Turkish Journal of Forest Science
Available online at dergipark.gov.tr/turkjforsci

# INVESTIGATION OF HEAVY METAL CONCENTRATIONS IN SOIL CAUSED BY KASTAMONU CITY WILD STORAGE DUMPSITE

Gamze SAVACI[1,*] Çağatay ÖKSÜZ[1]

[1]Department of Forest Engineering, Faculty of Forestry, University of Kastamonu, Kastamonu

[*]Corresponding author: gsavaci@kastamonu.edu.tr

Gamze SAVACI: https://orcid.org/0000-0003-4685-2797
Çağatay ÖKSÜZ: https://orcid.org/0000-0003-4900-8655

**Please cite this article as**: Savacı, G. & Öksüz, Ç. (2020) Investigation of heavy metal concentrations in soil caused by Kastamonu city wild storage dumpsite. *Turkish Journal of Forest Science*, 4(1), 26-39

**ESER BILGISI / ARTICLE INFO**
Araştırma Makalesi / Research Article
Gelis 15 Mart 2020 / Received 15 March 2020
Duzeltmelerin gelisi 19 Nisan 2020 / Received in revised form 19 April 2020
Kabul 21 Nisan 2020 / Accepted 21 April 2020
Yayımlanma 30 Nisan 2020 / Published online 30 April 2020

**ABSTRACT:** The aim of this study was to reveal the effects of domestic dumpsite on the some soil chemical properties in the surface soils in Kastamonu city. The soil samples were collected from the 5 different distances namely; Very adjacent (VA), Adjacent (A), Middle (M), Far (F) and Very far (VF). The results showed that the accumulation of heavy metal in the soil varied significantly with the distances. Among the heavy metals, the concentrations of Co, Cr, Cu (only A and VA), Zn (only A and VA), Ni (except for M) exceeded the Maximum Allowable Limit (MAL) for Turkey values. However, the concentrations of Mo, Pb and Cd were below the MAL limit values. When all results are considered, it can be stated that the waste dumpsites can negatively affect the environment. Therefore, we make sure that the dumped materials should be concentrated and recycled in order to decrease the amount of heavy metals in the dumpsites and in the soils around the dumpsites. In addition, phytoremediation, which is all the remediation technique available for metal contaminated soils, is the most costly, environmentally friendly and easy to apply. Phytoremediation can be used to remove, displace or reduce contaminants from soil by using plants that hyperaccumulate these contaminants.

**Keywords:** Heavy metal concentration, dumpsite, contamination, Kastamonu

# KASTAMONU İLİ VAHŞİ DEPOLAMA ALANI TOPRAKLARINDA AĞIR METAL KONSANTRASYONLARININ İNCELENMESİ

**ÖZET**: Bu çalışmanın amacı, Kastomonu ilinde yer alan evsel nitelikli çöp sahası topraklarının bazı kimyasal özellikleri üzerindeki etkileri ortaya konulmaya çalışılmıştır. Şehir çöplüğüne yakınlık-uzaklık mesafesine göre Çok yakın (ÇY), Yakın (Y), Orta (O) Uzak (U) ve Çok uzak (ÇU) şeklinde 5 farklı mesafeden toprak örnekleri toplanmıştır. Sonuçlar topraktaki ağır metal birikiminin mesafelere göre önemli ölçüde değiştiğini göstermiştir. Ağır metal konsantrasyonlarından Co, Cr, Cu (sadece Y ve ÇY), Zn (sadece Y ve ÇY) ile Ni (O hariç) konsantrasyonları, Türkiye değerleri için izin verilen maksimum sınırı (MAL) aşmıştır. Bununla birlikte, Mo, Pb ve Cd konsantrasyonları MAL sınır değerlerinin altındadır. Sonuçlar değerlendirildiğinde, şehir çöplüğü atıkların çevreyi olumsuz yönde etkilediği görülmektedir. Bu nedenle şehir çöplüğü topraklarında biriken ağır metallerin miktarını azaltmak için bu alana boşaltılan atıkların konsantre edilmesi veya geri dönüştürülmesi etkili olacaktır. Ayrıca metalle kirlenmiş topraklar için iyileştirme tekniğinden birisi olan fitoremediasyon en uygun maliyetli, çevre dostu ve kolay bir uygulamadır. Fitoremediasyon tekniği, bu kirletici maddeleri bünyesinde biriktiren bitkiler kullanılarak kirletici maddelerin topraktan uzaklaştırılması, yer değiştirmesi veya azaltılması sağlanabilir.

**Anahtar kelimeler:** Ağır metal konsantrasyonu, şehir çöplüğü, kirlilik, Kastamonu

## INTRODUCTION

The municipal garbage area is one of the most common ways to dispose of urban solid wastes in the world (Xiaoli et al., 2007). Increasing human activity both industrial and domestic causes the increase of waste volume produced from time to time. Most waste is directly discharged into the environment without any intervention. As a result, pollution that harms people and nature occurs. It is the soil pollution that the chemicals enter and change in the natural soil environment (Artiningsih et al., 2018). The factors that cause toxic metal to be included in the contaminant group are due to the nondegradable and easily absorbed properties of the heavy metals (Ni, Co, Cr, Cd, Pb, Cu, Zn, Mo etc.). Tatsi & Zouboulis (2002) noted that incorrect collection, separation, and disposal applications of domestic solid waste can produce leachates containing high concentrations of ammonium, organic matter, and heavy metal. Uncontrolled storage area is very dangerous for people health and environment (Sakawi et al., 2017).

The total domestic waste disposal in Turkey is estimated to be approximately 27 million tons in 2006. Sixty-four percent (64%) of municipal waste is maintained through regular storage, 30% by wild storage (uncontrolled storage), and 6% by recycling. Thirty percent (30%) of the waste collected in municipalities is plastic, 9.7% metal, 40.7% paper and cardboard, 10.9% glass, 2% wood and 6.7% composite. According to the Turkey Statistical Institute (TÜİK 2017), the amount of municipal waste has increased from 17.76 million tons in 1994 to 31.58 million tons in 2016. According to the data of the Ministry of Environment and Urbanization in 2017, the ratio of the population served by regular storage facilities to the total municipal population is 74%. The Kastamonu Environmental Status Report has shown that 26% of urban waste is organic waste, 5% glass waste, 10% paper-cardboard, 4% plastic waste, 6% metals, 1% composites, 12% inert materials, 19% the functions smaller than 10 mm and 13% the other categories (Anonim, 2014).

The objectives of the present study were to (1) determine the concentrations of 8 heavy metal (Ni, Co, Cr, Cd, Pb, Cu, Zn and Mo) in the soils around the city dumpsite of Kastamonu (2) to investigate the effects of different distances to the dumpsite, and (3) asses the concentration and average distribution of heavy metals according to Earth Crust, Maximum Allowable Limit for Turkey (MAL) and Sedimentary-Carbonates Rocks values. Turkey has standard Regulation on Control of Soil Pollution for heavy metal concentration in the soil (Anonim 2001). Therefore, the results of this study will be compared to the Regulation on Control of Soil Pollution and Earth Crust values.

## MATERIAL AND METHODS

### *Study Area*

This study was conducted in City Wild Storage Dumpsite, located in the north part of Kastamonu province, northwest Turkey (41°25'16" N, 33°45'44" E). This study area was 9 km away from the city center and covered an area of approximately 70 000 $m^2$ and a depth of approximately 25 m (Fig. 1). The elevation was 863 m. a.s.l. and the capacity of the garbage dump was 180.000 $m^3$ (KASMİB, 2018).

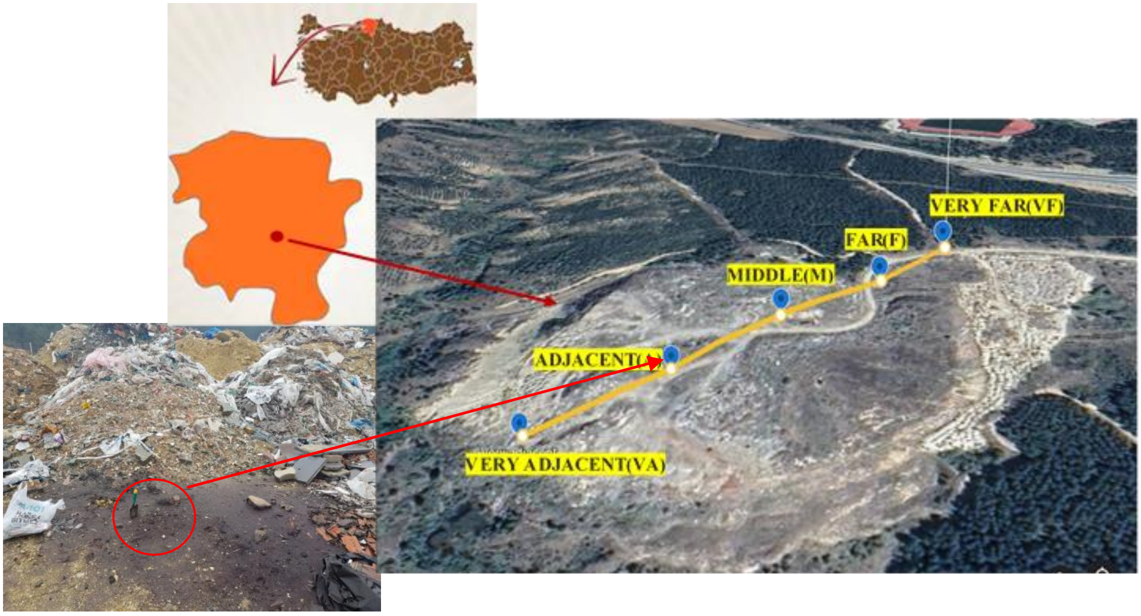


Figure 1. Location of the Study Site

According to the geology maps by the General Directorate of Mineral Research and Exploration, the bedrock of dumpsite is mostly dominated by sedimentary rocks, medium to thick bedded, abundant jointed, gray-beige colored, massive structure, Eocene-bearing neritic limestone (Akbaş et al., 2015). The soil type presents the characteristics of brown forest soil (Anonim, 1990). The characteristics of such soils are loamy or fine-structured, high base saturation (more than 50%) and high biological activity. The soil is calcareous and the soil pH varies from 8 to 9.

The study area is characteristic to Black Sea climate with winters, warm and rainy, summer months, hot but not arid in the region. According to the weather data for 2008-2019 (Kastamonu Meteorology Station at 800 m a.s.l.), mean annual precipitation is 623.6 mm, with the highest amount in June (122.5 mm), and the lowest amount in October (24.8 mm), while mean annual temperature is 10.4 $^oC$, with the highest month in August 20.7 $^oC$ and the lowest month in January -0.8 $^oC$ (DMİ, 2019).

### *Sample Collection and Analysis*

Soil samples were taken from 5 different locations away from the dumping site, with the distance at least 30 m each other namely; Very adjacent (VA), Adjacent (A), Middle (M), Far (F) and Very far (VF). The area of the study is approximately 70 000 $m^2$ (L: 300 m and W:

250 m), but it was studied at 5 different points in a 180 m long area due to the fact that the pile of rubble in the land is excessive and has a rough terrain structure (Fig. 1). A total of 15 soil samples, with three replicate each distance, were taken from a depth of 10 cm using soil core device with an inner diameter of 5 cm. In addition, the soil samples could not be taken too much since the city dump is in group and group garbage dump (Fig. 1). The moist field samples were sieved to remove stones, roots and macrofauna and collected to give a single representative soil sample for each distance. The samples were placed into labelled polythene bags and taken to the laboratory for chemical analysis. Soils were air dried for two weeks, ground and sieved through a 2 mm sieve.

Soil pH ($H_2O$) and heavy metal concentrations were determined. Soil pH ($H_2O$) was measured in a 1:2.5 mixture of distilled water and soil by pH meter (LaMotte pH 5 series meter) after equilibration for 1 h in solution (Jackson, 1962). Determination of heavy metal concentration in the soils was analyzed using XRF (X-ray Fluorescence Spectrometer). Soil analyses were triplicate.

References of heavy metal concentrations with the standard Regulation on Control of Soil Pollution for Turkey are given in Table 1. These standards were marked as Maximum Allowable Limit (MAL) and determined heavy metal concentrations in the soil (Anonim, 2001). In addition, the results of heavy metal concentrations have compared to distribution of the elements in the Earth's Crust (Turekian & Wedepohl, 1961).

Table 1. The distribution of the heavy metal concentrations compared to Turkey and Earth's Crust

| **Heavy Metal concentration** | **pH>6 (MAL) oven-dried soil ( mg kg$^{-1}$)** | **Earth's Crust (Sedimentary-Carbonates) ( mg kg$^{-1}$)** |
|---|---|---|
| **Nickel (Ni)** | 75 | 20 |
| **Cobalt (Co)** | 20 | 0.1 |
| **Cadmium (Cd)** | 3 | 0.035 |
| **Crome (Cr)** | 100 | 11 |
| **Lead (Pb)** | 300 | 9 |
| **Copper (Cu)** | 140 | 4 |
| **Zinc (Zn)** | 300 | 20 |
| **Molybdenum (Mo)** | 10 | 0.4 |

***Statistical Analysis***

An Analysis of variance (ANOVA) has been carried out for analyzing the effects of the distances on the soil heavy metal concentrations using the SPSS program (Version 22 for Windows). Following the results of ANOVAs, Tukey's Honestly Significant Difference (HSD) test ($\alpha$=0.05) was used for multiple comparisons to examine the significant response of the heavy metal concentrations to the distances. The correlation coefficient was also used to measure the strength of inter-relationship among the heavy metals.

## RESULTS AND DISCUSSION

As is known, data must fulfill two assumptions in order to apply the analysis of variance. The data should have minimum interval scale and show a normal distribution. Therefore, fitness of data to normal distribution was checked through the Shapiro-Wilk one sample test. It was found that the the majority of heavy metal concentrations demonstrated normal distribution ($P>0.05$) (Table 2).

Table 2. The normality distribution with Shapiro-Wilk analysis

| Heavy Metal Concentration | N | M±SE | Statistic | P |
|---|---|---|---|---|
| nickel | 15 | 264.40±93.98 | .533 | .000* |
| cobalt | 15 | 29.37±1.44 | .948 | .499 |
| crome | 15 | 122.71±2.16 | .899 | .091 |
| cadmium | 15 | 2.00±0.05 | .958 | .659 |
| lead | 15 | 39.513±5.12 | .918 | .180 |
| copper | 15 | 252.75±78.22 | .742 | .001* |
| zinc | 15 | 286.68±74.31 | .764 | .001* |
| molybdenum | 15 | 1.523±0.19 | .886 | .059 |

*P<0.05

### *Heavy metal concentrations*

The variation in mean Ni concentration with the distances in the soil is shown in Fig. 2. The Maximum Allowable Limit in Turkey (MAL) for Ni is 75 mg $kg^{-1}$ (Anonim, 2001). The adjacent distance (A) had the highest Ni concentration (967.2±78.9 mg $kg^{-1}$), whereas the middle distance (M) had the lowest Ni concentration (64.1±3.82 mg $kg^{-1}$), which was the only Ni concentration below the MAL value in the soil. The other distances also had Ni concentration above the MAL values (Fig. 2). Najib et al. (2012) found that the concentration of Ni was 30 mg $kg^{-1}$ in the Kangar dumping site. Similarly, Tumuklu et al. (2007) reported that the concentration of Ni increased with decreasing the distance to the Niğde city garbage dumpsite (460 mg $kg^{-1}$). Olafisoye et al. (2013) reported that Ni concentration decreased from the top soil (85.43±0.02 mg $kg^{-1}$ at 0-15 cm) to the subsoil (35.45±0.01 mg $kg^{-1}$ at 15-30 cm). In most countries, Ni concentrations were found to be over the critical value. The results in this study were in agreement with the study by Adelekan & Alawode (2011) who found Ni concentration ranging between 18 mg $kg^{-1}$ and 335 mg $kg^{-1}$. Turhan et al. (2020) reported that the Ni concentrations under the agricultural surface soil samples in Kangal varied from 89.5 mg $kg^{-1}$ to 971.0 mg $kg^{-1}$ with an average value of 610.1 mg $kg^{-1}$.

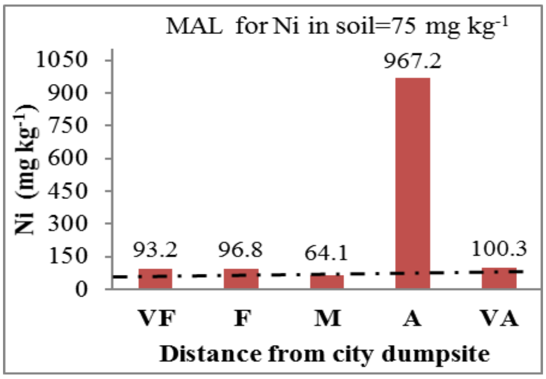


Figure 2. Mean Ni Concentration in the Soils around the Dumpsite

Mean Co concentration was above the MAL value in the soil (Fig. 3). The highest Co concentration was found in the soil of very far (VF) distance (34.2±4.24 mg $kg^{-1}$), whereas the lowest Co concentration was seen in in the soil of the middle (M) distance (26.1±4.03 mg $kg^{-1}$). The lower concentration of Co was also shown by a number of studies. For example, Lu et al. (2010) found that the concentration of Co at the street dust of Baoji was 15.9 mg $kg^{-1}$.

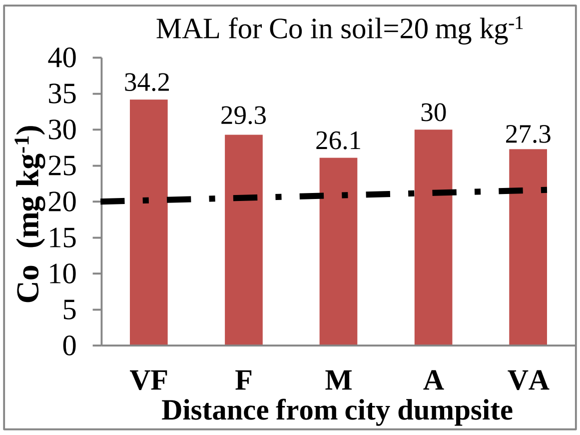


Figure 3. Mean Co Concentration in the Soils around the Dumpsite

Mean Cd concentration from all the distances were under the MAL values (Fig. 4). This result could be due to the lower Cd concentration in the wastes in the dump site. Uba et al. (2008) stated that cadmium had the highest level bioavailability in the dumpsites. In general, the higher concentrations of Cd in a dumpsite may be attributed to various sources, some of which include automobile tire dust, burning of oil and tyre, plastic wrappings, paints, dyes, and especially, refuse dumps and commercial activities (Ali et al., 2005). Sulaiman et al. (2018) reported that the concentration of Cd in soil samples of two dumpsites (A and B) varied from 2.20 mg $kg^{-1}$ to 1.53 mg $kg^{-1}$. They argued that this variation in Cd concentration may depend on the types and the compositions of waste at the dumpsites. Asemave & Anhwange (2012) stated that anthropogenic release of Cd under soils might be as a result to the increase in disposal of Cd containing substances such as batteries in phones and torches, plastics and other electronic gadgets, to the municipal waste dumpsite. Jafaru et al. (2015) found that the Cd concentration was higher than 0.73 mg $kg^{-1}$ in a dumpsite soil in Ghana. Adaikpoh (2013) noted that the average Cd concentration in the dumpsites was 1.18 mg $kg^{-1}$ and ranged from <0.001 - 2.30 mg $kg^{-1}$ in Imoru. Asemave & Anhwange (2012) noted that cadmium uptake was high in acids soils and was reduced when the soil was limed. In the present study, the soil pH was generally alkaline, and this could be the reason that Cd concentrations were lower in the soil samples of all distances.

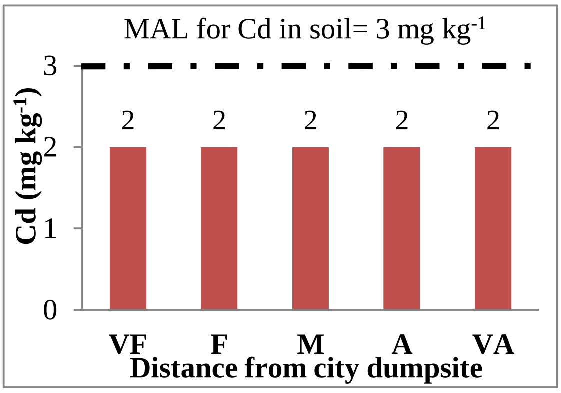


Figure 4. Mean Cd Concentration in the Soils around the Dumpsite

The concentration of Cr in the soil of all distances showed higher values than the MAL values (100 mg kg$^{-1}$) (Fig. 5). The soils from the far, middle and adjacent distances showed similar values (128.2±8.56 mg kg$^{-1}$, 126.1±8.34 mg kg$^{-1}$ and 126.3±7.99 mg kg$^{-1}$ respectively), but higher values than the soils from the very adjacent (121.4±15.13 mg kg$^{-1}$) and the very far distances (111.6±0.21 mg kg$^{-1}$). Turhan et al. (2020) noted that Cr concentrations under soil varied from 125.3 mg kg$^{-1}$ to 1327.0 mg kg$^{-1}$ with an average value of 713.2 mg kg$^{-1}$. Sulaiman et al. (2018) found the lower Cr concentration in one dumpsite A (1.65 mg kg$^{-1}$) than the other dumpsite B (2.16 mg kg$^{-1}$). The higher Cr concentrations in the present study could be due to the wastes which had higher Cr concentrations such as plastic materials, empty paint containers and colored polythene bags. According to Jung et al. (2006), Cr resources under soils can be caused by wastes consisting of lead-chrome batteries, colored polythene bags, disposable plastic materials and empty paint containers.

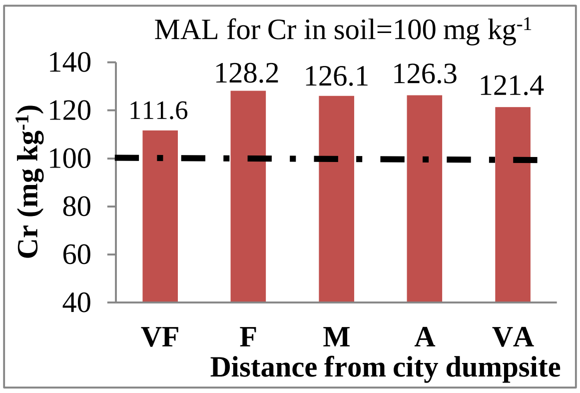


Figure 5. Mean Cr Concentration in the Soils around the Dumpsite

The average concentration of Pb in the soils of the dumpsite from all distances showed the lowest concentrations compared to the MAL value (300 mg kg$^{-1}$) (Fig. 6). Among the different distances, the Pb concentrations were higher from the adjacent (66.3±4.67 mg kg$^{-1}$) and the very adjacent distances (55.6±3.75 mg kg$^{-1}$) than the soils from the middle, the far and the very far distances (Fig. 6). Ebong et al. (2008) reported that the concentration of Pb at the dumpsites ranged from 9.46 mg kg$^{-1}$ to 18.83 mg kg$^{-1}$ compared to the control sites which ranged from 5.21 mg kg$^{-1}$ to 7.53 mg kg$^{-1}$. However, Peramaki & Decker (2000) found that the concentration of Pb varied between 8.0 mg kg$^{-1}$ to 1185 mg kg$^{-1}$ which were clearly exceeded the MAL limit value. The higher values in Pb concentrations were also shown by

Kanmani & Grandhimathi (2013), ranging from 44.09 mg $kg^{-1}$ to 178.84 mg $kg^{-1}$. Madhaven et al. (1989) have stated that Pb is liable to accumulate in the top soil. They have emphasized that if any city is less populated, it creates little wastes in the dumping sites and consequently it may result in lower Pb concentrations in the soils around the dumpsite.

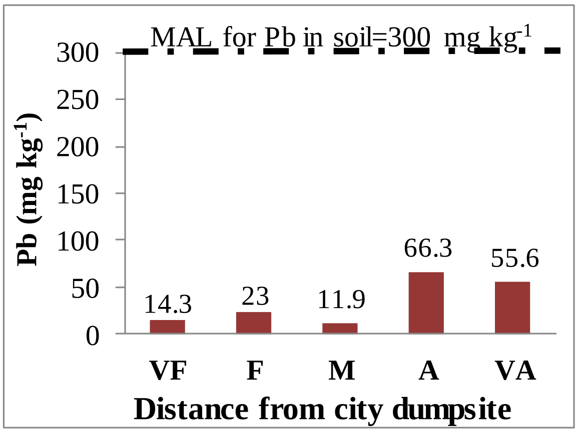


Figure 6. Mean Pb Concentration in the Soils around the Dumpsite

The soils from the adjacent and very adjacent distances had higher Cu concentrations compared to the other distances (Fig. 7). The values of Cu concentrations from the adjacent (636.5±50.61 mg $kg^{-1}$) and very adjacent (493.1±50.4 mg $kg^{-1}$) distances clearly exceeded the MAL values (140 mg $kg^{-1}$). Ebong et al. (2008) found lower concentration of Cu under soils ranged from 2 to100) mg $kg^{-1}$. According to Dara (1993), the higher concentration of Cu at the dumpsite might be connected to biodegradable waste releasing the metallic Cu into the soil. This can be due to the incorrect disposal of waste lubricants, as well as waste containing electrical and electronic components (Nwachukwu et al., 2011). When the Cu concentration enters the soil, it usually adheres strongly to organic substances and minerals (Jaradat et al., 2005). As a result, it doesn't go very far after releasing (Adriano, 1986). Perhaps this situation can explain why the higher Cu content recorded in the soil near the dumpsite than the further away from the dumpsite in this present study.

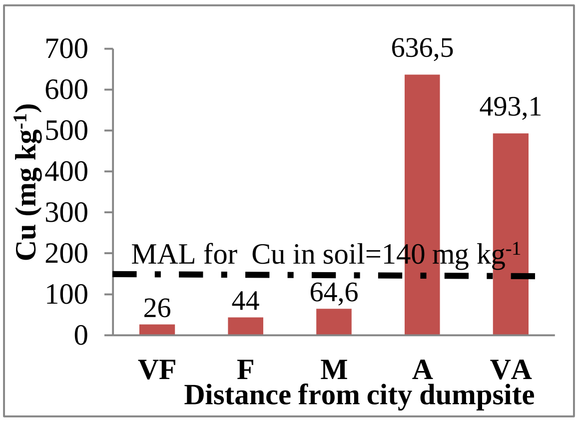


Figure 7. Mean Cu Concentration in the Soils around the Dumpsite

The concentrations of Zn in top soil of the adjacent (422.9±4.60 mg $kg^{-1}$) and the very adjacent distances (760±24.32 mg $kg^{-1}$) were higher than the other distances (Fig. 8). The higher concentrations of the adjacent and the very adjacent distances were also over the limit value of the MAL for Zn in the soil (300 mg $kg^{-1}$). The other distances, however, showed much lower values than the MAL value. Asemave & Anhwange (2012) also found lower Zn concentration in the soils ranging between 13.82 mg $kg^{-1}$ to 17.26 mg $kg^{-1}$ compared to the control sites ranging from 6.32 mg $kg^{-1}$ to 8.15 mg $kg^{-1}$. However, a study by Odukoya et al. (2000) showed higher Zn concentration in the soils ranging from 100.80 mg $kg^{-1}$ to 226.00 mg $kg^{-1}$. The reason for this change is due to the disposal of high content Zn waste to the landfill.

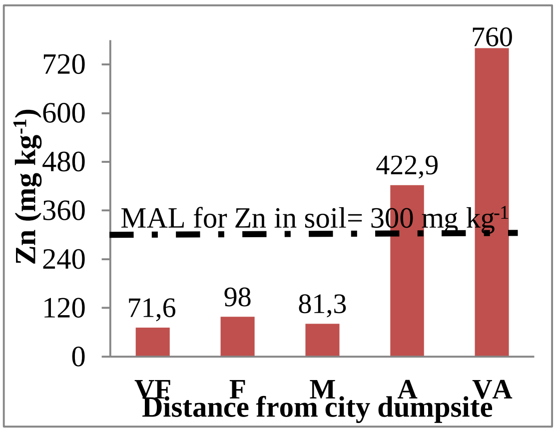


Figure 8. Mean Zn Concentration in the Soils around the Dumpsite

The concentrations of Mo in the soils of the different distances from the dumpsites were very low compared to the MAL value (10 mg $kg^{-1}$) (Fig. 9). This result indicates that the dumped wastes consisted of less Mo concentration. Similar results were shown by Yalçın & Çimrin (2019) who stated that there was no heavy metal pollution or lack of Mo in the soil around the dumpsites.

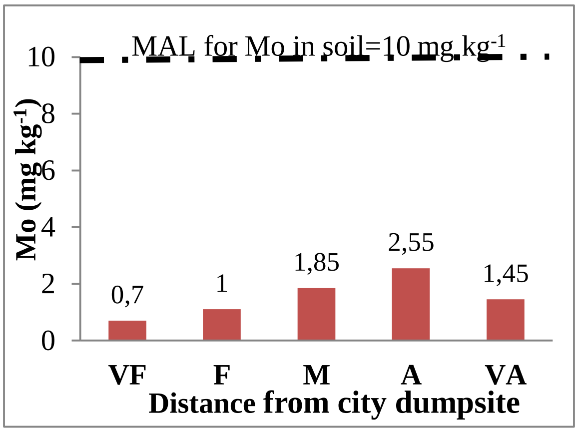


Figure 9. Mean Mo Concentration in the Soils around the Dumpsite

Comparisons the average concentrations of heavy metal in the soils from dumpsite distances are given in Table 3. Ni, Pb, Cu, Zn and Mo concentrations are the highest value at adjacent (A) and very adjacent (VA) distances.

**Table 3.** Sequence of Heavy Metals Concentrations based on the Distances from Dumpsite

| **Heavy Metal** | **Sequence of the distances from dumpsite** |
|---|---|
| Ni | A > VA > F > VF > M |
| Co | VF > A > F > VA > M |
| Cd | VF = F = M = A = VA |
| Cr | F > A > M > VA > VF |
| Pb | A > VA > F > VF > M |
| Cu | A > VA > M > F > VF |
| Zn | VA > A > F > M > VF |
| Mo | A > M > VA > F > VF |

Compared to Earth Crust ratios in sedimentary-carbonated rocks (Turekian & Wedepohl, 1961), the average Ni concentration is about thirteen times higher than earth's crust average of 20 mg $kg^{-1}$ (Tab. 1). Similary, Turhan et al. (2020) noted that the average of Ni concentration in the agricultural ultrabasic soils were about ten times higher than the earth's crust average of 58 mg $kg^{-1}$. Cobalt (Co) concentrations were an average value of 29.37 mg $kg^{-1}$ (Tab. 2). The average Co concentration was about three hundred times higher than earth's crust average of 0.1 mg $kg^{-1}$ (Tab. 1). Cadmium (Cd) concentrations in the soil were an average value of 2 mg $kg^{-1}$ (Tab. 2). The average Cd concentration was about fifty seven times higher than earth's crust average of 0.035 mg $kg^{-1}$ (Tab. 1). Chrome (Cr) concentrations in the soil were an average value of 122.71 mg $kg^{-1}$ (Tab. 2). The average Cr concentration was about eleven times higher than earth's crust average of 11 mg $kg^{-1}$ (Tab. 1). Similary, Turhan et al. (2020) noted that the average of Cd concentration in the ultrabasic soil were about nine times higher than the earth's crust average of 83 mg $kg^{-1}$. The average lead (Pb) and molybdenum (Mo) concentrations were about four times higher than the earth's crust average of 9 mg $kg^{-1}$ and 0.4 mg $kg^{-1}$, respectively (Tab. 2). Finally, copper (Cu) and zinc (Zn) concentrations were approximately sixty four times and fourteen times higher than the earth's crust average of 4 mg $kg^{-1}$ and 20 mg $kg^{-1}$, respectively (Tab. 1).

***Correlation Coefficient Analysis***

Correlation coefficients of Pearson for the heavy metals in the wild storage dumpsite of Kastamonu city are shown in Table 4.

**Table 4.** The Relationship is a Correlation Analysis between Heavy Metal Concentrations

| | Ni | Co | Cr | Cd | Pb | Cu | Zn | Mo |
|---|---|---|---|---|---|---|---|---|
| **Ni** | 1 | | | | | | | |
| **Co** | -.694** | 1 | | | | | | |
| **Cr** | .993** | -.696** | 1 | | | | | |
| **Cd** | -.056 | .118 | -.050 | 1 | | | | |
| **Pb** | .777** | -.465* | .764** | -.067 | 1 | | | |
| **Cu** | .947** | -.761** | .934** | -.067 | .859** | 1 | | |
| **Zn** | .428* | -.336 | .411* | .007 | .851** | .647** | 1 | |
| **Mo** | .991** | -.746** | .985** | -.053 | .715** | .934** | .373 | 1 |

*Correlation is significiant at P<0.05 (two-tailed).
** Correlation is significiant at P<0.01 (two-tailed).

A significantly positive correlation at P<0.01 was found between the elemental pairs Cr-Ni (r= 0.993), Pb-Ni (r= 0.777), Cu-Ni (r= 0.947), Mo-Ni (r= 0.991), Pb-Cr (r= 0.764), Cu-Cr (r= 0.934), Mo-Cr (r= 0.985), Cu-Pb (r= 0.859), Zn-Pb (r= 0.851), Mo-Pb (r= 0.715), Zn-Cu (r= 0.647) and Mo-Cu (r= 0.934). Co is also significantly negatively correlated with Ni, Cr, Cu and Mo at P<0.01 different from dumpsite soils (Table 4). Pb and Co was negatively correlated (r= -0.465) (P<0.05), while Zn-Ni and Zn-Cr were positively correlated (P<0.05). However, Cd did not show any correlation with the other heavy metals. Similary, Tumuklu et al. (2007) reported that there was high level of positive correlation between Cr-Ni (r=0.824) in the Niğde City Garbage dumpsite soils. Yalcin et al. (2007) found that there was moderate positive correlation for Cr-Ni (r=0.505) and Pb- Ni (r=0.385) heavy metals in the soils. Liu et al. (2013) found that there were significant positive correlations between Cu-Zn (r=0.878, p<0.01), Cu-Cr (r=0.426, p<0.05), and Cd-Pb (r=0.732, p<0.01). Yalçın & Çimrin (2019) noted a positive correlation between the Co and Ni (r= 0.52, p<0.001), Pb (r= 0.24, p<0.05) and Fe (r= 0.34, p<0.001). Costa et al. (2017) investigated the natural content of heavy metals in South Amozon region in Brazil, and found that Co and Cd, Pb and Fe contents were positively correlated. Yalçın & Çimrin (2019) also found a significant positive correlation between the Ni-Pb (r= 0.31, p<0.001) and Pb-Cu (r= 0.61, p<0.001) - Fe (r= 0.44, p<0.001. Liu et al. (2016) noted a positive correlation between the Ni-Pb.

Liu et al. (2013) noted that all heavy metals (except for Pb) relatively low concentrations from 0.1 to 1 km from the dumpsite. Therefore, they are much lower than that found in the soils in the dumpsite in other countries including Turkey. In this present study, we found serious accumulation of heavy metal except for Cd, Pb and Mo in relation to the different distances. Tumuklu et al. (2007) showed that the heavy metal concentrations in study area soils diminished with distance to the dumpsite. In our study, Cd and Pb concentrations regularly showed a decreasing trend with the distance to the dumpsite (p<0.05). However, Cu, Zn and Cr concentrations did not show same trends (Table 4). This result has indicated that the enrichment of Cd and Pb concentrations can be caused by the dumpsite. It is due to the fact that Cd concentration has the highest mobility and is more susceptible to release than Zn, Cu, Cr or Pb concentrations (Xiao et al., 2005; Prechthai et al., 2008; Liu et al., 2013). In study area, the strong correlation between these heavy metals can be said to increase the contaminants which originates from anthropogenic (Tumuklu et al., 2007).

## CONCLUSIONS

The study has indicated that the concentrations of eight heavy metal (Ni, Co, Cd, Cr, Pb, Cu, Zn and Mo) in the soils around dumpsite in Kastamonu vary significantly with the distances to the dumpsite. Except for Cd, Pb and Mo concentrations, the polluted levels of Ni (except for M) Co, Cr, Cu (only A and VA), Zn (only A and VA) exceed the standards of MAL and Turkey Pollutant Standards which could result in eco-toxicological risk. In particular, the concentrations of Ni, Cu and Zn are noted to be highest. This study also clearly indicates that human activities can be a significant factor of heavy metal contamination in the soil. Consequently, phytoremediation techniques such as phytoextraction is more ideal as a method of remediating contaminated soil and water. Future studies should be focused on identify remediating plants that are adapted the local climate and soil conditions, the combined use of more than one phytoremediation approach  for the successful remediation of the contaminant area under field conditions.

## ACKNOWLEDGEMENTS

The article is prepared under the supervision of Assist. Prof. Dr. Gamze SAVACI at Kastamonu University, Graduate School of Natural and Applied Sciences, Department of Forest Engineering between 2014 -2019 by Çağatay ÖKSÜZ and contains a part of the MSc. thesis (Öksüz, 2019).

## AUTHOR CONTRIBUTIONS

**Çagatay Oksuz**: Taking soil samples in the study area, preparing for analyses of soil samples in the laboratory and writing the manuscript. **Gamze Savaci**: Evaluating and interpreting the statistical analysis and writing manuscript.

## REFERENCES

Adaikpoh, E. O. (2013), Distribution and enrichment of heavy metals in soils from waste dump sites within Imoru and environs, Southwest, Nigeria. *J. Environ. Earth Sci*, 3, 45-54.http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.920.2587&rep=rep1&type=pd

Adelekan, B. A., & Alawode, A. O. (2011), Contributions of municipal refuse dumps to heavy metals concentrations in soil profile and groundwater in Ibadan Nigeria. *Journal of Applied Biosciences*, *40*, 2727-2737.

Adriano, D. C. (1986), Trace elements in the terrestrial environment.-Springer-Verlag. New York, 533. ISBN 978-1-4757-1907-9 (eBook)

Akbaş, B., Akdeniz, N., Aksay, A., Altun, İ., Balcı, V., Bilginer, E., et al. (2015), Türkiye Jeoloji Haritası. *Maden Tetkik ve Arama Genel Müdürlüğü Yayını.* Ankara Türkiye. http://yerbilimleri.mta.gov.tr/anasayfa.aspx

Ali, N., Oniye, S. J., Balarabe, M. L., & Auta, J. (2005), Concentration of Fe, Cu, Cr, Zn, and Pb in Makera–Drain, Kaduna, Nigeria, *ChemClass Journal*, 2, 69-73.

Anonim (1990), Topraksu Genel Müdürlüğü, Türkiye Geliştirilmiş Toprak Haritası Sınıf ve Haritaları, Ankara. (in Turkish publication)

Anonim (2001), Toprak Kirliliğinin Kontrolü Yönetmeligi, 25831 Sayili Resmi Gazetede, Ankara . https://www.resmigazete.gov.tr/eskiler/2001/12/20011210.htm#3

Anonim (2014), Kastamonu ili 2014 yılı çevre durum raporu. Kastamonu Çevre ve Şehircilik İl Müdürlüğü. Kastamonu (in Turkish publication).

Artiningsih, A., Zubair, H., Imran, A. M., & Widodo, S. (2018), Distribution of Cu metal on the soil around the landfills of Antang, Makassar City. In IOP Conference Series: *Earth and Environmental Science* (Vol. 175, No. 1, p. 012021). IOP Publishing. DOI:10.1088/1755-1315/175/1/012021

Asemave, K., & Anhwange, B. A. (2012), Evaluation of heavy metals in waste dumpsites. *Germany, Lambert Academic Publishing*; ISBN: 978-3-659-37380-0

Costa, R. D. S., Neto, P. P., Campos, M. C. C., do Nascimento, W. B., Do Nascimento, C.W.A., Silva L. S., Cunha, J. M. (2017), Natural contents of heavy metals in soils of the southern Amazonas state, Brazil. Semina: *Ciências Agrárias*, 38(6), 3499-3514. DOI: 10.5433/1679-0359.2017v38n6p3499

Dara, S.S. (1993), A textbook of environmental chemistry and pollution control. S. Chand &Company Ltd. Ram Nagar, New Delhi 110055. ISBN:8121908833, 9788121908832

DMİ (2019), Devlet Meteoroloji İşleri Gn. Md., Kastamonu Meteoroloji İl Müdürlüğü, Kastamonu Meteoroloji İstasyonu Verileri, 20082018. Kastamonu.

Ebong, G. A., Akpan, M. M., & Mkpenie, V. N. (2008), Heavy metal contents of municipal and rural dumpsite soils and rate of accumulation by *Carica papaya* and *Talinum triangulare* in Uyo, Nigeria. *Journal of Chemistry*, 5(2), 281-290.

Jackson, M. L. (1962), Soil chemical analysis. (Constable and Company, Ltd: London).

Jafaru, H. M., Dowuona, G. N. N., Adjadeh, T. A., Nartey, E. K., Nude P. M., & Neina D. (2015), Geochemical assessment of heavy metal pollution as impacted by municipal solid waste at Abloradjei waste dump site, Accra-Ghana. *Research Journal of Environmental and Earth Sciences*, 7(3), 50-59.

Jaradat, Q. M., Masadeh, A., Zaitoun, M. A., & Maitah, B. M. (2005), Heavy metal contamination of soil, plant and air of scrapyard of discarded vehicles at Zarqa City, Jordan. *Soil & Sediment Contamination*, 14 (5), 449-462. DOI: 10.1080/15320380500180507

Jung, C. H., Matsuto, T., & Tanaka, N. (2006), Flow analysis of metals in a municipal solid waste management system. *Waste Management*, 26(12), 1337-1348.

Kanmani, S., & Gandhimathi, R. (2013), Assessment of heavy metal contamination in soil due to leachate migration from an open dumping site. *Applied Water Science*, 3(1), 193-205. DOI 10.1007/s13201-012-0072-z

KASMİB (2018), Kastamonu ili 2017 yili çevre durum raporu. Kastamonu Çevre ve Şehircilik İl Müdürlüğü. s. 117.

Liu, C., Cui, J., Jiang, G., Chen, X., Wang, L., & Fang C. (2013), Soil heavy metal pollution assessment near the largest landfill of China. *Soil and Sediment Contamination: An International Journal*, *22*(4), 390-403. DOI: 10.1080/15320383.2013.733447

Liu, Y. R., He, Z. Y., Yang, Z. M., Sun, G. X., & He, J. Z. (2016), Variability of heavy metal content in soils of typical Tibetan grasslands. *Rsc Advances*, 6(107), 105398-105405. https://pdfs.semanticscholar.org/3732/be08dca20094f17bf8cf55835cedbe46e96a.pdf

Lu, X., Wang, L., Li, L. Y., Lei, K., Huang, L., & Kang, D. (2010). Multivariate statistical analysis of heavy metals in street dust of Baoji, NW China. *Journal of hazardous materials*, *173*(1-3), 744-749.

Madhaven, S., Rosenman, K. D., & Shehata, T. (1989), Lead in soil: maximum permissible levels. *Environ. Res.* 49, 136-142. https://doi.org/10.1016/S0013-9351(89)80028-3

Najib, N. W., Mohammed, S. A., Ismail, S. H., & Ahmad, W. A. (2012), Assessment of heavy metal in soil due to human activities in Kangar, Perlis, Malaysia. *Int J Civil Environ.*, 12(6), 28-33.

Nwachukwu, M. A., Feng, H., & Alinnor, J. (2011), Urban Environmental Pollution 2010: Trace Metal Dispersion in Soil from Auto-Mechanic Village to Urban Residential Areas in Owerri, Nigeria. *Procedia Environmental Sciences*. 4, 310-322.

Odukoya, O. O., Bamgbose, O., & Arowolo, T. A. (2000), Heavy metals in top soils of Abeokuta dump sites. *Global Journal of Pure and Applied Sciences*, 6(4), 651-653. http://dx.doi.org/10.4314/gjpas.v7i3.16273

Öksüz, Ç. (2019), Determination of heavy metal concentration of soil and vegetation the city waste of Kastamonu. MSc Thesis, Kastamonu University, Graduate School of Natural and Applied Sciences, Department of Forest Engineering, s. 90, Turkey.

Olafisoye, O. B., Adefioye, T., & Osibote, O. A. (2013), Heavy Metals Contamination of Water, Soil, and Plants around an Electronic Waste Dumpsite. *Polish journal of environmental studies*, 22(5).

Peramaki, L. A., & Decker, J. F. (2000), Lead in soil and sediment in Iqaluit, Nunavut, Canada and links with human health. *Environ. Monitor. and Assess*. 63, 329-339.

Prechthai, T., Padmasri, M., & Visvanathan, C. (2008), Quality assessment of mined MSW from an open dumpsite for recycling potential. *Resources, Conservation and Recycling*, 53(1-2), 70-78. https://doi.org/10.1016/j.resconrec.2008.09.002

Sakawi, Z., SA, S. M., Jaafar, O., & Mahmud, M. (2017), Community perception of odour pollution from landfills. *Geografia-Malaysian Journal of Society and Space*, 7(3): 18-23. http://ejournal.ukm.my/gmjss/article/view/19840/6283

Sulaiman, M. B., Santuraki, A. H., Isa, K. A., & Oluwasola, O. H. (2018), Geo-accumulation and Contamination Status of Heavy Metals in Selected MSW Dumpsites Soil in Gombe, Nigeria. *Bima. J. Sci. Techno*, 2(2), 31-40.

Tatsi, A. A., & Zouboulis, A. I. (2002), A field investigation of the quantity and quality of leachate from a municipal solid waste landfill in a Mediterranean climate (Thessaloniki, Greece). *Advances in Environmental Research*, 6(3), 207-219. https://doi.org/10.1016/S1093-0191(01)00052-1

TÜİK (Türkiye İstatistik Kurumu Başkanlığı) (2017), Belediye Atık İstatistikleri, 2016. Haber Bülteni, 29/11/2017, Sayı: 24876 (in Turkish publication).

Tumuklu, A., Yalcin, M. G., & Sonmez, M. (2007), Detection of Heavy Metal Concentrations in Soil Caused by Nigde City Garbage Dump. *Polish Journal of Environmental Studies*, 16(4): 651-658. http://www.pjoes.com/Detection-of-Heavy-Metal-Concentrations-in-Soil-r-nCaused-by-Nigde-City-Garbage-Dump,88034,0,2.html

Turekian, K. K., & Wedepohl, K. H. (1961), Distribution of the elements in some major units of the earth's crust. *Geological Society of America Bulletin*, 72(2): 175-192. https://doi.org/10.1130/0016-7606(1961)72[175:DOTEIS]2.0.CO;2

Turhan, Ş., Garad, A. M. K., Hançerlioğulları, A., Kurnaz, A., Gören, E., Duran, C., Karataşlı, M., Altıkulaç, A., Savacı, G., & Aydın, A. (2020), Ecological assessment of heavy metals in soil around a coal-fired thermal power plant in Turkey. *Environmental Earth Sciences*, 79(6), 1-15. https://doi.org/10.1007/s12665-020-8864-1

Uba, S., Uzairu, A., Harrison, G. F. S., Balarabe, M. L., & Okunola, O. J. (2008), Assessment of heavy metals bioavailability in dumpsites of Zaria Metropolis, Nigeria. *African Journal of Biotechnology*, 7(2).

Xiao, Z., He, P., & Shao, L. (2005), Effect of the total amount and speciation of heavy metals on its mobility in municipal solid waste landfill. *Environmental chemistry-beijing-*, 24(3), 269.

Xiaoli, C., Shimaoka, T., Xianyan, C., Qiang, G., & Youcai, Z. (2007), Characteristics and mobility of heavy metals in an MSW landfill: Implications in risk assessment and reclamation. *Journal of hazardous materials*, 144(1-2), 485-491. https://doi.org/10.1016/j.jhazmat.2006.10.056

Yalcin, M. G., Battaloglu, R., Ilhan, S., Tümüklü, A., & Topuz, D. (2007), Heavy metal contamination along the Nigde-Adana highway, Turkey. *Asian Journal of Chemistry*, 19(2), 1506.

Yalçın, M., & Çimrin, K. M. (2019), Determination of Molybdenum Contents and Relation of Some Heavy Metals in the Soil of Meadow-Pasture Terraces Between Kırıkhan-Reyhanlı. *Turkish Journal of Agriculture-Food Science and Technology*, 7(1), 13-21. https://doi.org/10.24925/turjaf.v7i1.13-21.1997