DOI: http://dx.doi.org/10.30684/etj.36.1C.8

3rd Scientific Conference on Environment and Sustainable Development, (3rd SCESD), Baghdad, 15-16 November 2017

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Received on: 05/07/2017
Accepted on: 18/02/2018
Published online: 07/10/2018

Environmental Risk Assessment of Industrial Soil Polluted with Chromium

Abstract- *Thirty-five soil samples were collected from the Tanning Factory Industrial District within Baghdad city to investigate the soil pollution occur through four directions of the tanning plant. The soil samples exhibited high concentrations of Cr than the reported values of worldwide mean of unpolluted soils. The geoaccumulation index showed that the soil samples were moderately polluted by Cr at the north of the factory while the soil sample showed extremely polluted at the south and east of the factory. Moreover, the soil samples collected from west of the factory were strongly polluted. The result of the calculated enrichment factor (64.52-1075.22) showed to extremely high enriched and suggesting a significant role of anthropogenic pollution because of various industrial activities by the Tanning Factory.*

Keywords- Soil pollution; Chromium; Enrichment factor; Contamination Level

How to cite this article: R.S. Mahdi and A.A. Al-Mashhady, "Ecological Risk Assessment of Chromium Pollution in the Soil of Industrial Area within Baghdad City," *Engineering and Technology Journal*, Vol. 36, Part C|, No. 1, pp. 49-53, 2018.

1. Introduction

Through quick growth in urbanization, soil pollution has become a serious problem. Pollution and negative effect on the air, water, and soil quality by population development, quick urbanization, and industrial activities have been identified by numerous works [1,2]. Among the most substantial soil pollutants causing by natural and man-made causes, heavy metals are of major significance because of their long term harmfulness effect [3,4]. Heavy metals generated from soil and dust can be accumulated in the human body through direct inhalation, ingestion, and dermal contact absorption [5,6].

Little care is being given to suitable dumping of industrial waste due to the higher treatment technology cost, and lack of effective application of eco-friendly control laws, [7].

Chromium is being disposed because of numerous industrial techniques such as chromium plating, stainless steel trade, paint industry, and tanning industry. The chromium from the effluents of the tannery industry may cause severe ecological problems. US EPA was selected chromium element as an importance pollutant because of its adverse effects on human health [8]. However, Cr-III is necessary nutritional element [9], Cr-VI is a toxic form of the element found in compound forms prepared for different industries. Exposure to hexavalent Cr can cause adverse effects on warm-blooded organisms [10]. Occupational Safety and Health Administration (OSHA) [11] has stated lung cancer; irritation or damage in the nose, throat, and respiratory tract because of breathing in the environment polluted by chromium; and eye and skin rashes, which may result from chromium direct contact. For eight hours, the higher recommended values set in a workstation in the form of particles is 5 μg·m-3. Cr-VI decreases biotic activity and the enzymatic activity of microorganisms by changing their living locations [12].

This research paper aimed to determine the heavy metals named Chromium, deposited in soil due to the tanning industries. Tanning Factory located in Al-Nahrawan at the north part of Baghdad city, Iraq.

2. Materials and Methods

The study site (33°. 21′ 55″ N, 44°. 51′ 11″ E), is located in the Al-Nahrawn a district in the north part of Baghdad city, Iraq (Figure 1). It is described as arid to semiarid environment. Al-Adili, reported that the mean annual rainfall was about 151.8 mm [13].

Figure 1: Sampling location in the study site

A composite soil samples were arranged by gathering nearby 1 kg of soil from the industrial zone (Area) in the city of Baghdad and the region surrounding the tanning factor, samples were collected at a distance (50, 500 and 1000) m in the four directions around the area of the factory. These samples were then taken from three deeps (0, 50 and 100) cm (Figure 2), by hand digging with a stainless steel spatula. The soil samples were air-drying, and passed through a (2mm) sieve for removing large debris and stones. After that, the soil samples were stored in polyethylene bags for additional analysis. Samples were digested using a combination of HCl and HNO_3 [14]. Heavy metals were tested using Atomic Absorption Spectrometry (model AAS 6300, Shimadzu, Japan) in laboratories of Environmental Research Center, University of Technology, Baghdad, Iraq.

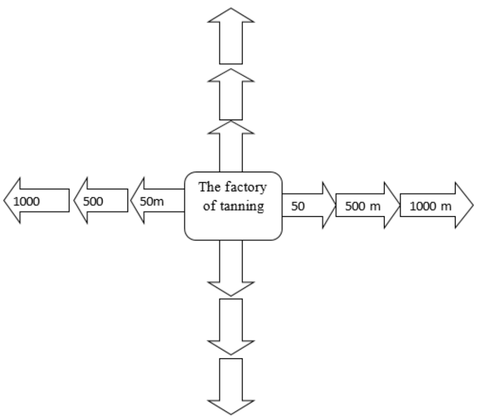

Figure 2: The tanning factory directions samples

2. Results and Discussion

I. Distribution of heavy metals in soil

Descriptive statistics for the examined heavy metal in this study are shown in Table 1. All the measured metal display higher concentrations than the considered world mean of unpolluted soils [15], (Table 1, 2, 3, 4 and 5). Where tacked nine samples from each side of the tanning factory, the north, south, east and west of the tanning factory.

The Cr content, the calculated mean values (567.31, 9453.29, 6304.12 and 2032.9) and median values (236.14, 347.64, 6654 and 2218) were much higher than the average value (84.0 mg/kg) [16] and similarly more than the observed mean value of unpolluted soils (83.0 mg/kg) [15]. This study shows that (94.28%) of all soil, samples contain Cr concentration greater than the standard limit of chromium mentioned above. Maximum concentrations of Cr were at the south of tanning factory. The main causes of these high levels of pollution are Ignorance of the environmental hazards caused by the presence of heavy metals in the soil, air and water, wrong ways follow-up in the disposal of industrial waste for tanning plant, there is a defect in the work of the treatment plants for tanning factory, the presence of leaks in the sewage pipes.

II. Contamination level assessment

In the current study, Igeo and EF were calculated to assess the metal contamination levels. Reference standards (Earth crust mean) of the studied metals, which were used as background values, were taken from Riley and Chester [17].

A. Index of Geoaccumulation

Geoaccumulation index (Igeo) used to assess the contamination by comparing present and preindustrial concentrations [18]. This method applied to some heav metals. It is computed by using the following equation:

$$Igeo = \log_2 (Cn/ 1.5Bn) \quad (1)$$

Where: Cn is the measured content of the studied metal in the soil and Bn is the geochemical background content of the similar metal. The constant 1.5 is presented to reduce the effect of probable differences in the background values, which may be recognized to anthropogenic influences [19,20]. The geoaccumulation index were grouped as: <0=practically unpolluted, 0-1=unpolluted-moderately polluted, 1-2=moderately polluted, 2-3=moderately-strongly polluted, 3-4=strongly polluted, 4-5= strongly-extremely polluted, and >5=extremely polluted [18]. Table 1 shows Igeo values for the measured heavy metal in the tested soil. The contamination ranks of these metals were shown in terms of geoaccumulation index showed that the soil in the study industrial area were moderately polluted at north of tanning factory, extremely polluted at south and east of factory and strongly polluted at the west of factory.

Table 1: Heavy metal concentrations with recommended levels (mg/kg)

Direction	North	South	East	West	Mean of Unpolluted Soils [15]
Cr concentrations (mg/kg)	2080	18158	5822	2356	83
	71.00	18158	7070	970	
	194.06	235.08	7070	1386	
	250.86	347.64	14832	1940	
	1802	24396	9288	2218	
	336.06	23148	6100	2218	
	66.80	161.46	317.12	3882	
	236.14	169.88	6238	3050	
	68.90	305.56	-	276.1	
Max	2080	24396	14832	3882	
Min	66.80	161.46	317.12	276.1	
sum	5105.82	85079.62	56737.12	18296.1	
mean	567.31	9453.29	6304.12	2032.9	
median	236.14	347.64	6654	2218	
Std. Deviation	787.44	7540.43	11104.40	1890.81	
EF	64.52	1075.22	717.03	231.22	
Igoc	1.91	5.97	5.39	3.7605	

Table 2: Concentration of Cr mg/Kg at the surface of soil depth (0 cm)

Location	N	S	E	W	Mean of Unpolluted Soils [15]
A (50 m from the factory)	2080	18158	5822	2356	83.0 mg/kg
B(500 m from the factory)	250.86	347.64	14832	1940	
C (1000m from the factory)	66.8	161.46	317.12	3882	
max	2080	18158	14832	3882	
min	66.8	161.46	317.12	1940	
mean	799.22	6222.36	6990.37	2726	
Median	250.86	347.64	5822	2356	

Table 3: Concentration of Cr mg/Kg at the surface of soil depth (50 cm)

Location	N	S	E	W	Mean of Unpolluted Soils [15]
A (50 m from the factory)	71	18158	7070	970	83.0 mg/kg
B(500 m from the factory)	1802	24396	9288	2218	
C (1000m from the factory)	236.14	169.88	-	3050	
max	1802	24396	9288	3050	
min	71.00	169.88	7070	970	
mean	703.04	14241.29	5452.66	2079.33	
Median	236.14	18158	5452.66	2218	

Table 4: Concentration of Cr mg/Kg at the surface of soil depth (1000 cm)

Location	N	S	E	W	Mean of Unpolluted Soils [15]

A (50 m from the factory)	194.06	235.08	7070	1386	83.0 mg/kg
B(500 m from the factory)	336.06	23148	6100	2218	
C (1000m from the factory)	68.9	305.56	6238	276.1	
max	336.06	23148	7070	2218	
min	68.9	235.08	6100	276.1	
mean	199.67	7896.21	6469.33	1293.36	
Median	194.06	235.08	6100	1386	

B. Enrichment factor (EF)

Enrichment factor calculation is based on normalization of an element verified against a reference element. The greatest communal reference elements are Sc, Mn, Ti, Al, Ca, and Fe [21,22,23]. Iron was selected as a traditional tracer to differentiate natural from anthropogenic constituents, due to the assumption that its content in the earth crust has not been disturbed by anthropogenic activities and it was selected as the standardization element since natural sources (98%) vastly dominate its input [24]. The metal enrichment factor (EF) is calculated using the following equation [25]:

$$EF = \frac{\left(\frac{M}{Fe}\right)sample}{\left(\frac{M}{Fe}\right)background} \quad (2)$$

Where:
EF is enrichment factor, and (M/Fe) sample is the ratio of metal and Fe content of the sample and (M/Fe) background is the ratio of metal and Fe content of a background. Five contamination groups are documented based on the enrichment factor [26].

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

The results of the enrichment factor as shown in Table 1 recommend that the heavy metals source may not originate from the local background of soil but extra natural and/or anthropogenic sources in industrial areas [1]. The reported values of EF such as 64.52 to 1075.22 display that important heavy metal pollution was expected to initiate from the industrial activities of the tanning factory. The EF results showed that the soils samples collected from this study area were extremely high enrichment with metal Cr at all the four directions of tanning factory.

Acknowledgements

We cordially thank, Environmental Research Centre, University of Technology, Baghdad, Iraq, for her help in carrying out the laboratory analysis.

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