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# Heavy metal contamination in soil in an industrial zone and its relation with some soil properties

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**ABSTRACT**

*A study on quality of soil with reference to Zn, Pb, Fe, Mn and organic carbon in the soils of Eastern Guwahati Industrial zone, Assam has been presented in this paper. Industrial emissions which go to the atmosphere and is finally deposited on soil and or dumping of industrial wastes on disposal land may cause the environmental pollution to a great extent. Nineteen different soil samples were collected from different sites for study at East Guwahati industrial zone. The study revealed that the top soils in the area are heavily polluted with heavy metals. Statistical analysis of the data is presented to find out the correlation among measured variables. Resulting coefficient of correlation between heavy metals and other soil properties such as organic matter, pH etc. established a nonlinear relationship between the parameters*

**Keyword:** Heavy metals, Soil organic matter, conductivity, Ca, pH, Coefficient of correlation.

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## INTRODUCTION

Industrial emissions of contaminant to the atmosphere which is finally deposited on soil or dumping of industrial wastes on disposal land may cause the problem in the environment beyond the limit. Generally topsoil layer contain largest amount of pollutants. The contaminant concentration in soil mainly depends on the adsorption properties of soil matter. The adsorption properties are largely determined by organic matter in soil and heavy metals concentration in soil directly or indirectly depends on the soil organic matter. Variation of organic matter may be the predominant cause of variation in environmental concentration in soil [17]. Heavy metals accumulation in soil can be studied by different statistical method. Generally organic matter contains different types of functional groups such as phenolic group (-OH) which are capable of complexing metals [13]. Organic matter may influence the concentration of heavy metals in soil by different processes such as release of heavy metals containing organic matter into the soil, extraction of heavy metals by organic matter in the soil forming organic complexes etc. [1]. Environmental factors such as land use, temperature, rainfall etc. can artificially change organic matter content as well heavy metals concentration in soil. The solubility of heavy-metal ions in soil was mainly influence by many factors such pH, conductivity etc. So the main aim of this work was

- To assess the heavy metal concentration (Zn, Pb, Mn and Fe) in soil around East Guwahati Industrial area.
- To investigate the statistical relation between heavy metal concentration and other soil properties such as organic matter, conductivity, pH and Ca concentration.

**Study area:**
The industrial complex under the present study is situated at Noonmati area of Kamrup District. Generally two large scale industries viz. Guwahati refinery and India Carbon Company are located in this part of Kamrup district. Physiographically the study area can be divided into hills and plains i.e. undulating topography with varied slopes.

The hills are generally steep sided and are trending east-west. The area is relict type and the hills are standing out of pen plain. The valleys that are formed within the hillocks are covered generally with thick cover of alluvium. The climate of the area is tropical, humid climate with forest type of vegetation. The overall climate of the area can be summarized as follows:

- December and January are the coldest month
- February and March with retreating summer, occasional dust wind and warmness.
- April to mid October with occasional rainfall (South West monsoon) and hot and unpleasant days.

The soil type of greater Noonmati area can be divided into sediment fill and alluvial soils. The sediment fill cover all the hillocks are thought to be formed by the atmospheric weathering of different rocks present in the hillocks under monsoon conditions. The alluvial soils are formed by the silts brought by the rivers and deposited on their mouth and banks. Geologically, the area is continuation of the Khasi and Jaintia hills of Meghalaya state and forms the northern edge of the Shillong plateau, which is considered as the disconnected portion of the peninsular India separated from the main land by the alluvial plains of the Ganges and the Brahmaputra **[8]**. The area is characterized by the gneissic complex composed of granite gneisses, Quartzo feldspathic gneisses, and quartzite and biotite schist. The Archaean gneisses and schist form the basement cover.

## MATERIALS AND METHODS

Chemical of analytical grade and standard methods were followed for the determination of physicochemical parameters. For determination of physicochemical parameters, chemical of analytical grade and standard methods were followed. Sampling site was divided into three zones as per classification prescribe by Pollution Control Board, New Delhi ***(****ISI, 1979*) and samples were collected from three sites located in parts of the city.

a) Site1: industrial area.
b) Site2: Residential area.
c) Site3: Commercial area.

Heavy metals were determined spectrochemically using Atomic absorption spectrophotometer (*Perkin Elmer, Model No.Aanalyst200*). All chemical used in assessing these parameters were of AR grade[1]. Nineteen soil samples were collected around the study area during July to September, 2008, where no regular tests have been performed (TABLE-I). At each site, soil samples were collected from topsoil (0-20 cm in depth) using a hand auger.

## RESULTS AND DISCUSSION

Most of the soil samples revealed organic matter above 6% which were extremely high according to ICAR rating, 1997. Highest organic matter was recorded as 7.34% (Table2). So as per the investigation, effluents discharge from nearby industries may be the main source for abnormally high organic matter in the soil of study area as it was proved by few researcher earlier that mixing of sewage effluents increased the organic matter in the soil .

% soil organic matter =% organic carbon x 1.724 (*Allison, L.E., 1965*)

Soil organic matter also influences environmental processes at a global scale. Top soils are a huge terrestrial reservoir of C, which has a modifying effect on carbon dioxide concentrations in the atmosphere and can thus influence climate warming [16]. Out of nineteen soil samples, ten samples showed $P^H$ below 7 and rest of the samples showed $P^H$ above 7. Soil $P^H$ ranged from 4.34-7.47. Soil $P^H$ was neutral (6.5-7.5) for almost all the samples. Among all the heavy metals analyzed, Mn concentration was higher and Zn concentration was lower. The soils around the study area have lead concentration ranging from 0.5mg/Kg-119mg/kg. Comparatively high value of Lead in the study area is ascribable to the high traffic and smoke discharge from nearby industries in the atmosphere which is finally deposited on the soil in the study area. Within the study area, high concentration of Manganese was recorded with an average value of 171.789 mg/kg. Highest concentration of Manganese was observed near Indian Carbon Company which was recorded as 841.2mg/Kg. The anthropogenic source of Manganese in soil around the study area may be due to the use of one octane enhancer namely Methylcyclopentadienyl Manganese and An NGO had issued a public alert in March, 2010 over the use of MMT in petrol by oil companies in India and said that the lethal neurotoxin manganese particles from MMT blended petrol is hazardous to human health. It has been found that cadmium concentrations are low in most of the samples around the study area. The soils around the study area have zinc concentration ranging from 1mg/Kg-17mg/kg (Figure4) which is considerably low compared to rest of the heavy metals. Krishna and Govil (2007) studied the soil around Manali industrial area in Chennai, Southern India which is surrounded by industries like petrochemicals, refineries, and fertilizers generating hazardous wastes on the

basis of geo accumulation index, enrichment factor (EF), contamination factor and degree of contamination and found high concentrations of Chromium , Copper, Nickel , Zinc and Molybdenum and they also observed metal depletion for EF<1 (As, Ba, Pb and V) which may be mainly due to the leaching of the elements from the soil into water-bearing formations. Iron concentration in the soil ranged from 0.557mg/kg-22.74mg/k (Figure3). Iron is very insoluble under oxidizing condition in soil, the organic matter in the soil may form chelate complex by keep considerable amount of Fe (III) in a mobile form.

**Table1: Total concentration of heavy metals and selected properties of soil samples collected from the study area.**

| No of samples | Mn ( mg/Kg) | Pb( mg/Kg) | Zn (mg/kg) | Fe(mg/kg) | organic matter | pH |
|---|---|---|---|---|---|---|
| s1 | 14.9 | 60.4 | 1.002 | 22.74 | 6.15 | 6.24 |
| s2 | 66.8 | 0 | 2.11 | 14.45 | 6.51 | 6.34 |
| s3 | 521.7 | 91.4 | 2.21 | 5.8 | 5.68 | 6.56 |
| s4 | 178.2 | 64.3 | 4.01 | 15.22 | 6.3 | 6.03 |
| s5 | 94.9 | 0.5 | 17 | 12.202 | 6.82 | 6.34 |
| s6 | 373.1 | 62.4 | 3.1 | 13.56 | 7.34 | 6.07 |
| s7 | 435.7 | 65.4 | 5.1 | 1.391 | 7.24 | 6.24 |
| s8 | 86 | 0 | 7.2 | 1.872 | 7.24 | 7.39 |
| s9 | 282.1 | 119 | 3.04 | 5.754 | 3.93 | 7.35 |
| s10 | 6.7 | 0 | 5.02 | 3.482 | 6.5 | 7.19 |
| s11 | 23.4 | 78.8 | 2.05 | 20.654 | 6.93 | 6.95 |
| s12 | 71.9 | 1.3 | 2.15 | 31.2 | 6.102 | 7.05 |
| s13 | 21.9 | 107.7 | 8.46 | 2.718 | 6.93 | 7.31 |
| s14 | 841.2 | 89.9 | 8.26 | 8.757 | 6.82 | 7.37 |
| s15 | 42.3 | 6.4 | 2.7 | 1.728 | 6.04 | 7.23 |
| s16 | 75 | 62.6 | 0 | 12.156 | 6.102 | 7.22 |
| s17 | 63.05 | 0 | 5 | 0.951 | 6.51 | 4.34 |
| s18 | 64 | 3.7 | 2.1 | 0.557 | 6.206 | 7.47 |
| s19 | 9.7 | 3.8 | 0 | 6.648 | 6.62 | 6.99 |
| Mean | 172.239 | 43.031 | 4.237 | 9.5705 | 6.419 | 6.72 |
| Median | 71.9 | 60.4 | 3.04 | 6.648 | 6.51 | 6.99 |
| Standard Deviation | 223.53 | 42.92 | 3.954 | 8.5459 | 0.7572 | 0.763 |
| Variance | 49967.07 | 1842.58 | 15.637 | 73.0329 | 0.5734 | 0.5823 |

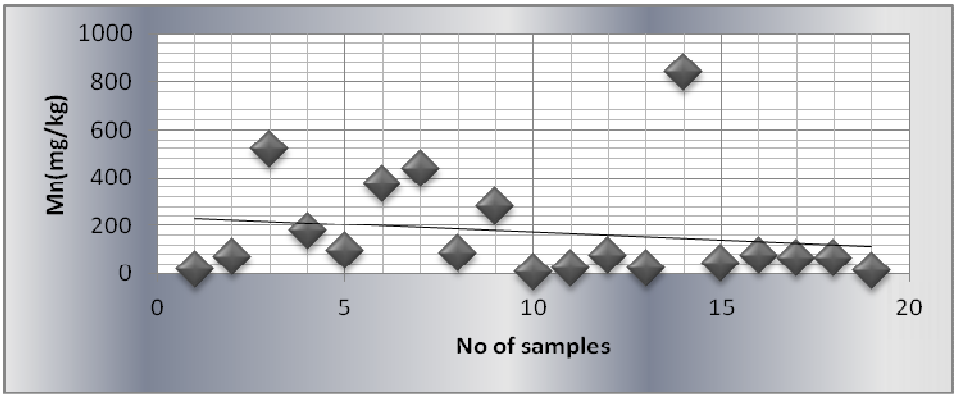


**Fig.1: Mn distribution around the study area**

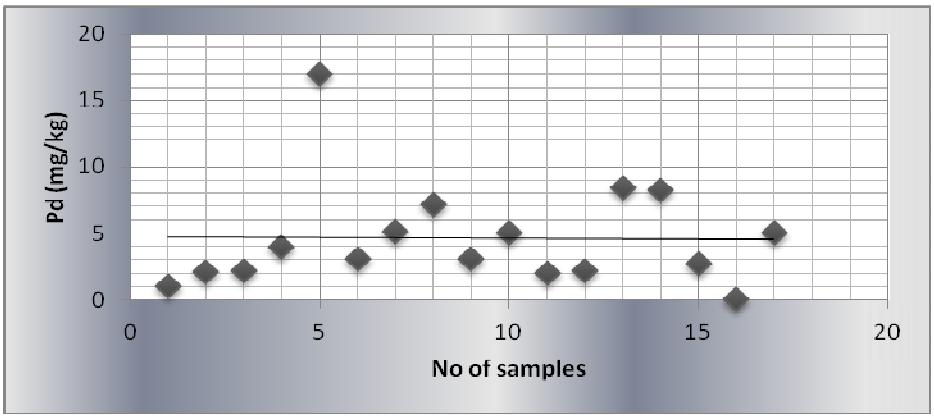


**Fig.2: Pb distribution around the study area.**

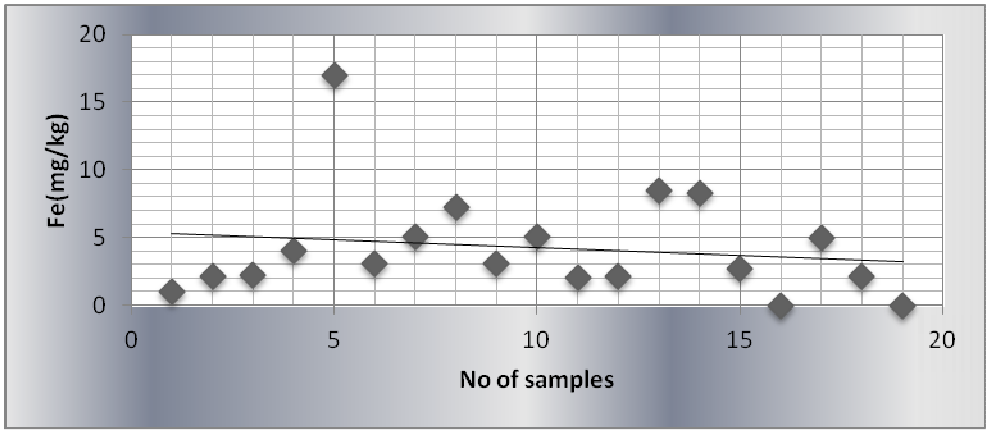


**Fig.3: Fe distribution around the study area.**

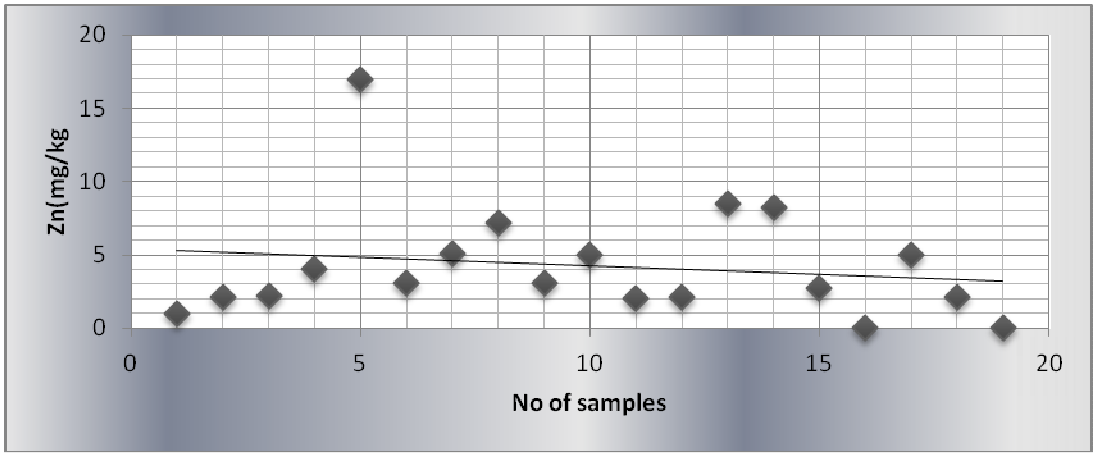


**Fig.4: Zn distribution around the study area.**

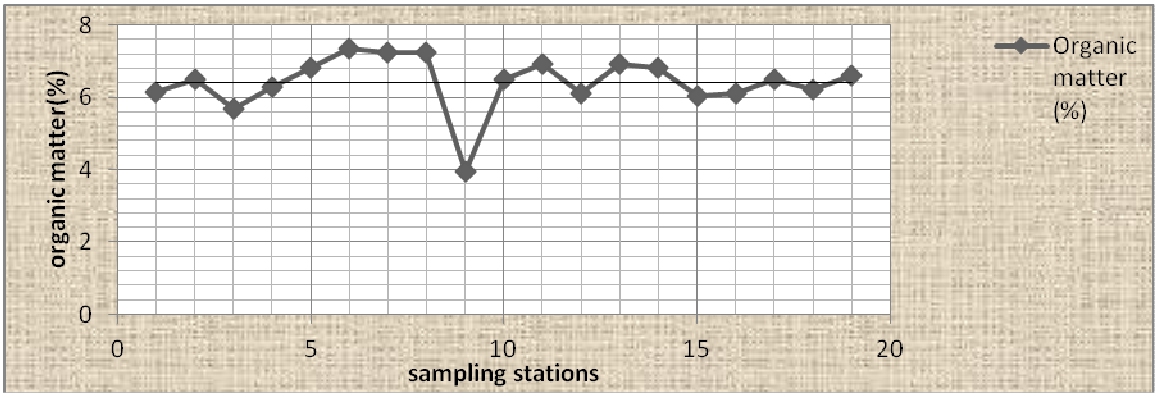


**Fig5. Variation of organic matter in different sampling stations**

**Statistical analysis**:

The significant relationships between concentration of heavy metals and OM content were further established by performing correlation analysis (Table 1). Heavy metals, especially Pb, Mn and Fe were weakly negatively correlated with SOM content. As in the study area, the level of organic matter is high in soil due to some anthropogenic sources; OM may contain high level of pollutants. So regular accumulation of OM may increase the probability of deposition of high concentration of heavy metals at the study area. Statistical analysis revealed the strong binding of SOM with heavy metals in the study area. Gao *et al*. (1997) observed that metal adsorption at low metal loadings is related to soil organic matter content. Increased hydroxides of iron and manganese in soil can reduce the concentration of cadmium or lead dissolved in contaminated soil [9][11].

***Relation of heavy metals with conductivity and Ca***:
The results typically show statistically significant correlation. The effect of conductivity is strongly pronounced on availability concentration of Fe in soil. Conductivity(r=-0.41) and Ca (r=-0.12) have negative correlation coefficient with Fe as shown in Table3. Fe solubility in surrounding soil was mainly influenced by conductivity of soil. Soil EC can serve as a proxy for soil physical properties such as organic matter [6] and cation exchange capacity [11] .CEC are largely determined by the concentration of oxide and hydroxide of Fe. As pH increases, the negative charge on such surfaces is increased. These negatively charged sites may increase the probability of absorption of positively charged ions in the surrounding soil by increasing CEC. CEC increases with increasing pH and so does the capacity to absorb cations such Na+, K+ etc. (Van der Perk). High concentration of Ca may also lead to the reduction in Fe solubility.

**Table2: Correlation analysis of heavy metals with pH and SOM.**

| Metal | Correlation Coefficient | | |
|---|---|---|---|
| | Conductivity | Ca | |
| Fe | -0.416843549 | -0.125394827 | |
| Pb | -0.276274621 | 0.203888309 | |
| Mn | -0.257549539 | 0.068253406 | |
| Zn | -0.067182298 | -0.392741734 | |

**Table3: Correlation analysis of heavy metals with conductivity and Ca.**

| Metal | Correlation Coefficient | | | | | |
|---|---|---|---|---|---|---|
| | Fe | Pb | Mn | Zn | pH | SOM |
| Fe | 1 | 0.0352 | -0.126 | -0.202 | -0.052 | -0.02235 |
| Pb | 0.0352 | 1 | 0.519 | -0.066 | 0.1589 | -0.28715 |
| Mn | -0.126 | 0.519 | 1 | 0.16 | 0.01962 | -0.00193 |
| Zn | 0.16078 | -0.066 | 0.16 | 1 | -0.0669 | 0.3222 |

But the result show statistically positive correlation of Pb and Mn with Ca (table.3).So available Ca in soil may increase the probability of Mn and Pb solubility in soil. Negative correlation of Mn (r= -0.257), Zn(r= -0.067) and Pb(=-0.276) with electrical conductivity was not statistically significant which was also confirmed by Mali *et al*. (2002) in the soil of salt effected area of Pune , Maharashtra, India . Total concentration of Zn(r=-0.39) was strongly negatively correlated with Ca in the study area.CEC may play major role in this relation.

## CONCLUSION

Enhanced concentration of lead, manganese and iron seem to be associated with high value of organic matter, pH and conductivity in soil. Atmospheric deposition of contaminated dust and industrial discharge may be the prime cause of heavy metals contamination in soil. The concentration of Pb, Fe and Mn appeared to be negatively correlated with organic matter and soil conductivity of the soil. Statistical analysis shows the nonlinear relationship of all soil properties to the heavy metals in soil. All the soil samples analysed in the investigation are contaminated with lead and manganese. Based on the study, it is concluded that the intrinsic soil quality in the study area is not encouraging and thus suitable protective measures for soil health is suggested.

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