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Analysis Of Physico-Chemical Characteristics And Heavy Metal Contamination In Industrial Soil Of Bhagwanpur Industrial Area, India

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Abstract: ***Due to rapid industrialization, the soil in the industrial areas are polluted by various toxic substances such as heavy metals, dioxins, poly vinyl compounds etc from diverse sources. The present study was conducted to analyse the physico-chemical properties and heavy metal concentration of soil samples collected from three different sites of Bhagwanpur Industrial area. The range of various physic-chemical parameters were found as pH 5- 7.2, water holding capacity 29 -39.7, Moisture content (%) 0.8 -1.16, organic carbon (%) - 0.04 -0.57, organic matter (%)- 0.14 – 0.56, available nitrogen-(%) 0.1-0.5 and heavy metal concentration in soil were Cr 6 -21 ppm, Ni 3.4 -8 ppm, Zn 27- 32 ppm, Cu 1.4 – 4.3 ppm, Lead- 3.1 -3.9 ppm, Co 0.9 -1.8 ppm, Cd 0.02- 0.04 ppm, Fe_2Co_3 0.3- 0.9 ppm. Therefore, heavy metal contamination is in the sequence of Zn>Cr>Ni>Pb>Cu>Co> Fe>Cd.***

Keywords: Heavy metals, Bhagwanpur, Poly vinyl compounds, Industrialisation, Toxic and Contamination.

I. INTRODUCTION

Soil is a natural body consisting of layers (soil horizons) of mineral constitutes of variable thickness; which differ from the parent materials in their morphological, physical, chemical and mineralogical characteristics. Soil is a dynamic system because of micro-organisms and their biochemical activities liberating a lot of enzymes in soil, which become stabilized in by binding to soil component. Soil pollution and contamination is a serious problem especially in country as densely populated as India. Soil pollution is defined as the build-up in soils of persistent toxic compounds, chemicals, salts, radioactive materials or disease causing agents which have adverse effects on plant growth and animal health. Due to industrialization and urbanization, biodiversity, soil, surrounded by the industry get polluted by discharge of effluents directly or after treating to the surface. The metal pollution is of great concerns, as these hazardous pollutants are accumulated in living organisms including microorganisms, plants, animals and humans and are responsible for many metabolic and physiological disorders. Heavy metals such as cadmium, Zinc, Lead, Chromium and copper, are important environmental pollutants and their accumulation in soils is of concern in agriculture production due to the adverse effects on food quality (safety and marketability), Crop growth (due to phytotoxicity) and environmental health[2]. Heavy metals at higher concentration are toxic in nature to higher life forms because of their recalcitrant nature which can lead to biomagnifications. Exposure to these metals at lower concentrations results various disorders[3]. Heavy metals concentration in soil directly or indirectly depends on soil organic matter. So the main objective of the work was to determine the heavy metal concentration (Pb, Zn, Cr, Fe, Co, Cd, and Cu) in soil around Bhagwanpur industrial area.

II. MATERIAL AND METHODS

The study area Bhagwanpur is a town in Roorkee tehsil, Haridwar district in the state of Uttarakhand, India. It is 47 km far from Dehradun which is a capital of Uttarakhand. It is located at latitude of 30.06941°N and longitude of 77.83997°E. Roorkee city is 11 km far away from Bhagwanpur. Besides SIDCUL, another industrial estate is also developed at Bhagwanpur near Roorkee. It had attracted many pharmaceutical and biotech units.

The soil samples were collected randomly from different points around the Raipur industrial area of Bhagwanpur, India. After separating out inorganic objects such as plastics, rubber and metals manually, the soil samples were kept in polythene bags. The samples were air dried and ground to pass through a 2mm sieve. These samples were further analysed for physico-chemical parameters and heavy metal analysis.

Physico- chemical parameters of soil samples were analysed using standard methods[12]. The physico-chemical properties such as pH, water holding capacity (%), moisture content, organic carbon, organic matter and nitrogen were analyzed. The pH was measured in a soil suspension (1:5 w/v dilutions) with pH-meter that has been previously calibrated with buffer solutions. Moisture content and water holding capacity were computed following Trivedy & Goel[12]. Organic matter and organic carbon were examined by dichromate titration method as described by Trivedy & Goel[12]. Total nitrogen was determined by kjeldahl method.

Total metal concentration of heavy metals such as Cr, Ni, Cu, Co, Zn, Pb, Cd and Fe were anlayzed. For heavy metal analysis one gram of each samples were taken in 250 ml glass beaker and digested with 8 ml of aqua-regia on a sand bath for 2 hrs. After evaporation to near dryness the samples were dissolved with 10 ml of nitric acid, and the diluted to 50 ml with distilled water. Total metal concentrations of digested soil samples were analysed with ICPMS *(Perkin Elmer SCIEX ELAN DRCE).*

III. RESULTS AND DISCUSSION

PH

The pH value of soil quality is an important index of acidity or alkalinity. The pH of samples from different site was in the range of 5 to 7.2 (Table 1). pH of the samples could be positively correlated to the water holding capacity and nitrogen content of the soil, whereas, there was negative correlation between pH and moisture content of the soil samples (Table 3).

WATER HOLDING CAPACITY AND MOISTURE CONTENT

Water holding capacity is a term that all farms should know to optimize crop production. It is the amount of water that a given soil can hold for crop use. In this study average water holding capacity and moisture content of samples was found to be 35.58 % and 1.23%, respectively (Table 1). Correlation analysis indicated the positive correlation between pH and Nitrogen content of the samples. Furthermore, moisture content was negatively correlated to the pH water holding capacity and nitrogen content of the soil samples (Table 3).

ORGANIC MATTER AND ORGANIC CARBON

Soil organic carbon improves the physical properties of soil. Soil organic matter is important for plant growth as it provides nutrients cations and trace elements to plants. The result of this study shows that the content of organic carbon and organic matter is 0.23 % and 0.33% respectively (Table 1). Organic matter and organic carbon were positively correlated (Table 3).

NITROGEN

Nitrogen is the most important fertilizer elements. This element encourages above ground vegetative growth as plant root take up nitrogen in the form of NO_3 & NH_4^+. In the present study, the levels of Nitrogen in the sample is 0.34% (Table 1). These results indicate that due to industrialization there is a decrease in nitrogen content availability for crop or plant growth. Nitrogen content of the analyzed soil samples were positively correlated to the pH and water holding capacity, but negatively correlated to the moisture content of soil samples (Table 3).

S.No	Parameters	Min	Max	Ave rage	SD	Variance
1.	pH	5.0	7.2	6.30	0.78	0.68
2.	Water holding capacity (%)	29.0	39.7	35.58	4.26	20.42
3.	Moisture content (%)	0.8	1.16	1.23	0.34	0.13
4.	Organic carbon (%)	0.04	0.5	0.23	0.18	0.04
5.	Organic matter (%)	0.14	0.56	0.33	0.15	0.03
6	Nitrogen (%)	0.1	0.5	0.34	0.13	0.02

Table 1: Physico-chemical properties of soil samples

Metal	Min	Max	Average	SD	Variance
Cr	6	21	11.29	6.20	43.29
Ni	3.4	8	6.27	1.98	4.40
Cu	1.5	4.3	3.21	1.08	1.32
Co	0.9	1.8	1.34	0.31	0.11
Zn	27	32	30.11	1.37	2.11
Pb	3.1	3.9	3.50	0.27	0.08
Cd	0.02	0.04	0.027	0.008	7.50×10^{-5}
Fe	0.3	0.9	0.58	0.19	0.04

Table 2: Total heavy metal concentration in industrial soil samples (ppm)

ZINC

The total metal concentrations of selected heavy metals in three samples are showed in table 2. In the present study, the soil samples are highly contaminated with zinc metal. The

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results showed zinc concentration in the range of 27-32 ppm (Table 2). This may be due to the higher input of zinc from the industrial products of Bhagwanpur industrial area. Highly contamination of soil with zinc has been associated with the haematological disorder. Zn was only positively correlated with the Cu and not with other heavy metals, indicating the presence of special sources of Zn contaminations (Table 4).

COPPER, LEAD, COBALT, CADMIUM AND IRON

The Copper and Lead content in the industrial area are ranged from 3.1 -4.3 ppm in the soil samples. Cobalt, Cadmium and Iron were found in very low concentration. The results showed that the ranges of these three metals are from 0.02 -1.9 ppm in industrial area (Table 2). Levels of copper were negatively correlated to the presence of Co and Fe, whereas, the level of the Cd was not correlated to the presence of any heavy metal pointing towards the special sources of contaminations of Cd (Table 4).

CHROMIUM

Sample studied indicated that the concentration of chromium was in the range of 6 -20 ppm (Table 2). Cr exists in two oxidation state i.e., Cr (III) and Cr (VI). Higher doses of chromium cause liver & kidney damage and chromate dust is reported to be carcinogenic. Hence, Bhagwanpur industrial area has high chromium concentration. Level of Cr in soil samples were negatively correlated to the concentrations of Ni, Co, Pd and Fe, indicating that the concentration of the Cr was low where the other heavy metals were in abundance (Table 4).

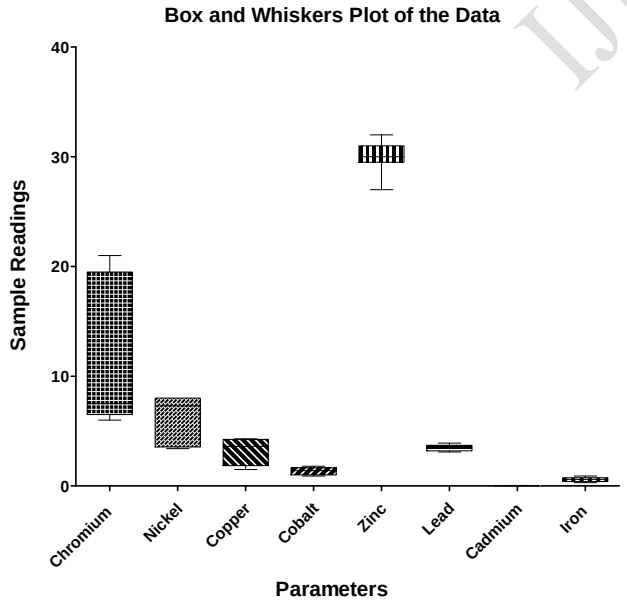

Figure 1: Box and whiskers plot indicating the range and average values of the heavy metal concentration in samples collected at various sites. Values here indicate the range with SD of the samples

	pH	Water holding capacity	Moisture content	Organic carbon	Organic matter	Nitrogen
pH	1	0.917	-0.851**	-0.146	-0.287	0.760*
Water holding capacity	0.917	1	-0.920	0.143	-0.110	0.941
Moisture content	-0.851**	-0.920	1	0.073	0.369	-0.928
Organic carbon	-0.146	0.143	0.073	1	0.90	0.254
Organic matter	-0.287	-0.110	0.369	0.902	1	-0.065
Nitrogen	0.760*	0.941	-0.928	0.254	-0.065	1

**Correlation is significant at the 0.05 level*
***Correlation is significant at the 0.01 level*

Table 3: Correlation analysis and coefficient for the physico-chemical factors in industrial soil samples (r values)

	Cr	Ni	Cu	Co	Zn	Pb	Cd	Fe
Cr	1	-0.994	0.627	-0.799**	0.034	-0.862**	0.598	-0.740*
Ni	-0.994	1	-0.578	0.783*	-0.003	0.872**	-0.523	0.709*
Cu	0.627	-0.578	1	-0.894	0.689*	-0.613	0.621	-0.926
Co	-0.799**	0.783*	-0.894	1	-0.400	0.865**	-0.507	0.927
Zn	0.034	-0.003	0.689*	-0.400	1	-0.030	0.232	-0.467
Pb	-0.862**	0.872**	-0.613	0.865**	-0.030	1	-0.408	0.757**
Cd	0.598	-0.523	0.621	-0.507	0.232	-0.408	1	-0.485
Fe	-0.740*	0.709*	-0.926	0.927	-0.467	0.757**	-0.485	1

**Correlation is significant at the 0.05 level*
***Correlation is significant at the 0.01 level*

Table 4: Correlation analysis and coefficient for the heavy metals concentration in industrial soil samples (r values)

NICKEL

Nickel is highly corrosion- resistant metal and commonly used for corrosion resistant pure – nickel plating. In the present study, Nickel was found in the range of 3.4 -8 ppm (Table 2). Ni concentration was positively correlated to the Co, Pb and Fe concentration in the samples specifying a common contamination source of these heavy metals (Table 4).

IV. CONCLUSION

The present study recites that Bhagwanpur Industrial area is facing increased human interventions due to rapid industrialization as well as urbanization. The soil of industrial area is highly contaminated with heavy metals mainly Zinc, chromium, Nickel, copper and Lead. The fate of metals depends on physical and chemical properties like pH, organic matter, organic carbon and nitrogen. The pH of most of the soil samples was found to be alkaline. An increase in pH, organic carbon and organic matter leads to strongest adsorption of heavy metals to soil particles, which decreases the essential nutrient such as nitrogen and phosphorous availabity to plants or agriculture crops. Heavy metal analysis revealed the relation between Cu and Zn. Furthermore, Ni, Co, Pb and Fe were related and indicated the common source of contaminations. Presence of Cd was not correlated to any of the heavy metal presence indicating the presence of special source. Levels of Cr were found low where the other heavy metals were in abundance. Hence, some steps or management practices must be considered to check the flow and accumulation of industrial wastes to avoid any harm to human existence.

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