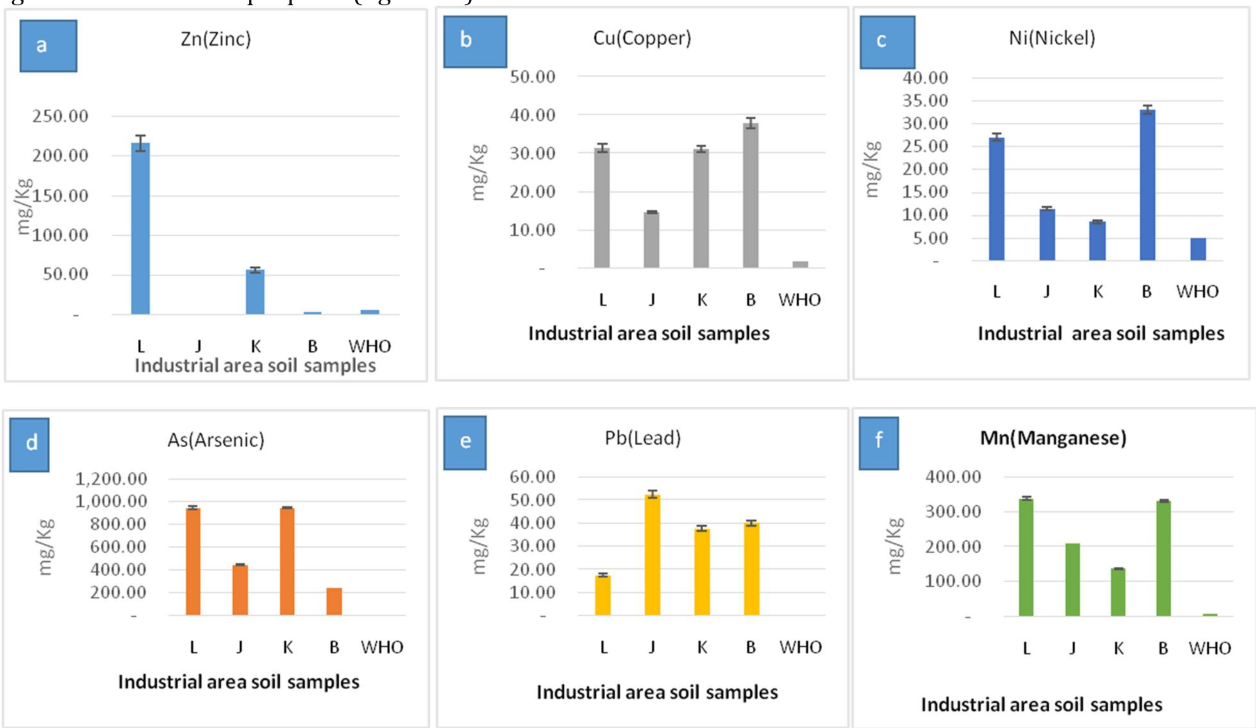

Figure 2: -Metal content of the studied soil samples (a) Zinc (b) Nickel (c) Copper (d) Arsenic (e) Lead (f) Manganese.

Many studies reported that the industrial areas of Jaipur, Punjab, and West Bengal are polluted due to industrialization. A research paper by([33]) studied the heavy metal contamination of sugarcane and sorghum crop from Punjab and found significantly higher concentrations of chromium, cadmium, and lead, much above the permissible limits. In another study published by ([34]), the roadside soil along Buddha Nullah in Ludhiana was contaminated with heavy metals such as copper, lead, zinc, and cadmium, showing that the soil was polluted due to industrialization. The concentration of arsenic, selenium, and uranium in groundwater is higher in Amritsar, Tarn, and Gurdaspur districts ([35,36]). A study on the Dravyawati River in Jaipur shows higher pollution levels in the water above the Indian standards ([37]). In the industrial zone of Durgapur in West Bengal, metal pollution was found by ([38]). This research work has revealed the disturbance in the balance of soil physicochemical parameters with elevated or reduced levels of various essential soil components in the studied industrial soil samples. It is essential to analyze the metal contamination levels in the soil before using them for any purpose. As the growth of microbes, plants, and biogeochemical cycling of pollutants greatly depends upon the quality of the soil which in turn plays an important role in the supply of minerals, water, available nutrients, and xenobiotic degradation([39]). Therefore, the determination of soil type and properties is an important and necessary measure for the organisms living in it. The microbial community in the soil decreases with the increased heavy metal contamination. These soils lose their sustainability, fertility, productivity as well as physicochemical properties, which affect the quality of the food chain. Thus, the regular monitoring of soil quality parameters is essential to find and employing methods of remediation.

CONCLUSION

In the present investigation we found that all the soil samples of the industrial areas were deficient in important nutrients and highly contaminated with heavy metals. Very high level of pollution level observed in industrial soil samples according to the results and found in the order of Ludhiana>Kasba>Sanganer>Bapi. Overall these soil samples are not suitable for the growth of flora fauna and other domestic purposes.

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