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RESEARCH PAPER

Impact of Landfills on Soil Contamination by Some Heavy Metals at Kani-qrzhala in Erbil City- Iraqi Kurdistan Region

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A B S T R A C T:

The present study was carried out in November 2019 to investigate the impact of Kani-qrzhala landfill on soil pollution of the surrounding area caused by the disposed of refuses from houses, factories, and hospitals. Soil samples were collected from 6 sites in Kani-qrzhala landfill on Erbil-Mosul Road ((Latitude 36˚13' N, Longitude 43˚.58' E). Soil samples were taken randomly selected at different depths (0-10), (10-20), (20-30) cm, were collected randomly at the dumpsite field in the study area with a control sample. The different parameters of soil samples were analyzed of contaminated metals such as Iron (Fe), Manganese (Mn), Nickel (Ni), Lead (Pb), and Zinc (Zn) were determined in the study soil samples by using portable x-ray fluorescence (XRF). Additionally, specialization index Geoaccumulation (I geo) was calculated and used for evaluating the soil pollution status: In the depth (0-10) cm, the heavy metals concentration was recorded as follow: Fe > Pb > Zn > Ni > Mn. Also in the depth (10-20) cm Fe > Pb > Zn > Mn > Ni. In the depth (20-30) cm depth Fe > Pb > Mn > Zn > Ni (0 mg kg-1). Measuring Geoaccumulation index (I geo): The results show that most the most location of the study area of soil surrounding the dumpsite were polluted by heavy metals followed by series: Ni, Pb > Zn > Fe >Mn.

KEY WORDS: Heavy metals, dumpsite soils, soil properties, I geo.
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1. INTRODUCTION:

As the population grows rapidly, along with the technological and industrial advances in the recent years, the chemical composition of municipal solid waste (MSW) in the country has also become more complex. This includes the presence of various toxic heavy metals. Considerable amount of toxic heavy metals that may create potential adverse effects on human, crops and animals, have been a great concern to both regulatory bodies and environmental activist in the recent years. Due to this reason, the availability of good heavy metal data in local MSW is important (Steven, 2003).

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Moreover, it's necessary to carry out research for investigate and monitoring the soil pollution degrees in order to evaluate for economic sustainable development and public health (Eni and Bosneaga, 2010). Basically, the term soil pollution indicates for a substance or a chemical out of normal concentration which has a negative effect on surrounding living organisms and the physicochemical properties of soils. Most of the pollutants are derived from anthropogenic sources directly or indirectly, while, other metals are observed naturally from rocks and mineral (Jeong, 2022). Soil has been increasingly used for dumping and buried solid and liquid wastes during the expansion of urban industrialization, thinking it was out sight with no risk to human and the environment whatsoever and the pollutants will disappear (Shui et al., 2020) As the pollution grow rapidly, along with the technological and industrial advances in the recent years, the chemical composition of municipal soil waste (MSW) in the country has also become more complex this includes various toxic heavy metal .considerable amount of toxic heavy metals that may create potential adverse effects on human, crops and animals, have been a great concern to both regulatory bodies and environmental activities in the recent years, due to this reason the availability of good heavy metal data in local MSW is important (Steven, 2003). Trace elements and heavy metals occur naturally in the earth's crust. The natural geological and biochemical cycle of heavy metals is massively altered by anthropogenic activities. Therefore, a continuous descending of pollutant concentration especially heavy metals in soil turn a red light for environmental concern in the ecologists, biologist and farmers. Assessing heavy metals concentration in soil for environmental risk assessment and their essentiality for the agricultural and non-agricultural area. The persistence of heavy metals in soil for long period of time besides their potential toxicity creates major human health issues. An alteration and accumulation of heavy metals through natural and anthropogenic activities and need to be subjected under the scope for their poses and threat to ecological phenomena (Al Obaidy et al., 2013). The objectives of this study were to know the effect of the Kani-qrzhala landfill at different locations and depths on soil contamination by heavy metals, and to quantify the number of heavy metals in the soils were taken under MSW, and Determining the Geo-accumulation Index (Igeo) here was to determination of the spatial distribution of the Geoaccumulation indices (Igeo) of Pb, Cd, Ni, Fe and Mn in surface soil horizons in the landfill of the study area as a parameter of soil contamination.

2. MATERIALS AND METHODS

2.1 Descriptions of the study area

Soils were collected from landfills which were located at the road of Arbil-Mosul governorate. The soils were taken from the soil surface (0 -30) cm depth (Table 1). The dump field investigated is located at the west of Erbil city lies between latitude 36˚13' North and longitude 43˚58' East. It's an open dump area for all of the wastes (domestic, commercial, industry, and wastes from hospitals and clinics…etc) together without any segregation before dumping.

Table (1) combination effect of depths and directions of soil samples on total heavy metals concentration (mg kg^{-1}) in polluted soils.

Sample Number	Directions	Depth (cm)	Pb	Cd	Ni	Fe	Mn
			mg kg^{-1}				
1	North	0-10	298	1.98	4.30	15690	17.0
		10-20	252	2.07	0.00	12149	16.0
		20-30	206	2.19	0.00	7968	0.00
2	East	0-10	238	2.07	4.30	12210	16.0
		10-20	218	2.11	0.00	11306	14.0
		20-30	164	2.15	0.00	10158	16.0
3	South	0-10	160	1.41	2.10	6139	16.0
		10-20	57	1.46	0.00	7108	12.0
		20-30	0.0	2.00	0.00	5278	11.0
4	West	0-10	135	1.21	0.00	6060	13.5
		10-20	45	1.25	0.00	8214	21.0
		20-30	0.0	1.31	0.00	5826	17.0
5	Control	0-10	0.0	0.25	0.00	4752	11.0
		10-20	0.0	0.21	0.00	4656	11.3
		20-30	0.0	0.01	0.00	4848	9.0

2.2 Soil sample location pretreatments

Six soil samples were taken randomly obtained under the dumpsite area after removing the overlying wastes of surface soil samples, six locations chosen to represent various location of the dumpsite. While one sample located outside of the dumpsite area which chosen as a control sample at the dumpsite from unfarmed land, at 100 m away from the landfill. The soils were air dried ground and sieved through a 2 mm, and kept until physical and chemical analysis. The samples were taken from soil surface (0-10), (10-20), (20-30) cm (Halverson, 2001).

2.3 Total heavy metal concentration in soil samples (mgkg^{-1})

The determination of heavy metals content in soil samples directly done by using portable (X-MET7500) XRF analyzer after drying, grinding, and sieving with 2mm the samples (Sitko et al., 2004).

2.4 XRF (X-Ray Fluorescence)

XRF it's essential for determining heavy metals content in the soil sample, it can be operated in situ in the investigated area which tremendously decrease the number of sample for the laboratory. Furthermore, a direct analyzed can be done after drying and powdering of the material (Sitko et al., 2004). X-MET7500 (X-ray Metorex) handheld energy dispersive X-ray fluorescence analyses are rapid multi-element analyzers. This device it's well-known for their high capability for more than (50) years in Oxford Instruments. The X-MET7500 are capable for providing a rapid and precise analysis from the wide range of material including some essential macro, micro and heavy metals like magnesium and other trace elements. X-MET7500 provides additional analytical flexibility, and the higher performance needed to determine low levels of impurities. One of the major pros for using XRF it's the lack of digestion of sample which is necessary step need to be done while operating ICP method for screening for total element. Moreover, XRF technique provide non-destructive for homogeneous materials analysis. Only a tiny preparation for samples are require, which makes XRF quite cost effective and each measurement require less than 5 min compared to other devices which takes enormous amount of time from cutting, weighing, and digesting the materials. Other pros for XRF device the lack for adding a hazardous acid, and elimination the chance for disposing those acids. Some XRF provide are portability for analyzing of materials, allowing for field-screening of products (David, 2015). The Geoaccumulation index (Igeo) was used as a quantitative determination of the spatial distribution (random and systematic variation) of heavy metals in surface soil horizons in the study area. A good indicator of environmental pollution of soils by heavy metals is their Geoaccumulation index (I geo) (Grzebisz et al., 2002). For the evaluation of soil contamination by heavy metals, the pollution indices may differ from each other due to several factors that affect their importance (Ahiamadjie et al., 2011and Kowalska et al., 2016).

Geo-accumulation index (Igeo) = log2 Ci / (Cig*1.5)………. (1)

Where: Ci it's the concentration of selected metal in the investigated area and Cig it's the background concentration of the selected metal or concentration of metal in the control sample, and 1.5 is constant that is used for lithological variations of the heavy metal. Determining the soil pollution indices needs the evaluated level of the geochemical background (GB). This term was presented to discriminate natural concentrations of heavy metals in the soil from unusual concentrations (Reimann and Garret 2005). (Muller, 1979) who defined Geo-accumulation index (Igeo) as a single index to affirm metal contamination and it's a basic, accurate, and commonly used for quantitative method to evaluate degree of single metal concentration in a soil sample with respective to the geological background (BG). This parameter can be used for comparison between the past pollution levels and present. Furthermore, for minimizing the variation of lithogenic effects the (1.5) value is employed in Igeo index equation. However, Igeo index has also many weak points such as; in case of using incorrect geological background (BG), unreliable results will be obtained, possible natural fluctuation within the geological background (BG) will also lead to mistaken results, and dismissing the possible capability of another present, heavy metal for causing pollution) Kowalska et al., 2016).The authors Forstner et al., (2014) have classified the geo-accumulation index into seven intensity classes and they are as follow: I geo ≤ 0 named as class 0 or uncontaminated; 0<Igeo≤1 called class 1or uncontaminated to moderately contaminated; 1<Igeo≤2, termed class 2 or moderately contaminated; 2<Igeo≤3 named class 3 or moderately to strongly contaminated; 3<Igeo≤4 is termed as class 4 or strongly contaminated; 4<Igeo≤5 is considered as class 5 or strongly to very contaminated, and finally Igeo>5 is regarded as class 6 or very strong contaminated.

Fig. 2 Portable XRF (X-MET 7500 Metorex)

3. RESULTS AND DISCUSSION

3.1 Total heavy metals concentrations (mgkg-1) in soils at different depths

The present study has endeavored to determine the concentrations of Pb, Zn, Fe, Mn and Ni in the assortment samples of soil. The appraisal of soils in the dumpsite for the levels of harmful elements is indispensable for in good health crop yield; (Table 1) shows the heavy metals concentrations were in attendance in the soils. The accumulation of heavy metal from the soils of landfill was higher than the control samples (100 m) away from the landfill area.

3.1.1 Lead (Pb)

The mean values of Pb in the landfill soil samples ranged 00.00-298.00 mg kg^{-1} against 0.00 mg kg^{-1} in control (Table.1). The Pb was higher than observed by Koaser (2003), with the highest value of 298.0 mg kg^{-1} and the maximum allowable limits proposed for farmland soils 15 mg kg^{-1} of uncontaminated soils (Kabata-Pendias and Pendias 2011) and higher than the standard background rate of 10 mg kg^{-1} reported by (Alloway,1995). This is in conformity with the results obtained from similar modification by Umoh and Etim (2013) for soils from dumpsites. Concentration of lead in the soils from both areas should be as a result of batteries dry cell, sewage waste water, atmospheric depositions of wastes and runoff. The sampling depth caused a significant decrease on the total concentration of Pb in soil samples, the decrease of Pb under the effect of depth may be due to the heavy metals characteristics (Fig. 1a).

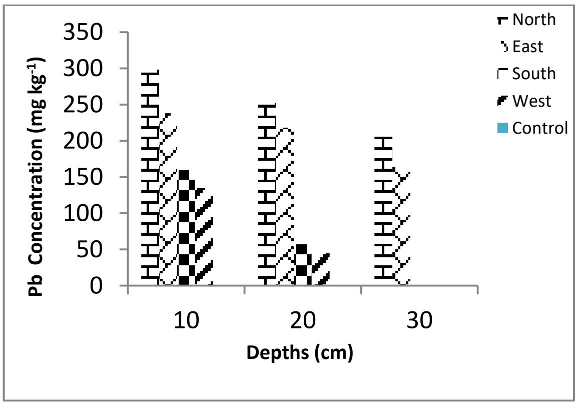

Figure (1a): Relationship between Heavy metal concentrations with depths in the different directions of the studied soils.

Organic matter its great sink for Pb in contaminated soil which is responsible for accumulating Pb near the soil surface in the most soil sample. (Shenglu et al., 2008).The highest value of lead (298.00 mg kg^{-1}) was from north direction and in depth (0-10 cm) and may be as a result of long term waste disposal because the waste disposed contained several sources of lead such as cans, fuels, pigments, wheels, and chemicals. Traunfeld and Clement (2001) identified that lead accumulated in the upper (20 cm) of the contaminated soil and is highly immobile. Ahmed (2012) observed that highest amount of Pb accumulated at surface soil. The lowest value of lead (00.00 mg kg^{-1}) was from the south direction from the source of pollution this may be due to mobility which could not be easily leached to bottom layer and physical properties of the soil and soil pH value (Al- Khashman and Shawabkeh 2006). Al Farraj and Al Wabel (2007) also observed that the heavy metals concentration decrease with increasing soil depth or may be due to the low mobility of Pb in the soil (Bansal and Singh, 2014). There results indicates that the maximum amount of Pb was concentrated on the soil surface, Miclean et al., (2009) concluded that Pb is mainly accumulated in surface horizon of soil due to its poor water solubility within an environmentally relevant pH range results in very low mobility. Soil polluted at the surface with Pb deposits from aerial contamination show little indicators of metal leaching over many years. Furthermore, lead accumulated in the surface horizons of the soil and it's not usually leached due to its lower mobility (Ekeleme et al., 2013).

3.1.2 Cadmium (Cd)

The mean concentration of cadmium in the dumpsite soil samples were 1.21-2.19 mg kg^{-1} (Table1, Fig.1b) that located between normal range of 0.1-7.0 mg kg^{-1} in soil (Das, 2005). The lowest value of cadmium (1.21 mg kg^{-1}) was obtained from west direction at 0-10 cm depth and this may be due to geochemical properties of soil such as pH, organic matter, and inorganic legends. Cd was known as more mobile and highly soluble than other heavy metals. Cadmium in soil was not strongly affected by soil organic matter, but cadmium existed in solution as a free divalent cation (Cd^{2+}) or with inorganic legends Cl^- , SO_4^{2-}, or HCO_3^- . The compound formation between metals and inorganic compounds Cl^- and SO_4^{2-} prevent the adsorption of Cd on soil and this may be due to the creation of cadmium complexes that were not strongly adsorbed by soil. Cadmium is precipitate as $CdCO_3$ or CO^- precipitate with $CaCO_3$ with resulting decrease in solubility/ availability when soil pH > 7 (Saha et al., 2017). Ahmed (2012) mentioned the highest value of Cd was accumulated at surface layer, while the lowest value recorded at bottom layer.

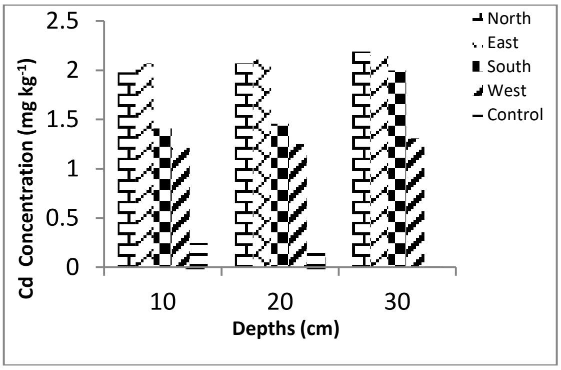

Figure (1b): Relationship between Heavy metal concentrations with depths in the different directions of the studied soils.

3.1.3 Nickel (Ni)

Nickel concentration in the landfill soils which ranged between 0.00 to 10.17 mg kg^{-1} slightly higher than the control soil samples (0.00 mg kg^{-1}) table (1). Figure (1c).and results It concentration was located within allowable value (5-500 mg kg $^{-1}$ soil) of nickel according to Allen et al., (1974) and less than with the permissible range in United State 13-30 mg kg^{-1} soil (McBride, 1994). The highest value of nickel (10.17 mg kg^{-1}) was recorded at the south from the depth (0-10 cm). This may be due to soil contamination with different sources of nickel as a result of anthropogenic activities which leads to release higher level on nickel to the soil. Esakku et al., (2003) observed that higher levels of heavy metals at the middle layer may be due to the downward migration of leachates. The higher level of metals (Ni, Cd, Pb and Zn) occurred in MSW. The lowest value of nickel (0.00 mg kg^{-1}) was obtained from the most of locations, this may be due to high level of Fe and Mn oxides and a part of soil nickel occluded in Fe and Mn oxides also seems to be available to plant roots (Saha et al 2017). Ahmed (2012) was recorded lowest amount of Ni at bottom layer. These results agree with Das (2005) and Esakku et al., (2003). The concentration of heavy metals both in natural and in converted soil at varying depth does not follow any specific trend .The concentration of some parameters increased with increasing depth and other parameters decreased with depths since the concentration does not follow any regular trend (Mamtaz and Chowdhury 2008). These results may be due to the single effect of the study factors since the combination between two factors or more may create different environmental condition.

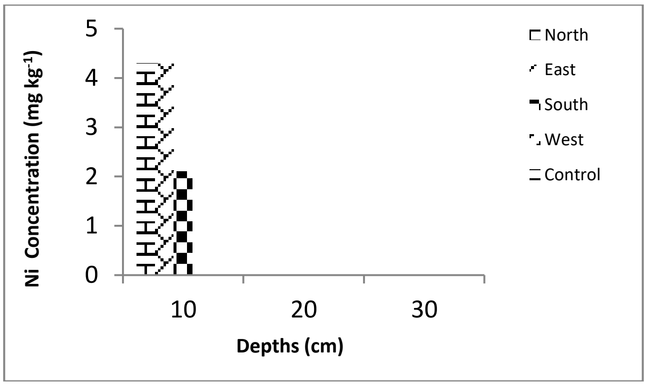

Figure (1c): Relationship between Heavy metal concentrations with depths in the different directions of the studied soils.

3.1.4 Iron (Fe)

The highest value of iron concentration (15690 mg kg^{-1}) which was recorded from the north direction at the depth (0-10) cm table (1). Figure (1d).The occurrence of highest concentration of Fe at north site is attributed to use of the site as storage of scraps for iron wastes. This finding agrees with Aisien et al., (2013). Lak (2007) reported that the most abundant mineral in soils was Fe because of disposing scrap metal (mostly iron) at this site (scrap yards). According to Aisien et al., (2013) and Ahmed and Abdalhamed, (2019) scrap vehicles are mainly made of iron, which corrode very fast when exposed to environmental condition. The lowest value of iron (4656 mg kg^{-1}) was recorded from control which lies 100 m away from the source of pollution, this may be due to this location was away from the source of pollution (steel scrap site) and this agree with (Simon and Fadoju, 2016) obtained that the concentration of iron decreased with increasing horizontal distances from the scrap metal dump.

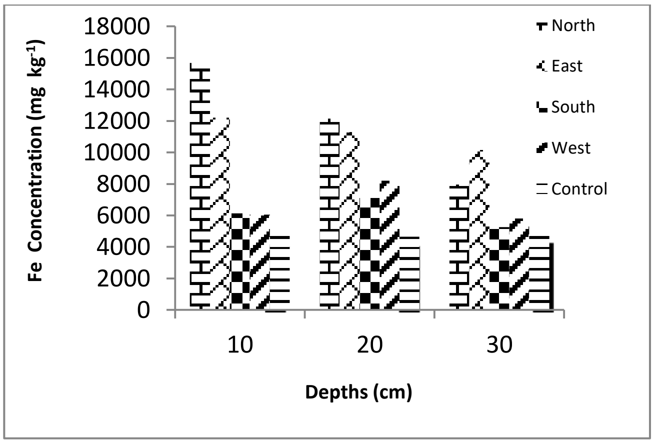

Figure (1d): Relationship between Heavy metal concentrations with depths in the different directions of the studied soils.

3.1.5. Manganese (Mn)

Table (1) figure (1e) shows the highest value of manganese concentration as (23 mg kg^{-1}) was in the Center. This site of pollution which causes increase of manganese content and this agree with Sibley (2004) evaluated that manganese was recycled mostly within old scraps of which 96% was from iron and steel scraps, while the lowest value of manganese was (0 mg kg^{-1}) was obtained in the N direction which lies 5 m away from the source of pollution and this is may be due to this location far away from the source of contamination or probably due to plant absorption and this is agree with Chukwujindu et al., (2009) estimated that the manganese is easily absorbed and utilized by plants and other organisms, the levels of heavy metals concentration decrease with distance to industrial area mining sites.

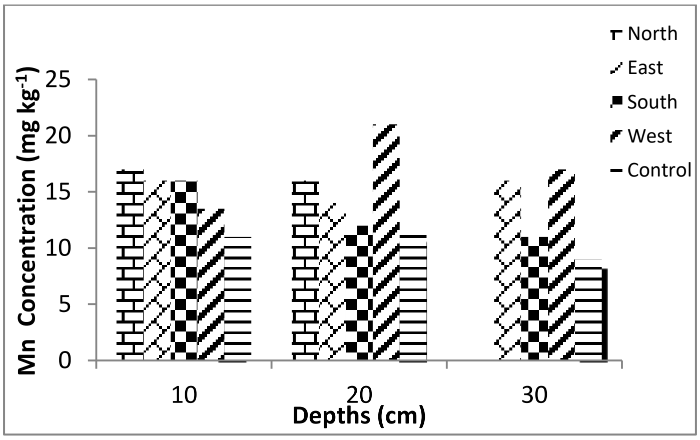

Figure (1e): Relationship between Heavy metal concentrations with depths in the different directions of the studied soils.

4.2 Geoaccumulation index (I *geo*)

In the present study, an exchangeable and available fraction of metals were extracted in soil sample, which represent mainly the mobile fraction of the elements. The pollution levels of these metals in the environment expressed in terms of the Geoaccumulation indices indicate that the soil is highly polluted with Ni, Pb. Metals Zn, Fe, and Mn showed unpolluted to moderately pollute while Pb and Ni show moderate polluted (Table 2). This indicated that the soils zone is polluted by Pb and Ni to be highly dangerous to human health. (Assah et al., 2005). Pb and Ni had high pollution class in the sites this was because the main sources of scrap waste with Pb and Ni (Janke et al., 2000). The toxic limits for Pb and Ni are much higher than for other essential element sand this is agreeing with Venalainen (2007) who classified that the toxic limits for Pb and Ni are much higher than for other essential elements, it can be toxic in large doses, especially in certain genetic disorders.

Table (2) Classification of metal contamination in the landfill soils based on (I geo) in the studied area.

Station / items	I *geo*				
	Pb	Zn	Ni	Fe	Mn
1	>6	7	>6	1	0.7
2	>6	6	>6	1	0.7
3	>6	2	>6	0.6	0.7
4	>6	2	>6	0.6	0.6
5	>6	2	>6	0.6	0.7

CONCLUSIONS

Based on data which was obtained from this research the most important conclusions were: Kani- qrzhala refuses effects on soils properties like increases in heavy metals content at area surrounding the landfills. Geoaccumulation index of the soil samples of the landfill showed that metals Zn has very high polluted, Ni and Pb has moderate polluted while metals Fe, Mn showed unpolluted to moderately pollute.

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