Assessment of the effects of municipal landfills on the metal pollution in the surrounding soils: A case study in Iraq

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Abstract. The present investigation has been devoted to assessing the environmental impacts of a local landfill, in the north of Hilla city, Iraq, on the surrounding soils in terms of heavy metal pollution. The concentrations of heavy metals, namely chromium (Cr), copper (Cu), nickel (Ni), and lead (Pb) were measured during, November 2019, at three investigation sites that located at distances of 10 (site 1), 20 (site 2) and 30 m (site 3) from the edge of the mentioned landfill. Soil samples were collected from these sites at a constant depth of 20 cm. The collected samples were air-dried, manually crushed, and sieved through a 2 mm mesh before subjecting them to a chemical digesting process. The concentrations of the targeted metals were measured using an inductively coupled plasma optical emission spectrometry and compared to the standards of the State Environmental Protection Administration (SEPA). The obtained results showed that the highest concentrations of the targeted metals were in site 1, while the lowest concentrations were detected at site 3. Generally, it was found that the concentrations of the studied metals followed the order: Cr>Pb>Ni>Cu. Additionally, it was noticed that all the measured concentrations were within the limitations of the SEPA.

1. Introduction

Heavy metals are a basic component of the eco-system of the planet of Earth that makes them naturally present in the freshwater, groundwater, and soil [1-3]. For instance, the literature indicated that iron could naturally occur in surface water and groundwater at high concentrations that could reach 50 mg/L [4-6]. The natural occurrence of heavy metals does not represent a serious threat to the environment or public health as the eco-system can naturally balance the concentrations of heavy metals [7-9]. However, the combined effects of human activities, especially in the urban areas, have significantly altered the natural cycles of heavy metals, and other elements, which disabled or limited the ability of the eco-systems to balance the concentrations of the heavy metals in water and soils [10-12]. Generally, heavy metals could result from a wide range of anthropogenic activities, such as vehicular exhausts, agricultural wastewater, industrial wastewater, mining industries, planting and finishing plants, fertilizers and pesticides, and solid waste disposal (landfills) [13-18]. This type of
pollutant causes serious health problems, such as cancers and Alzahimer [19-21], and also harms the eco-system [11, 22]. The heavy metal pollution has recently intensified due to the effects of global warming on the availability of freshwater [23-26]. To remove heavy metals and other harmful pollutants from water, different methods have been used, including biological treatments [27-31], the addition of chemical coagulants [32, 33], electro-chemical technologies [34-37], bio-degradation [27, 38] and physical separation and recycling technologies [39]. With the uncontrolled increase in the global population and urbanization activities, the number and size of landfills have substantially increased to accommodate the disposed of municipal solid wastes (MSW) [16, 40]. For example, the average yearly generation of MSW in the urban areas in India is currently about 48 million tons, however, it is expected to reach as high as 250 million tons by 2047. In Iraq, the published literature indicates that the generation of the MSW has also rapidly increased during the last 15 years and, unfortunately, it still follows an increasing trend [41-43]. In addition, a significant amount of concrete wastes, and demolishing wastes are generated in the cities [44-49], which are disposed of in the local landfills. For example, the disposed of MSW in the Hilla city has increased from about 40,000 tons in 2009 to about 50,000 in 2013, and it will increase to the vicinity of 900,000 tons by 2030. Furthermore, Hilla city is one of the Iraqi cities that subjected to a regular sudden upsurge, during the yearly 15-days Arba’e’en religious festival, in the generation of MSW. Where, in this event, more than 20 million people walk towards Kerbala city passing through either Hilla, Najaf, or Baghdad city that results in to what similar to a sharp pulse in the generation of MSW [16, 50]. Regrettably, the majority of the global MSW is disposed of without enough or without management, for example, 90% of the MSW in India does not receive enough management. Hence, the MSW became a major concern for the environmental authorities as they not only pollute groundwaters and surface water bodies with a wide range of organic and inorganic pollutants but also substantially pollutes the surrounding soils with the same spectrum of pollutants [13, 15]. Additionally, the landfills generate greenhouses gases that are responsible for global warming, which in turn causes environmental disasters and elevated water consumption [51-54].

In this context, this study investigates the concentrations of four heavy metals (chromium (Cr), copper (Cu), nickel (Ni) and lead (Pb)) in the surrounding soils to a municipal landfill located in the Babylon province, Iraq, and compare it with the standards of the State Environmental Protection Administration (SEPA).

2. Studied area

The study landfill is located in Babylon province, north of Hilla city, near to the borders between Hilla city and Qadhaa Al-Mahaweel (32.645420, 44.373309), see Figure 1. This landfill receives different types of municipal solid wastes (MSW), ranging from simple kitchen wastes to the waste of the construction industry. Generally, the depth of wastes in this location was estimated to be in the range of 1.5-4.5 m. This landfill has been selected as a case study as it is, like many other landfills in Iraq, is not well managed, and the disposal process could be classified as a non-engineered process as the MWS are dumped without a proper sorting process. However, several rag pickers were noticed sorting out the recently dumped wastes to collect glass, cans, metals, and plastic to sell later for the relevant industries, which in turn recycles these materials.
3. Materials and methods
Soil samples were collected, during November 2019, three investigation sites (I1, I2, and I3) located at distances of 10, 20, and 30 m. These samples were collected at a depth of 20 cm. The collected soil samples were placed in plastic bags, labeled, and transferred into the laboratory as soon as possible to avoid any bacterial effects. Treatment and preparation of the collected samples were carried out following the relevant literature [55]. Initially, the collected samples were dried at a temperature of 60 °C for 24 hours using an electrical oven (SNOL, model: 300LFN). The dry samples were sieved through a 2 mm mesh to separate debris and stones/gravels. The sieved samples were digested before testing them for the concentrations of Cr, Cu, Ni, and Pb using an inductively coupled plasma optical emission spectrometry (model: OPTIMA-2000).

4. Results and discussion
As it has been mentioned above that soil samples have been collected from three sites that are distributed at 10 to 30 m away from the edge of the studied landfill. The obtained results are tabulated in Table 1, which indicates that generally, the concentrations of the studied four heavy metals decrease with the increase of the distance from the landfill. This relationship between the concentrations of the heavy metals and the distance could be attributed to more than one reason; firstly, is the seepage phenomenon, where the leached water from the accumulated MSW was not enough to travel to long distances, which concentrated the pollutants in a short distance around the landfill. Secondly, the last few years witnessed a decrease in the rainfall and high droughtiness, which significantly limited the seepage of surface runoff into the landfill and wash out pollutants into the surrounding soils and water sources. Thirdly, it can be noticed that the concentrations of the studied four heavy metals were below the stated limits by the SEPA [55], which is a healthy sign. Thirdly, it has been found that Cr had the highest average concentration, followed by Pb and Ni, while Cu had the lowest average concentration. This variation in the concentration of the studied heavy metals could be attributed to the chemical composition of the disposed of MSW and the composition of the studied soil.
Table 1. The measured concentrations of the studied heavy metals in the collected soil samples.

| Metal | Site | Concentration (mg/kg) | Average (mg/kg) | SEPA limitations |
|-------|------|-----------------------|----------------|-----------------|
| Cr    | I1   | 22.8                  |                |                 |
|       | I2   | 19.4                  | 19.2           | 250             |
|       | I3   | 15.4                  |                |                 |
|       | I4   | 17.9                  |                |                 |
| Cu    | I2   | 9.89                  | 11.5           | 100             |
|       | I3   | 6.7                   |                |                 |
|       | I4   | 18.3                  |                |                 |
| Ni    | I2   | 12.2                  | 12.8           | 60              |
|       | I3   | 7.8                   |                |                 |
| Pb    | I2   | 17.1                  | 16.8           | 350             |
|       | I3   | 13.3                  |                |                 |

The obtained results highlighted the serious need for more research studies to have a better understanding of the variation of heavy metals in the studied soil and about the transportation mechanisms of heavy metals from the landfills to the surrounding soils. For example, a number of researches should be conducted during the wet season (December-February) to check the change in the concentration of the studied heavy metals (due to the increase of the surface runoff). More researches could be allocated to check the feasibility to use sensors [56-59] to monitor the movement of heavy metals around the landfill area. Additionally, another set of researches are required to examine the chemical composition of the surrounding soils to ensure whether the measured concentrations were from the disposed of MSW or the natural soil.

5. Conclusions

The current study focused on the impacts of the municipal landfills on the surrounding soils in terms of heavy metals concentration; mainly focused on the concentrations of chromium, copper, nickel, and lead. The obtained results indicated that concentrations of the studied pollutants are inversely proportional to the distance from the landfill, where it was noticed that the concentration of all studied pollutants decreased with the increase of the distance from the landfill. Additionally, it was noticed that all measured concentrations of the studied heavy metals were within the recommended limits by the State Environmental Protection Administration (SEPA). The highest average concentration, in the studied locations, was of chromium, while copper had the lowest average concentration.

For future studies, a number of researches are needed to investigate the effects of the wet weather on the leaching of pollutants and to examine the chemical composition of both the disposed of MSW and the natural soil of the landfill to understand the geological and meteorological effects of the heavy metal distribution in the area of the landfill.

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