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ASSESSMENT OF POLLUTION AND ENRICHMENT OF SOIL IN AND AROUND INDUSTRIAL AREA OF RAIPUR CITY, C.G., INDIA

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ABSTRACT

The present study was aimed to assess the quality of the soil in and around industrial area of Raipur City. For sample collection the area was divided into four sites (North, South, East and West). Samples were analyzed for pH, EC, OC, Fe and Zn. Average concentration of heavy metal in world soil has been considered as background value. The EF value of 4.25, indicate moderate to significant enrichment due to Zinc in the studied region.

KEY WORDS: Heavy-metals, Fe, Zn, Enrichment factor, Background value, World soil

INTRODUCTION

The soil is the part of earth surface that support vegetation and is directly attached to their environments. The soil quality functions are very important for the nutrient cycling, water relations and plant growth support system in the environment (Oldmann *et al.*, 1990; Foth *et al.*, 1990; Costanza *et al.*, 1992; Sparling *et al.*, 2002; Larson *et al.*, 1991; Stoorvogel *et al.*, 1990; Janssen *et al.*, 2006; Banerjee *et al.*, 2003; Krishna *et al.*, 2004). The soil organic carbon serves as a primary indicator of soil quality (Krishna *et al.*, 2004). The agriculture soils are also affected from the industrial and anthropogenic effluents (Srinivasa *et al.*, 2010). The physico-chemical properties of soil around industrial area affected from industrial wastes, i.e. disposal of industrial wastes (solid, liquid and gas or fog) is the main sources of soil pollution, which affect and alter the physico-chemical and biological properties of soil (Chabukdhara *et al*., 2013). Mostly in the developing countries like India the more crop production activities and fast growing industrial activities are major reasons of degradation of soil quality (Krishna *et al.*, 2004, 2007, 2009). Since the beginning of the industrial revolution, pollutions with toxic elements have accelerated dramatically and the increasing industrialization and population growth develops the living standards, which results in highly polluted environments due to the industrial effluents (Tariq *et al.*, 2012; Marium *et al.*, 2013). Industrial development and fast growing activities are main causes of environmental soil pollution in developing countries like India (Oldmann *et al.*, 1990; Foth *et al*., 1990; Costanza *et al*., 1992; Sparling *et al.*, 2002, Larson *et al.*, 1991; Stoorvogel *et al*., 1990). Combustion of coal, usage of fly ash, chemicals, disposals and other hazardous effluents affects the soil health in and around Industrial area (Janssen *et al.*, 2006). Many Industries situated in Raipur city disposed their effluent in surface water and is the main reason of imbalance of nutrient in soils (Sumithra *et al.*, 2013; Khamparia *et al.*, 2013). Soil quality is one of the three components of environmental quality, besides water and air quality (Andrews *et al.*, 2002). Water and air quality are defined mainly by their degree of pollution that impacts directly on human and animal consumption and health, or on natural ecosystems (Carter *et al.*, 1997; Davidson, 2000). In contrast, soil quality is not limited to the degree of soil pollution, but is commonly defined much more broadly as "the capacity of a soil to function within ecosystem and land-use boundaries to sustain biological

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productivity, maintain environmental quality, and promote plant and animal health" (Doran and Parkin, 1994; Doran and Parkin, 1996). As Doran and Parkin (1994) state explicitly, animal health includes human health.

Factors influencing soil quality

Karlen *et al.* (1992) stated that inherent interactions among the five basic soil forming factors [parent material, climate (including water and temperature effects), macro- and micro-organisms, topography and time] identified by Jenny (1941) create a relatively stable soil quality that has distinct physical, chemical, and biological characteristics in response to prevailing natural or non-anthropogenic factors. However, humankind, the anthropogenic force described as a sixth soil forming factor in the basic model for describing a soil (SSSA, 1987), interacts with the non-anthropogenic factors and influences soil quality both negatively and positively. Soil and crop management practices imposed on land resources by humankind thus determine whether inherent soil quality will be lowered, sustained, or improved over relatively short time intervals. The relative importance of anthropogenic or management factors compared to non-anthropogenic physical, chemical, or biological factors will generally be determined by the function or application for which a soil quality assessment is made. Soil carbon content has been suggested as a soil quality indicator because decrease in this parameter can be directly related to decreased water stability of both macro- and micro-aggregates (Tisdall and Oades, 1982; Churchman and Tate, 1987; Pojasok and Kay, 1990).

Soil contamination:

In the developing countries like India, industrial growth and pesticides uses in agriculture fields are the main sources of soil pollution. The industrial based countries, i.e. China, Japan, America, Thailand, Pakistan etc. and the popular states of India, i.e. Madhya Pradesh, Gujrat, Uttar Pradesh, Rajashthan, Andhra Pradesh, Maharashtra, Orissa, Southern India etc. were reported of soil pollution with affects of industrial contaminants (Banerjee *et al.,* 2003; Marium *et al.,* 2013). The chemical and physical contents of contaminated soils around industries were serious and unbalanced for the productivity and other uses (Sumithra *et al.,* 2013). Raipur city known as fast industrial and urban based developing city of the central India. Siltara, Urla Rawabhatha, Gogaon etc. are the industrial area of the city, in which the Siltara industrial area is industries rich area and various types of the industries situated there. Every day, large quantity of industrial effluents is dumping to the area (Khamparia *et al.,* 2013; Sharma *et al.,* 2013). The soil samples of this area were analyzed in this study with suitable concentration of parameters and infertility criteria.

EXPERIMENTAL

Study area

The Raipur city is capital of Chhattisgarh state of India with fast developing urbanization and industrialization purposes. The various industries i.e. power plant, steel, paint, chemical, wire and others are situated in this city. The industrial area situated in agricultural surface of Raipur

The industries, i.e. power plant, steel, paint, chemical, wire, agro food and others are continue in the region. The Siltara, Urla, Gogaon, Rawabhatha villages are the industrial area of the city.

Sampling Process

The total 120 soil samples were collected in 2018-2019 with proper guidelines of the sampling procedure. After sampling the all soil samples were kept for dry and grind well for apply to mesh filter. The prepared soil samples were applied for analysis

Fig. 1. Study Area.

in laboratory (Khamparia *et al.,* 2013; Sharma *et al.,* 2013). Prior to the taking soil samples, study area was divided into four zodiac i.e. north, south, east and west industrial area, after that five soil samples of land were taken from each area in the year 2018-2019. The proper guidelines of the sampling procedure were followed during sampling, and analysis. All the soil samples were transported in the laboratory for the physical and chemical analysis. All the samples in the laboratory were dried filtered with proper mesh size digested and analyzed (Carter *et al.,* 1993; Kaiser *et al.,* 1960) following the standard process.

Analysis

The ultra-pure water and analytical grade fine chemicals were used for the preparation of samples and analysis of samples. The selective analytical method, chemical and instruments were used for the soil analysis. The selective analytical methods i.e. UV-Visible spectrophotometer, pH meter, conductivity meter, atomic absorption spectrophotometer was used for the analysis of soil parameters of all the soil samples. Soils were air-dried, crushed and sieved for various physico-chemical parameters through 2-mm stainlesssieve to remove debris (Janssen *et al.,* 2006). Soil moisture content was determined by gravimetric method in which the samples were dried to constant weight as described by (Krishna *et al.*, 2007). Bulk density was determined by core method asdescribed by (Krishna *et al.*, 2009). The pyenometer method described by Black (1965) was used to determine particle density. The pH and EC of the soils were determined using a calibrated pH-meter (JENWAY 3505) and an electrical conductivity meter (JENWAY 4510) in 1:1 (soil: water suspension) in line with the method proposed by (Tariq *et al.,* 2012). Particle size distribution and soil texture was determined by hydrometer method according to Tariq *et al.,* 2012. In order to ensure quality control in the course of the analyses, all the reagents used were analytical grades. Reagent blanks were also run in order to check purity of the reagents. Analyses were done in triplicate to ensure precision of the analytical procedure and the instruments used.

RESULTS AND DISCUSSION

The results of the physicochemical parameters of the soil samples collected from the studied area arepresented in Table 1. The pH of the soil ranged from 6.7 to 7.5, indicating slightly acidic to neutral soils. Significant differences between pH of the soils in sites SN2, SS1, SE1, SW1 and SE4 were observed when compared with control. The highest EC of 0.40 and 0.34 dS/m were obtained in both sites SN 4, SN5 and SS4 and the lowest EC of 0.11 and 0.13 dS/m was in SE4 and SN2 soil, however there were significant differences between all of the studied sites. The nature, content and behavior of the organic matter, or humus, in soil are factors of fundamental importance for soil productivity and the development of optimum conditions for growth of crops under diverse temperate, tropical and arid climatic conditions. The concentration of heavy metals from the studied soils is also included in Table 1. Zn has lowest concentration of 0.31 and 0.30 ppm at SS3 and SS4 while SN4 and SW4 has highest concentration 3.3 ppm and 3.2 ppm of Zn.

The highest Zn value in the studied soils was recorded in site 6 which was 3.078 ppm while the lowest value was recorded in site 1 which was 1.439 ppm.

Physical properties of the soil

The physical parameters i.e. pH and electrical conductivity (EC) were found with range of 6.8-7.5 and 0.11-0.40 dS/m (Table 1). The pH was neutral and the EC was beyond its permissible limits which is main indicator of the soil contamination and sodality (Ravindran *et al.*, 2007).

Chemical properties of the soil

The two types of chemical parameters were differentiating i.e. macronutrient or primary nutrients and micronutrients or secondary nutrients, which play major role for soil fertility and health. The micronutrients or secondary nutrients i.e. Fe and Zn were analyzed with the range of 5.5–30 and 0.3–3.3 mg/Kg (Table 2). The trace levels of Fe and Zn support the internal growth of plant that is important for the soil quality. The OC were found with range of 1.2-3.64 mg/Kg. Soil is the main organic carbon reservoir, which get disturbed due to contaminants present in soil. The spatial distribution of parameters was shows in Figure 2, 3. The soil contaminations of this area were sourced from the improper dumping of industrial effluents and air dusts. High electrical conductivity and Zn enrichment factor calculation is indicator of anthropogenic sources of the contaminants. The anthropogenic or industrial contaminants are also affects, degraded and alter the soil quality for the

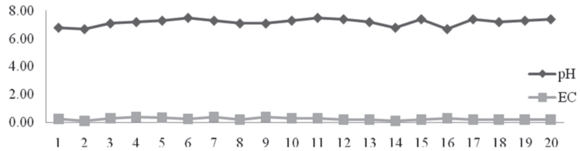

Fig. 2. Spatial distribution of pH and EC in soil samples

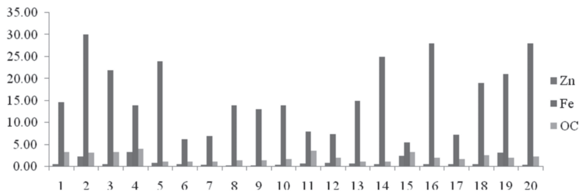

Fig. 3. Spatial distribution of Zn, Fe and OC

productivity.

Enrichment Factor Calculation

Determination of Enrichment Factor (EF)

EF was employed to assess the degree of contamination and to understand the distribution of the elements of anthropogenic factor. Enrichment factor analysis, a method proposed by Simex and Helz, (1981) to assess trace element concentration, is mathematically expressed as:

Enrichment ratio = (Cx/Fe) sample / (Cx/Fe) world soil

Where, Cx stands for concentration of metal 'x', (Cx/Fe) sample is the metal to Fe ratio in the sample of interest, (Cx/Fe) world soil is the natural background value of metal x to Fe ratio. Five contamination categories, recognized on the basis of the enrichment factor, are presented in Table 2.

Background value consideration

Background values act as a basis for assessment of anthropogenic pollution. Metal concentrations of average world soil have also been treated as the background values by many authors (Muller, 1969; Forstner and Wittmann, 1983). The metal concentration of the world soil has been taken as the background value.

Table 2. Contamination categories based on EF

EF = < 2	is deficiency to minimal enrichment
EF = 2 to 5	is moderate enrichment
EF = 5 to 20	is significant enrichment
EF = 20 to 40	is very high enrichment
EF = > 40	is extremely high enrichment

The Enrichment Factor (EF) in metals is one of the indicators used to assess the presence and intensity of anthropogenic contaminant deposition on surface soil. These indexes of potential

Table 1. Chemical properties of soil samples of the Raipur city

S. No.	pH	EC, dS/m	OC	Zn mg/Kg	Fe mg/Kg	Enrichment Factor
SN 1	6.80	0.27	3.28	0.60	15	2.03
SN 2	6.70	0.13	3.13	2.30	30	3.88
SN 3	7.10	0.30	3.30	0.62	22	1.43
SN 4	7.20	0.40	4.00	3.30	14	11.94
SN 5	7.30	0.34	1.20	0.83	24	1.75
SS 1	7.50	0.25	1.20	0.63	6.3	5.07
SS 2	7.30	0.40	1.20	0.40	7.0	2.90
SS 3	7.10	0.20	1.50	0.31	14	1.12
SS 4	7.10	0.40	1.40	0.30	13	1.17
SS 5	7.30	0.31	1.76	0.40	14	1.45
SE 1	7.50	0.31	3.64	0.75	7.9	4.81
SE 2	7.40	0.20	2.02	0.91	7.4	6.23
SE 3	7.20	0.20	1.19	0.72	15	2.43
SE 4	6.80	0.11	1.12	0.60	25	1.22
SE 5	7.40	0.20	3.40	2.40	5.5	22.11
SW 1	6.70	0.31	1.99	0.63	28	1.14
SW 2	7.40	0.20	1.80	0.61	7.2	4.29
SW 3	7.20	0.20	2.65	0.56	19	1.49
SW 4	7.30	0.20	2.04	3.20	21	7.72
SW 5	7.40	0.20	2.30	0.40	28	0.72
World Soil average				75	3800	

Table 3. Enrichment factor calculation of the Studied Region.

Sample Location	pH	Zn mg/Kg	Fe mg/Kg	Enrichment Factor	Enrichment Status
SN	7.02	1.53	21	4.21	Moderate
SS	7.26	0.41	10.86	2.34	Moderate
SE	7.26	1.08	12.16	7.36	Significant
SW	7.20	1.08	20.64	3.07	Moderate
Mean	7.19	1.02	16.17	4.25	Moderate

contamination are calculated by the normalization of one metal concentration in the top soil respect to the concentration of a reference element. A reference element is an element particularly stable in the soil, which is characterized by absence of vertical mobility and/or degradation phenomena. The constituent chosen should also be associated with finer particles (related to grain size), and its concentration should not be anthropogenically altered. Typical elements used in many studies are Al, Fe, Mn and Rb, and also total organic carbon and grain size are among those most used. In this study Fe was used as the reference element.

Zn exists in five distinct pools in soils such as water soluble, exchangeable, adsorbed, and chelated or complexes of Zn. These forms differ in strength and therefore in their susceptibility to plant uptake, and leaching. The equilibrium among different forms is influenced by pH, concentration of Zn and other metals, particularly iron and manganese (Mandal *et al.,* 1992)

The EF values, given in Table 3 shows moderate to significant enrichment status of Zinc in studied soil with respect to world's average soil. Samples from north, south and west regions of the study areas show moderate zinc enrichment, while east region of the study area has significant enrichment which may be attributed to anthropogenic activities. The higher concentration of Zn in the soil may facilitate bioaccumulation and biomagnifications in the foodchain.

CONCLUSION

The soil quality of the industrial area of Raipur city was analyzed with high conductivity and unbalanced of other basic parameters i.e. pH, Fe, Zn and OC. The enrichment factor calculations of zinc in studied region show a value of 4.25 which indicates moderate to significant enrichment. This suggests that industrial effluents are major sources of the soil contaminations in this area that are responsible for the polluted environments.

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