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Correlation of Heavy Metal contamination with Soil properties of Industrial areas of Mysore, Karnataka, India by Cluster analysis

Rakesh Sharma M.S. and Raju N.S.
Department of Studies in Environmental Science, University of Mysore, Mysore, Karnataka, INDIA

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Abstract

The present work was conducted to know the correlation between soil properties with heavy metal concentrations by cluster analysis in industrially polluted soil in Mysore, Karnataka. Mean metal concentrations for Fe, Cu, Zn, Ni, and Cr were 32.12 mg/kg, 52.72 mg/kg, 44.72 mg/kg, 10.86 mg/kg and 8.01 mg/kg respectively. The relationship between different physico-chemical properties and heavy metal concentrations were analyzed by Pearson's correlation coefficient. The correlation matrix, were moderate correlations between water holding capacity and Chromium with r values 0.651. Similarly a moderate correlation was found between Moisture content and Iron with r values 0.631 present in the soil sample. Apart from Moisture content and water holding capacity with heavy metal content such as Iron and Chromium, there is no significant correlation was found between rests of the soil properties with respect to other heavy metal content. The association with heavy metals and the similarity values were done by bray-Curtis similarity analysis. The values above 90% are only to be taken account to the distribution and occurrence of heavy metal contents in respective study sites. The species of heavy metals which shows the higher and constant similarities viz., in sites IS-6 and IS-8, IS-3 and IS-9. The lowest similarity observed in the sites of IS-1 and IS-7 was interlinked with other sites of the study area. Cluster analysis of the heavy metals in different study area was also observed and it indicates anthropogenic activities and natural origins.

Keywords: Industrial area, pollution, soil properties, heavy metals, correlation co-efficient.

Introduction

In the ecosystem soil is considered as a complex, living, seasonally changing and dynamic component. In this ecosystem soil may get polluted from anthropogenic activities in industrial areas and it may cause major heavy metal contamination and which is more responsible in increasing the pollutants in the soil[1-3]. When the soil gets accumulated by the toxic substances such as metals, trace elements and other organic substances from domestic and industrial sectors the pollutants get deposited on the soil[4]. Many industries dump their unwanted wastes like plastic materials, bottles, broken pieces of metal etc. These types of waste products may create an ecological imbalance in the soil. According to the researchers, the biological and chemical contaminants which are released from the solid waste leachate, the ground water possesses major contaminants[5-7]. The industries releases heavy metals enormously and it may affects on the ecosystem which includes plants, animals and human beings by interfering and they may cause great damage to the soil environment and their growth production rate[8]. The accumulation of heavy metals in the soil can be studied by different statistical method. Generally topsoil layer contain largest amount of pollutants. The contaminant concentration in soil mainly depends on the adsorption properties of soil matter. The solubility of heavy metal ions in soil was mainly influence by many factors such as pH, Conductivity, Moisture content etc. In the municipal sewage water in which it contains the domestic liquid waste and industrial effluents are commonly found. The pollution level in the environment is increasing due to industrialization, urbanization, anthropogenic activities and natural sources[9-10]. Soil serves as a nutrient medial for the growth of plants. In soil we can observe so many elements. Sometimes these elements occur naturally for certain extent but in some time they will enter through the human interference with the soil by so many processes.

In this type of input of unwanted things to soil the major problem is with the heavy metals. Among various pollutants, heavy metals are released into soils[11] from the industrial activities like transporting the raw materials and scrapes, metal forging, manufacturing of alkaline storage batteries and synthetic organic compounds etc[12]. This study was focused to investigate the quality of the soil and to find out the heavy metal concentrations and correlation coefficient with cluster analysis.

Material and Methods

Study area: Mysore is located at12^0 18'N $76^0$39'E $12^0$30'N 76^0 65'E and has an average of 770 meters (2526 feet). The climate is moderate throughout the year with temperature during summer ranging from 30^0C to 34^0C. The population of Mysore city is 1.25 million. According to Karnataka Industrial areas Development Board there are major, medium and small scale industries situated and the industries are listed in the table-1.

Table -1
Study area for Industrial Soil Samples

Sample Code	Industrial Area
IS-1	Automotive Axle Ltd
IS-2	Divya Engineering works
IS-3	Bhoruka Alluminium Ltd
IS-4	Falcon Tyres Ltd
IS-5	Varakud Paper Industry
IS-6	SKF Industries
IS-7	South India Paper Mills
IS-8	Bannari Amman Sugars Ltd
IS-9	Triton Valves Ltd
IS-10	Zenith textiles

Source- KIADB book let 22 Feb 2011-Mysore dist (1).

Physico-chemical properties of Soil: The soils samples were collected from 10 different study areas around the industrial areas of Mysore, Karnataka. The selected soils samples were accumulated in polythene bags and are labeled it properly. The soils samples were scrutinized in laboratory and by using standard methods[13] the physico-chemical properties as pH, EC, Moisture content, Water Holding Capacity were done. By using Atomic Absorption Spectrophotometer (AAS) the concentrations of heavy metal analysis such as iron (Fe), copper (Cu), Zinc (Zn), nickel (Ni) and chromium (Cr) were also determined.

Heavy Metal analysis: The samples were grinded using an acid pre-washed mortar and pestle sieved by passing them through a 1mm mesh. One gram of soil of each of the samples were accurately weighed and treated with 10ml aliquots of concentrated nitric acid. The mixture was on a hot plate until the sample is almost dry and then cooled. The digested soil samples were then warmed in 20ml of 2M hydrochloric acid to redissolve the mineral salts. Extract were filtered through filter papers and the volume was then adjusted to 25ml with doubled distilled water. By using Atomic Absorption Spectrophotometer (Model-SL168, ELICO Pvt Ltd) the heavy metal concentrations were determined and the results were tabulated.

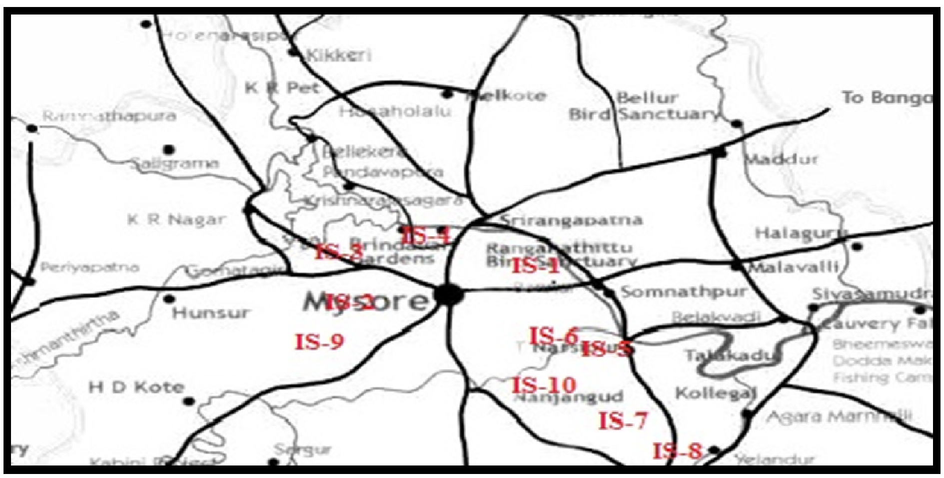

Figure -1
The map showing study area and sampling sites

Table -2
Physicochemical and heavy metal concentrations of soil from the study area

Sample No.	pH	EC	MC%	WHC%	Fe*	Cu*	Zn*	Ni*	Cr*
Control	**6.78**	**66.76**	**5.08**	**68**	**39.6**	**36**	**28**	**0.07**	0.05
IS-1	6.90	45.4	3.72	42	38.8	54	48	11.6	9.0
IS-2	6.50	178.9	3.25	35	42.5	60	52	14.3	3.8
IS-3	5.82	94.2	2.85	40	38.5	45	49	9.8	5.7
IS-4	6.22	197.8	2.65	38	29.6	62	35	10.6	7.6
IS-5	6.45	87.2	3.14	41	36.2	58	35	12.8	11.5
IS-6	6.72	172.7	2.85	35	28.5	45	47	14.6	6.8
IS-7	6.71	52.2	2.65	35	19.6	63	58	7.8	10.0
IS-8	6.47	178.2	3.12	40	24.5	50	55	11.9	12.0
IS-9	6.40	88.5	2.65	45	31.1	45	45	13.6	13.8
IS-10	6.60	134.2	2.45	35	24.5	62	40	12.4	7.9
Mean Value	**6.50**	**117.82**	**3.12**	**41.27**	**32.12**	**52.72**	**44.72**	**10.86**	8.01

EC- Electrical Conductivity **MC-** Moisture Content **WHC-** Water Holding Capacity ***mg/kg**

Table -3
Pearson's correlation coefficients between heavy metal concentrations with soil properties of different sites

	pH	EC	MC	WHC	Fe	Cu	Zn	Ni	Cr
pH	-	-	-	-	-	-	-	-	-
EC	-0.207	-	-	-	-	-	-	-	-
MC	0.330	-0.203	-	-	-	-	-	-	-
WHC	-0.221	-0.411	0.296	-	-	-	-	-	-
Fe	-0.258	-0.059	0.631	0.310	-	-	-	-	-
Cu	0.268	0.038	-0.103	-0.499	-0.192	-	-	-	-
Zn	0.210	-0.168	0.204	-0.197	-0.181	-0.188	-	-	-
Ni	0.219	0.429	0.205	0.066	0.374	-0.321	-0.266	-	
Cr	0.183	-0.373	-0.079	0.651	-0.422	-0.177	-0.064	-0.066	-

Significant 'r' at $p < 0.05$ level

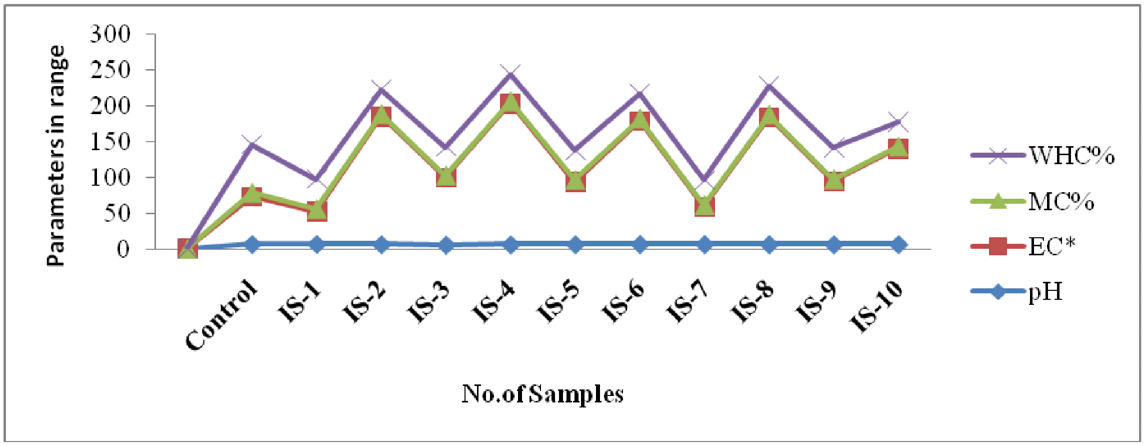

Figure -1
Variation of physicochemical properties in different study area

Results and Discussion

The data of physico-chemical properties of industrial area soil samples revealed that, the pH values was ranged from 5.82 to 6.90. Increase in soil depth, the pH was found to be decreased in the collected samples. Different factors like leaching action of wastes, soil nature, mechanical composition, etc may be responsible for the decrease in pH[14]. In most of the soil samples the pH was ranged as an optimum soil pH (6.5 to 7.0) from crop production[15]. When the values of electrical conductivity increas between 45.4 to 197.8mS/cm. The presence of large amount of ionic substance and soluble salts have resulted in increased value of EC in the industrial effluents treated soil samples in comparison to the others. When the values of electrical conductivity increase it may leads toxic to the plants. The moisture content of the soil samples were ranged mass of soil materials present per unit volume of moist soil in naturally undisturbed condition, in IS-10 sample the content in soil. The amount of water retain by the pores present in soil, generally in medium textured soils, the amount of water retain is very less when compare to clay textured soil, during the present study the water holding capacity ranged between 35 to 45%. In IS-9 sample was found to be high water holding capacity which is due to high pore space present in between the soil particles.

The Heavy metals are environmental contaminants are not a new phenomenon. They are essential part of all living organisms and are present in trace amount in soil naturally. A set of measurable attributes indicates the soil quality and it can be grouped as physical and chemical indicators[16]. Among all the different heavy metal concentrations were observed, correlation revealed that both spatial and temporal variations of all metals were significant. The magnitude of different heavy metals followed hierarchy, order: Cu> Zn> Fe> Ni> Cr. In this present study, Cu varied from 45 to 63mg/kg followed by Zn 35 to 58mg/kg; Fe varied from 19.6 to 38.8mg/kg; Nickel varied from 9.8 to 14.6mg/kg and Cr 3.8 to 13.8mg/kg. Copper was observed as maximum concentrations of heavy metals where as chromium were minimum in heavy metal concentrations of the study sites. In comparisons, the metal levels is different from industrial areas indicate that there is a detectable anthropogenic activity in the study area.

The relationship between different physico-chemical properties and heavy metal concentrations were analyzed by Pearson's correlation coefficient. The correlation analysis is a bivariant method which is applied to describe the relation between two different parameters. The high correlation co-efficient (near +1 or -1) means a good relation between two variables, and its concentration around zero means no relationship between them at a significant level of 0.05% level, it can be strongly correlated, if r>0.7, where as r values between 0.5 to 0.7 shows moderate correlation between two different parameters. From the above presented correlation matrix, we can observe a moderate correlation was noticed between water holding capacity (WHC) and chromium (Cr) with r values 0.651. Similarly a moderate correlation was found between Moisture content (MC) and Iron (Fe) with r values 0.631 present in the soil sample. Apart from moisture content (MC) and water holding capacity (WHC) with heavy metals such as iron (Fe) and chromium (Cr), there is no significant correlation was found between rests of the soil properties with respect to other heavy metals. Many other relationships between various quantitative variables are also significant with least values[17]. In order to understand the association heavy metals, the similarity values are determined[18]. The values above 90% are only to be taken account to the distribution and occurrence of heavy metal concentrations in respective study sites (Figure-7).The species of heavy metals which shows the higher and constant similarities viz., in sites IS-6 and IS-8, IS-3 and IS-9. The lowest similarity observed in the sites of IS-1 and IS-7 was interlinked with other sites of the study area.

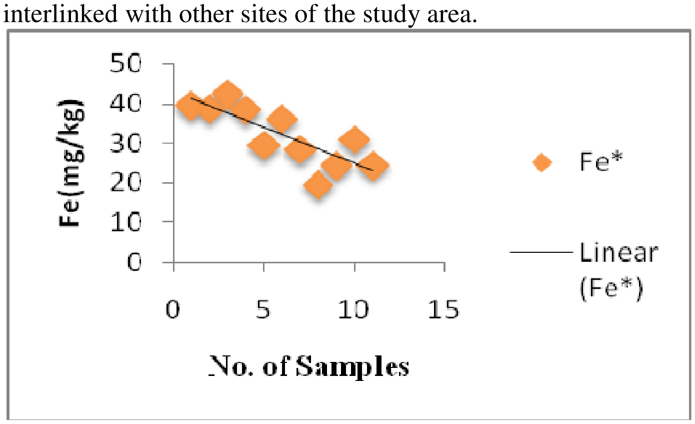

Figure-2
Fe distribution around the study area

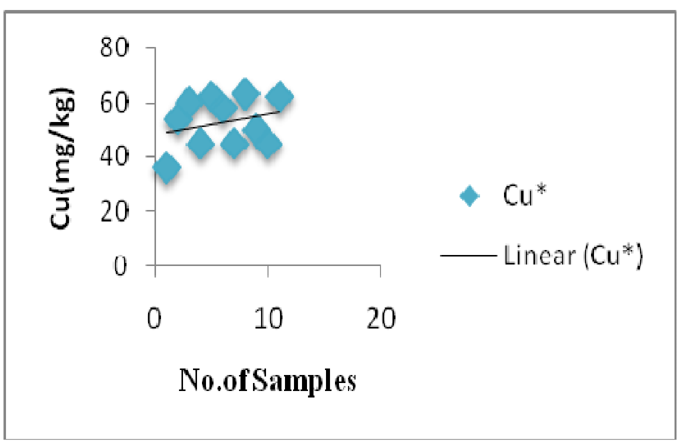

Figure -3
Cu distribution around the study area

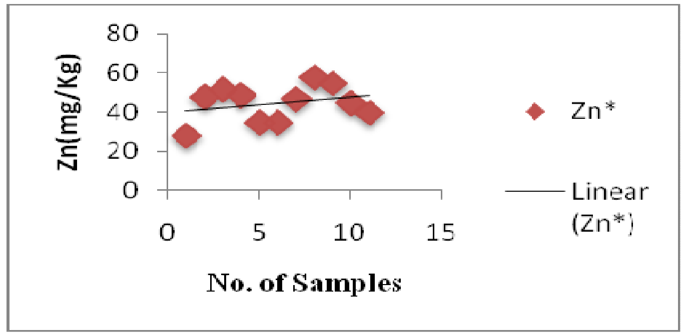

Figure-4
Zn distribution around the study area

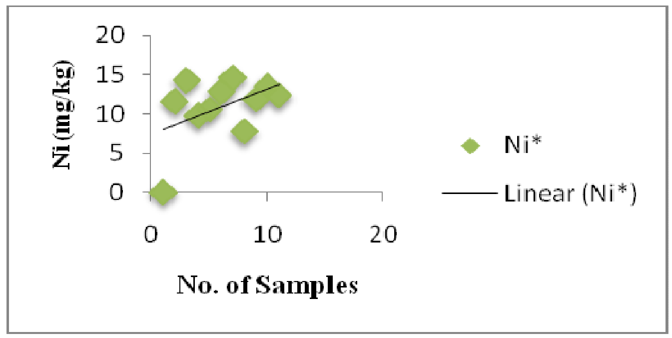

Figure -5
Ni distribution around the study area

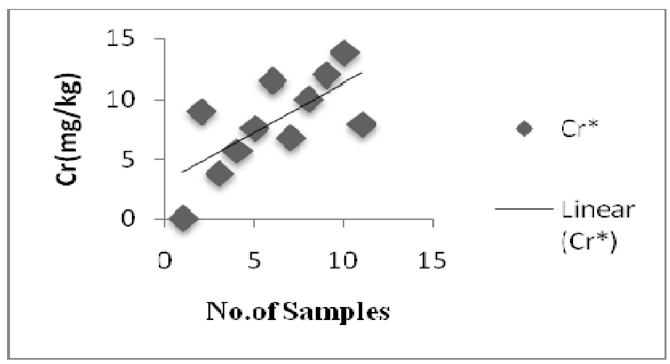

Figure-6
Cr distribution around the study area

Conclusion

The study concluded that, the heavy metal contents are introduced by so many sources and human activities which include industrial operations. Atmospheric deposition of contaminated dust and industrial discharge may be the prime cause of heavy metals contamination in soil. The heavy metals in the field were also showing the high concentration which also causes the adverse effects on the soil[19]. Due to increasing heavy metal contents in the soil it may affect soil quality and the study sites which is not encouraging for soil health is suggested[20]. When the heavy metals present in the natural condition they do not act as toxic up to certain extent. The indiscriminate dumping of waste into the soil is obviously detrimental for human being as they are not biodegradable and enter into the food chain[21]. When the concentration reaches the maximum level or up to the permissible level the heavy metals will be converted into toxic in nature.

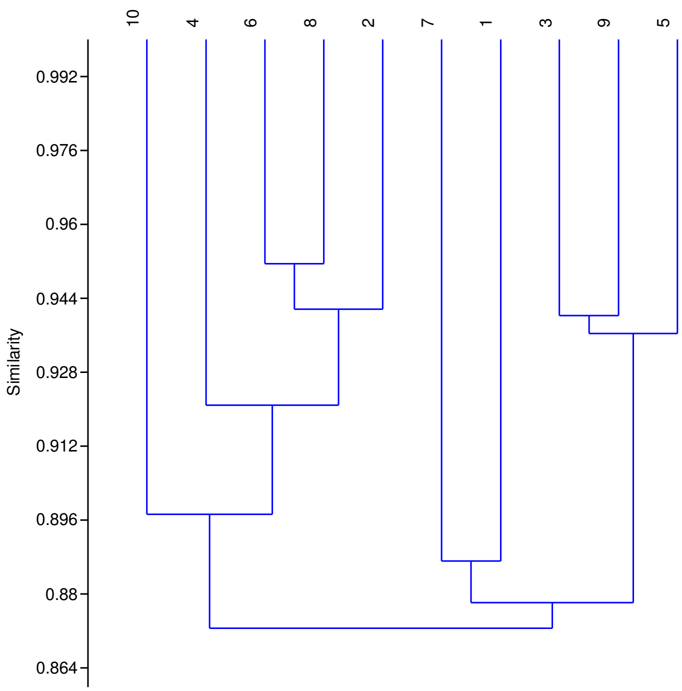

Figure -7
Cluster analysis using simple linkage method for selected study sites

Acknowledgement

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