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Heavy Metals Concentrations in Soil at the Closed Landfill in An Giang Province, Vietnam

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Abstract

The study was carried out to evaluate the quality of soil at the finished landfill located in Cai Dau town, Chau Phu district, An Giang province, Vietnam. Twelve soil samples were collected including 6 samples in the surface layer (0-20 cm) (namely S1-S6), 6 samples in the subsurface layer (60 - 80 cm) (namely S1-S6) for the analysis of heavy metals such as Fe, Mn, Cu, Pb, Ni, Cr, Zn. The analytical results showed that all the heavy metals occurred in soil in which Fe was the highest and Ni was the lowest. The concentrations of the heavy metals in the soil surrounding the closed landfill in both layers were in the descending order of Fe> Mn> Zn> Cr> Cu> Pb> Ni. These heavy metals concentrations were within the allowable range of QCVN 03: MT/BTNMT- agricultural land. The occurrence of heavy metals in different layers at the surrounding landfill could potentially result in negative impact on the environments since heavy metals have the capability of accumulation. Therefore, monitoring of the environments around closed landfill should be implemented and the long-term risk of heavy metals should be estimated.

1. Introduction

Nowadays, with the rapid process of economic growth, industrialization and modernization, a large amount of solid waste has been continuously and increasingly generated. For example, the total amount of national solid waste generated was about 17,682 tons/day in 2007 and increased to 26,224 tons/day in 2010, and 32,000 tons/day in 2015, an average increase of 12% per year and with the composition more complicated [1]. The rate of generation of solid waste ranged from 0.3 to 1.2 kg/day/person depending on the rural or urban areas, averaging at 0.75 kg/person/person/day; This rate in the Vietnamese Mekong Delta region was around 0.61 kg/person/day [1] and the amount of generated solid waste was 10,675 tons/day. According to the National Environmental Status Report 2011-2015 (2015) [1], 46% of solid waste was generated from municipal solid wastes, 17% from solid wastes from industrial production activities. The rest were from rural solid wastes, traditional villages and health care. However, the treatment and management of waste still faces many limitations. Most of the waste after collection will be transported to the centralized landfill that is not designed in accordance with regulations. This leads to many concentrated landfills being overloaded. Currently, domestic solid waste has not been classified, landfills are not properly shielded and leachate is not treated. Leachate is the water that passes through a landfill and carries the pollutants contained in the landfill. Rainwater and

solid waste decomposition cause leachate to move into soil, surface water and groundwater. Previous research showed that leachate from the landfill contains many heavy metals [2-3]. The concentration of heavy metals in leachate depends on the composition of the wastes. Heavy metals are considered hazardous wastes because they can enter the food chain and increase concentrations in the organism. Heavy metals present in the environment in the area around the landfill are a major threat to human and biological health because they are durable, not biodegradable, able to disperse and accumulate in the ecosystem, plants and animals, and ultimately to humans through consumption [4-5]. Currently, there are not many studies on the current state of the soil environment in the landfills that have been closed. Therefore, this study was conducted to evaluate the heavy metals concentration at the closed landfill in Cai Dau town, Chau Phu district, An Giang province. The findings provide very good information about the current state of the environment, contributing to the protection and management of the local environment.

2. Methodology

2.1 Soil sampling and analysis

Soil samples were collected in the rainy season (November of 2020) at five locations (S1, S2, S4, S5, S6) around the landfill and 1 sample in the rice field (S3, control sample where was mainly influenced by agricultural activity) at a depth of 0 - 20 cm and 60 - 80 cm. The sampling diagram was presented in Figure 1.

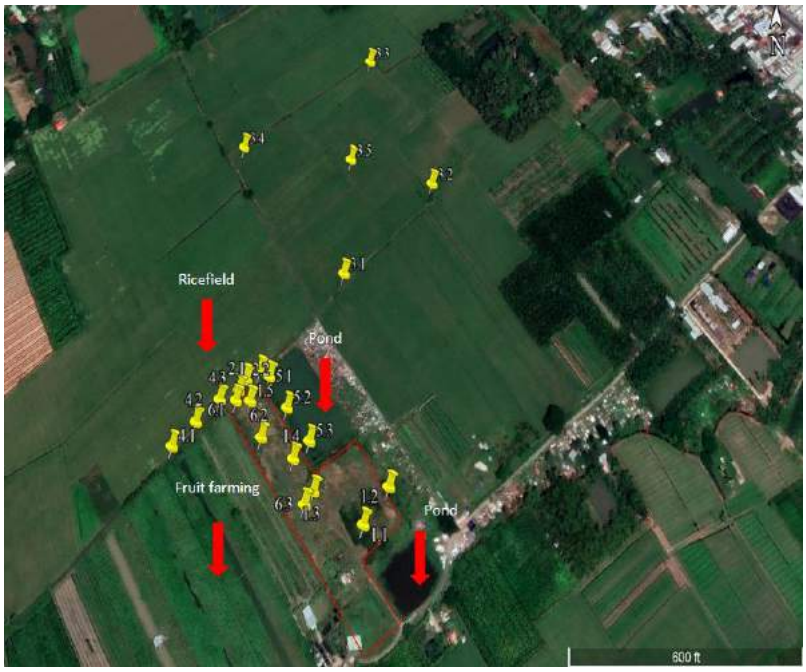

Figure 1. Maps of the sampling sites

Soil samples were collected by drilling and the collected samples were stored in nylon bags, labeled and brought to the laboratory and dried at room temperature. Samples were collected in the form of pooled samples. After air drying soil, plant residues were carefully removed. The soil samples were then pulverized, and sieved through a 0.05 mm sievers. The processed soil samples were then digested using microwave digester (microwave digester, Milestone, Ethos) using 10 ml of 65% nitric acid in temperature of 175^{o}C in 15 [4] for the eavy metals (Mn, Fe, Cu, Zn, Ni, Pb,

Cr) analysis by atomic absorption spectrometer (AAS, Agilent, AA240). The sample analysis methods are shown in Table 1.

Table 1. Summary of sample analysis methods

Heavy metals	Sampling and analysis methods	Equipment
Mn	SMEWW 3500 Mn-B	AAS
Fe	TCVN 6649:2000 + TCVN 6496:2009	AAS
Cu	TCVN 6649:2000 + TCVN 6496:2009	AAS
Zn	TCVN 6649:2000 + TCVN 6496:2009	AAS
Ni	TCVN 6649:2000 + TCVN 6496:2009	AAS
Pb	TCVN 6649:2000 + TCVN 6496:2009	AAS
Cr	TCVN 6649:2000 + TCVN 6496:2009	AAS

The analysis results of the soil samples were statistically processed with statistical software SPSS 20.0. Analysis of variance (One-Way ANOVA) was used to analyze the of difference of the heavy metal concentrations among the sampling sites while Independent-Samples T-Test was used to verify differences of heavy metals between depths of 0 - 20 cm and 60 - 80 cm. Hevay metals concentrations in the soil were compared with QCVN 03-MT: 2015/BTNMT-technical regulations on allowable limits of some heavy metals in the soil [6].

3. Results and Discussion

3.1. Manganese

The Mn concentration in the surface layer (0 - 20 cm) varied quite large in the range of 38.21 ± 0.15 - 143.5 ± 0.35 mg/kg and there were statistically significant differences at the locations ($p < 0.05$). For the depth layer of 60 - 80 cm, Mn concentration ranged from 19.17 ± 0.26 - 127.09 ± 0.18 mg/kg and there was a difference statistically at the 5% significance level ($p < 0.05$) at all positions. Analytical results on the fluctuation of Mn concentration between the sampling locations in the surface and depth layers are shown in Figure 2.

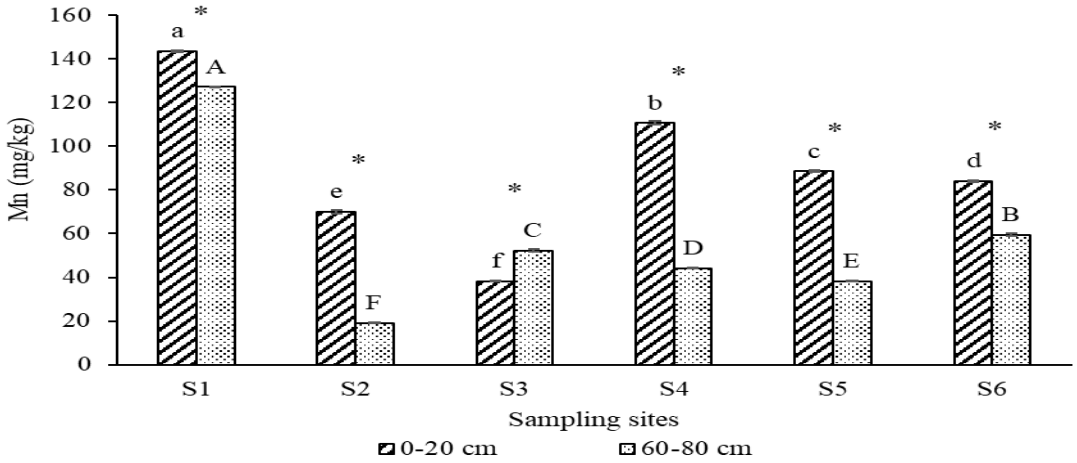

Figure 2. Mn concentrations at soil sampling locations by depth

The results showed that, the Mn concentration in the surface layer (0-25 cm) was highest at the position S1 (143.5 ± 0.35 mg/kg) and lowest at the position S3 (38.21 ± 0.15 mg/kg). For the depth layer (60 - 80 cm), the highest concentration of Mn was at position S1 (127.09 ± 0.18 mg/kg) and lowest at the position S2 (19.17 ± 0.26 mg/kg). The presence of high Mn concentrations in soil in both the surface and depth layers at the position S1, S2, S4, S5, S6 can be attributed to the presence of blades, pharmaceuticals, paints, pigments, pesticides, and cosmetics in the waste stream [7]. Mn concentration across the two soil layers fluctuated when Mn concentration in surface layer at the position S3 was lower than that in the depth layer while Mn in the remaining positions significantly decreased with depth (Figure 2). The movement of heavy metals in soil depends on many factors such as time, chemical properties of leachate, hydraulic regime of groundwater [8]. Therefore, Mn concentration in the surface layer at S3 was the lowest, possibly due to the lack of influence from leachate, but with high absorption and accumulation capacity, the Mn in the depth layer was higher than that in the surface layer. According to research by Kanmani et al. (2012) [7], Mn concentration in the soil surrounding the landfill was in the range of 420.7 mg/kg - 1711.6 mg/kg, 11 times higher than the current study's result. On the other hand, in the study of Nhien (2018) [9], Mn concentration found in rice fields around the landfill ranged from 190.33 ± 2.52 - 209.33 ± 19.66 mg/kg, about 1.5 times higher than the analyzed result. Thus, it shows that Mn concentration in the soil located far from the landfill site has not had Mn pollution occurred, the locations around the landfill may be affected by leachate and the possibility that the soil is contaminated with Mn.

3.2. Iron

Fe concentration in the surface layer (0 - 20 cm) ranged from 23239.65 ± 222.46 to 31956.75 ± 152.04 mg/kg and at the position S5 compared to S6 and there was no significant difference ($p > 0.05$). Fe at S5 had a statistically significant difference at the 5% significance level ($p < 0.05$) with the positions S1, S2, S3, S4. In the depth layer (60 - 80 cm), the average Fe concentration from 22831.05 ± 256.72 to 28649.76 ± 428.29 mg/kg and Fe at the position S1 had a statistical difference at the 5% significance level with that at the positions S2, S3, S4, S6 ($p < 0.05$). However, Fe at S1 was not statistically significantly different with the position S5 ($p > 0.05$). Analytical results of the variation of Fe concentration between the sampling locations in the surface and depth layers are presented in Figure 3.

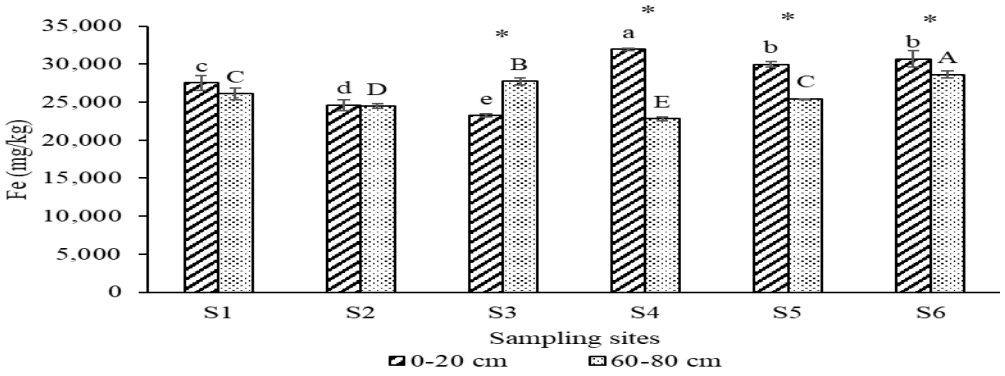

Figure 3. Fe concentration at soil sampling locations by depth

The Fe in the soil is exceptionally high at all positions (Figure 3). Specifically, Fe in the surface layer (0-25 cm) had the highest value at the position S4 (31956.75 ± 152.04 mg/kg) and the lowest value at the position S3 (23239.65 ± 222.46 mg/kg). For the depth layer (60 - 80 cm), Fe concentration has low value at the position S4 (22831.05 ± 256.72 mg/kg), the highest at the position S6 (28649.76 ± 428.29 mg/kg). Like Mn, Fe was also not regulated in QCVN 03-MT: 2015/BTNMT- agricultural land [6]. Over time, the organic chemicals present in the leachate are decomposed or filtered out of the landfill with water, but heavy metals remain due to their non-degradable nature [10] thus leading to the amount of Fe in the soil is exceptionally high at all positions of both layers. The high concentrations of heavy metals in the soil were due to the nature of the solid wastes [7-9]. At the same time, the analysis results in Figure 3 showed that Fe concentration tends to decrease gradually with depth at all locations (except S3). Fe in the surface layer at the location S3 was higher than that in the layer of 60-80cm could be because Fe has moved down and accumulated in the deeper layer of the soil. Besides, Fe concentrations in the surface layer at the locations around the closed landfill were higher than that in the control position (S3), indicating that there was movement of leachate from the closed landfill to the surrounding areas. The distribution of Fe concentration at the locations as well as in soil layers may be related to the leachate of landfill leachate into the soil, Fe mobility and soil properties [11]. There were significant different in Fe concentration at S3 ($p = 0.00$), S4 ($p = 0.00$), S5 ($p = 0.00$), S6 ($p = 0.041$) between the surface and the deeper layer while Fe at the positions S1 ($p = 0.108$), S2 ($p = 0.809$), there was no difference ($p > 0.05$) in Fe in various sampling layers. Fe concentration of the surface layer at the S3 position was also relatively high, but it was lower than that in the surrounding locations. It is possible that the soil has a lot of Fe and it has not been affected by the leachate. According to Makuleke (2020) [10], Fe concentration in the surface layer (0 - 30 cm) around the Lumberstewart landfill ranged from 32622 ± 428 to 44716 ± 889 mg/kg, 1.5 times higher compared with the current research results. However, Fe found in this present study was higher than that in the study of Klinsawathom et al. (2017) [4] in which Fe was from 19806.34 to 25772.80 mg/kg. In general, Fe concentrations accumulate high in the soil surrounding and the closed landfill site. However, the soil cannot absorb such a high concentration of Fe when it is released into the soil solution for plants to absorb or move down in the ground and eventually into groundwater [12].

3.3. Copper

Copper (Cu) is an essential micronutrient required for both plant and animal growth. In humans, it helps in the production of hemoglobin in the blood. The analysis results showed that Cu concentration in the surface layer (0-25 cm) ranged from 22.05 ± 0.48 to 31.95 ± 0.14 mg/kg, and Cu at the depth layer (60 - 80 cm) was in the range of 21.9 ± 0.33 - 39.38 ± 0.24 mg/kg. Cu at the

position S1 and S6 was not statistically significant in both layers, however, Cu at the other locations had statistical difference ($p < 0.05$). The results of the variation of Cu concentration between the sampling locations in the surface and depth layers are shown in Figure 4.

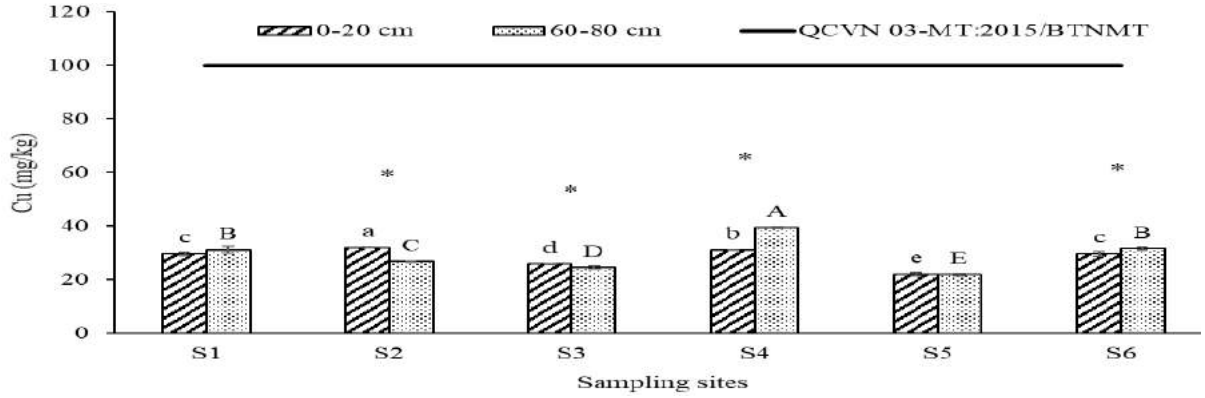

Figure 4. Cu concentration at soil sampling locations by depth

Concentration of Cu in the surface layer (0 - 20 cm) at the position S2 (31.95 ± 0.14 mg/kg) has the highest and the lowest concentration of Cu was at the position S5 (22.05 ± 0.48 mg/kg). For the depth layer of 60 - 80 cm, Cu was the highest at the position S4 (39.38 ± 0.24 mg/kg), the lowest at the position S5 (21.9 ± 0.33). mg/kg). Cu was present in both surface and depth layer with relatively low concentration and tended to change with depth. Specifically, according to the statistical results, the concentration of Cu in the surface layer at the locations S2, S3, S5 was slightly higher than that in the depth layer of 60-80cm. It could show that Cu has been moving to the lower layer which could potentially cause harm to underground water. However, Cu at the positions S1, S4, S6 of the depth layer (60-80cm) was higher than that of the surface layer, indicating a risk of affecting quality of groundwater. The concentration of Cu in soil at the locations S2 ($p = 0.0$), S3 ($p = 0.019$), S4 ($p = 0.0$), S6 ($p = 0.041$) in the surface layer (0 - 20 cm) and depth (60 - 80 cm) were significantly different ($p < 0.05$), while Cu at S1 ($p = 0.124$), S5 ($p = 0.665$) was no difference between the surface layer and depth layer ($p > 0.05$). Compared with QCVN 03-MT:2015/BTNMT-agricultural land [6], the Cu concentration in the surface layer was lower than the limit of the regulation at all locations, about 3.2 times lower. At the same time, the concentration of Cu at the control position (S3) was relatively lower than that of the surrounding sites (except for S5). This may be a sign of movement of Cu-rich leachate into the soil surrounding the fill site [10]. According to the limit of total concentration of some heavy metals in agricultural soil groups to the topsoil of the Institute of Agrochemical Turkey, the total Cu concentration in alluvial soils was low - average 13 mg/kg - 22.4 mg/kg, medium - high 22.5 mg/kg - 31.8 mg/kg. The concentration of Cu in S3 was in the range of medium to high, so the risk of Cu pollution has not occurred. This result was similar to the research results of Kha and Nhi (2019) [13], the concentration of Cu present in the soil surrounding the landfill was relatively low.

3.4. Zinc

Zn concentration in the surface layer (0-25 cm) ranged from 53.07 ± 2.41 to 67.9 ± 2.77 mg/kg (Figure 5). Zn at the position S3 was not statistically different ($p < 0.05$) with that at the positions S1, S4, S6. However, Zn at S3 were statistically significant different with that at the positions S2, S5. In the depth layer (60 - 80 cm), Zn concentration ranged from 43.42 ± 0.35 to 76.04 ± 0.71 mg/kg and Zn at the position S1 was not different in with that at S3 position, but it was significantly different with that at the positions S2, S4, S5, S6.

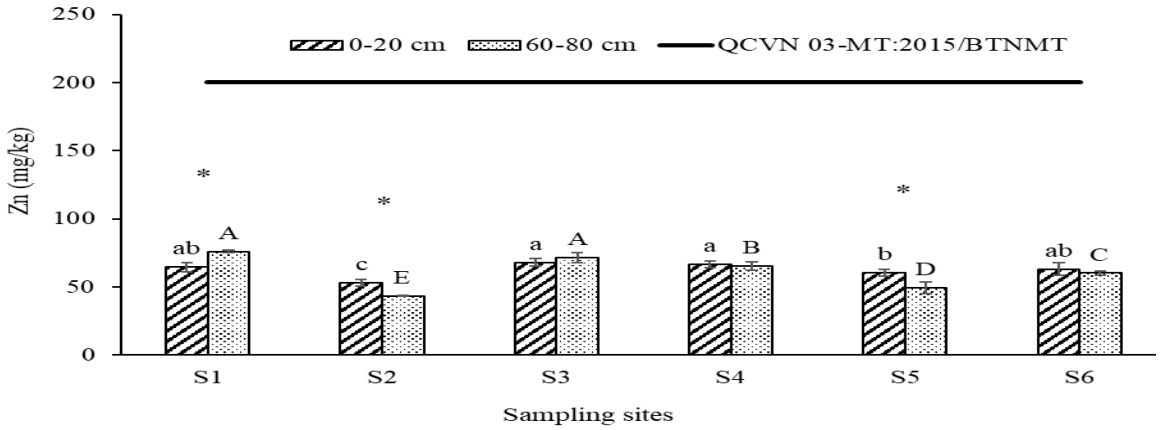

Figure 5. Zn concentration at soil sampling locations by depth

Zn is the element that has the potential to move through the soil [4]. Zn concentration in the surface layer (0 - 20 cm) was the lowest at the position S2 (53.07 ± 2.41 mg/kg) and the highest at the position S3 (67.9 ± 2.77 mg/kg). For the depth layer (60 - 80 cm), Zn was found the highest concentration at the position S1 (76.04 ± 0.71 mg/kg) and the lowest at the position S2 (43.42 ± 0.35 mg/kg) (Figure 5). Through statistical results, Zn at the positions S2, S4, S5, S6 in the surface layer was not much higher than that at the corresponding sites in depth layer (60-80 cm) indicating heavy metals have been moving down in the soil layers. Compared with QCVN 03-MT: 2015/BTNMT-agricultural land [6], Zn concentration was within the permitted standard limit of 200 mg/kg (Figure 5). At the same time, the amount of Zn in the surface layer at the reference position S3 was higher than other positions, possibly due to the presence of heavy metals in chemical fertilizers, pesticides [4]. According to the total concentration limit of some heavy metals in the agricultural soil groups for the topsoil of the Institute of Agro-Soil, Zn concentration in alluvial soil is low - average 21.65 mg/kg - 45.0 mg/kg, medium - high 45.0 mg/kg - 76.6 mg/kg [8]. Thus, it shows that Zn concentration at the position S3 in both layers was low - medium, so the risk of Zn pollution has not occurred. This study result was also consistent with the study of Klinsawathom et al. (2017) [4] that Zn concentrations around the landfill ranged from 18.11 to 512.67 mg/kg. But according to research results of Ha (2018) [8], the concentration of Zn around the landfill ranged from 94 to 295 mg/kg which was higher than that in the current study.

3.5. Nikel

Ni concentrations in the surface layer and depth layer are presented in Figure 6. Ni concentration fluctuated in the range of 17.98 ± 0.6 - 25.34 ± 2.68 mg/kg in the surface layer (0-25 cm). Ni at S6 position was statistically significant at level 5% ($p<0.05$) with the positions S3, S4 and it was no statistically significant difference with the positions S1, S2, S5 ($p>0.05$). For the depth layer (60 - 80 cm), Ni ranged from 16.9 ± 1.84 to 33.69 ± 3.98 mg/kg. Ni at the position S6 was statistically significant difference with the positions S1, S2, S5 ($p <0.05$) and it was not statistically significant differences with the positions S3, S4 ($p> 0.05$).

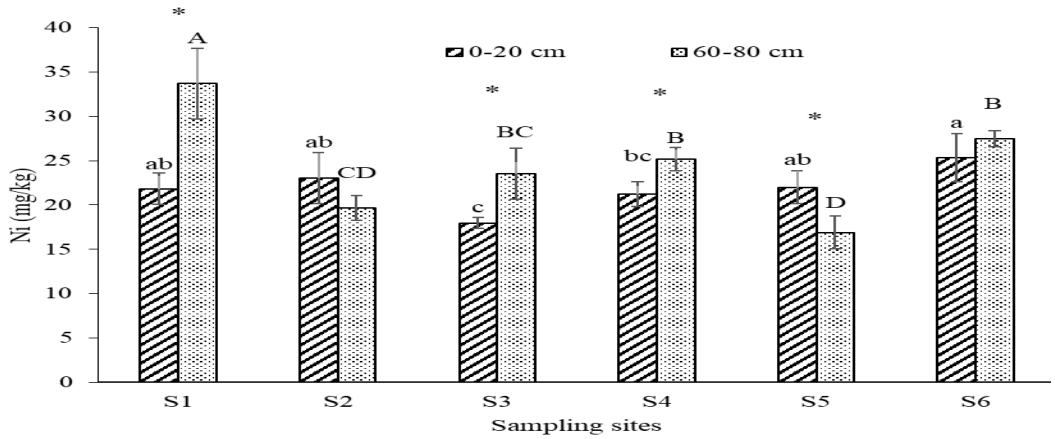

Figure 6. Ni concentration at soil sampling locations by depth

Ni concentration in the surface layer (0 - 20 cm) was found lowest at the position S3 (17,98 ± 0.6 mg/kg) and the highest at the position S6 (25,34 ± 2.68 mg/kg). Ni concentration has not been specified in QCVN 03-MT: 2015/BTNMT- agricultural land for surface layer [6]. For the depth layer (60 - 80 cm), Ni was found the highest at the position S1 (33.69 ± 3.98 mg/kg) and the lowest at the position S5 (16.9 ± 1.84 mg/kg). Ni concentration presented at the surveyed sites was low. However, this heavy metal may increase its concentration due to long-term accumulation [7]. Through the statistical results, Ni concentration in the surface and depth layers at the positions S1 ($p = 0.009$), S3 ($p = 0.03$), S4 ($p = 0.023$), S5 ($p = 0.028$) was significantly different ($p <0.05$). Ni of both layers at the positions S2 ($p = 0.141$), S6 ($p = 0.261$) was not significantly different. Comparing the depth layer with the surface layer, the accumulated Ni concentration at the locations S1, S3, S4, S6 of the depth layer was higher than that in the surface layer. This indicates that leachate movement has taken place or may still take place at this depth around the closed landfill site. Leachate movement at this depth is possible because of soil properties [10]. Besides, Ni concentration in the surface layer at the location around the closed landfill site was higher than that in the reference position (S3), indicating that there was movement of leachate from the closed landfill area. A study by Nhien (2019) [9] showed that Ni concentration in the surface layer around the landfill ranged from 190.33 ± 2.52 to 209.33 ± 19.66 mg/kg. Klinsawathom et al. (2017) [4] reported Ni concentration ranged from 5.05 to 26.3 mg/kg in the soil surrounding the landfill. The previous results were consistent with the result of the current study.

3.6. Lead

Pb concentration between the sampling locations in the surface and depth layers are illustrated in Figure 7. According to analysis results, Pb concentration in the surface layer (0 - 20 cm) fluctuated in the range of 20.93 ± 1.98 - 36.75 ± 1.99 mg/kg. Pb concentration was statistically significantly different at the 5% significance level for the positions S3, S4 and S5 ($p <0.05$) and there was no difference in statistical significance for the positions S1, S2 ($p> 0.05$). Unlike the surface layer, Pb in the depth layer (60 - 80 cm) ranged from 26.29 ± 2.15 to 33.68 ± 3.18 mg/kg. Pb concentration at S3 was not significantly different with the positions S1 and S6 but it was different with that at S2, S4, and S5 (Figure 7).

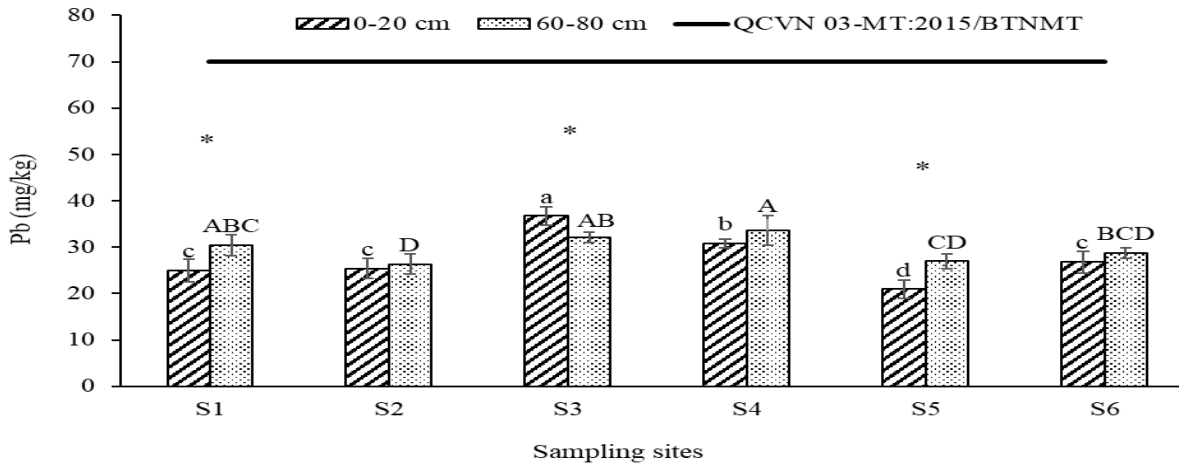

Figure 7. Pb concentrations at soil sampling locations by depth

Pb concentration in the surface layer (0 - 20 cm) had lowest concentration at the position S5 (20,93 ± 1,98 mg/kg) and the highest at the position S3 (36,75 ± 1,99 mg/kg). Compared with QCVN 03-MT: 2015/BTNMT-agricultural land for the surface layer [6], Pb concentration in all locations was lower than the standard, 1.9 times lower for the position S3 and 3.4 times lower for S5 position. For the depth layer (60 - 80 cm), Pb was the highest at the position S4 (33.68 ± 3.18 mg/kg) and the lowest at the position S2 (26.29 ± 2.15 mg/kg). Pb concentration did not differ much between surface and depth layers in most positions, but there was a significant difference between the surface and depth layers at the positions S1 ($p = 0.049$), S3 ($p = 0.024$), S5 ($p = 0.014$). In most locations, Pb concentration in the depth layer was higher than that of the surface layer, except for the location S3. Pb concentration at the position S3 was higher than that in surrounding locations, possibly due to the movement of metals from the landfill to agricultural land through leaching, flow and final uptake of plants and bioaccumulation to the food chain [14]. According to Rosen (2002) [15], the most serious source of lead exposure in soil is through direct ingestion of contaminated soil or dust. In general, plants do not absorb or accumulate lead. However, in the results of soil analysis with high lead concentration, lead can still be absorbed. In summary, Pb is considered safe when using soil-grown gardening products with a total lead concentration of less than 300 mg/kg. The risk of lead poisoning through the food chain increases as soil lead levels rise above this concentration. The current study showed that Pb concentration at the positions S3, S6 is suitable for agricultural cultivation. Another study by Kanmani et al. (2012) [7], Pb concentration in soil samples around the open landfill ranged from 44.09 to 178.84 mg/kg, which was higher than that in the current study.

3.7. Crom

The analytical results of the fluctuation of Cr concentration between the sampling locations in the surface and depth layers are presented in Figure 7. Cr concentration in the surface layer (0-25 cm) ranged from 43.27 ± 1.82 to 67.91 ± 0.41 mg/kg (Figure 7). Cr at position S2 was a statistically significant difference ($p < 0.05$) with that at the positions S1, S3, S6. However, Cr at S2 was not different statistically with that at the positions S4, S5 ($p > 0.05$). For depth layer (60 - 80 cm), Cr ranged from 43.66 ± 1.41 to 60.24 ± 1.03 mg/kg. Cr at the position S1 was not statistically significant difference ($p > 0.05$) with that at the positions S4, S6. However, Cr at S1 showed a statistically significant difference ($p < 0.05$) with that at the positions S2, S3, S5.

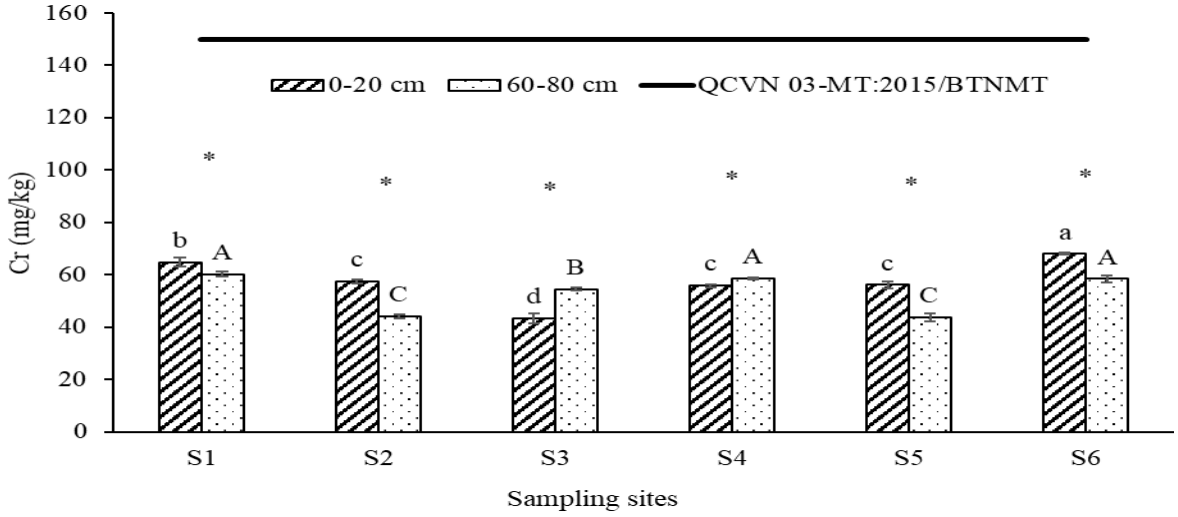

Figure 7. Cr concentration at soil sampling locations by depth

Cr concentration in the surface layer (0 - 20 cm) had low concentration at the position S3 (43.27 ± 1.82 mg/kg) and it was found the highest at the position S6 (67.91 ± 0.41 mg/kg). Compared with QCVN 03-MT: 2015/BTNMT- agricultural land for the surface layer [6], the Cr concentration at all locations was lower than the standard. For the depth layer (60 - 80 cm), Cr reached the highest value at the position S1 (60,24 ± 1,03 mg/kg) and lowest value at the position S5 (43,66 ± 1,41 mg/kg). Cr concentration at all locations tended to be higher than that at S3, showing that Cr originated from the closed landfill leachate. Cr occurred in the leather, wood preservatives, paints, and [8]. Thus, it can be initially assessed that the area around the closed landfill has been affected by leachate. There was siginificantly different ($p < 0.05$) in Cr concentrations at all positions including S1 ($p = 0.019$), S2 ($p = 0.0$), S3 ($p = 0.001$), S4 ($p = 0.003$), S5 ($p = 0.0$), S6 ($p = 0, 0$). The concentration of Cr in the surface layer at the positions S1, S2, S5, S6 tended to be higher than that in the depth layer, however, the difference was not significantly which could indicate that Cr has been moving into the deeper layer. This could lead to the risk of groundwater pollution. According to research by Klinsawathom (2017) [4], the concentration of Cr around the landfill ranged from 21.67 to 29.80 mg/kg which was lower than the results of the current study in both surface and depth layers. According to Kha and Nhi (2019) [13], the soil surrounding the landfill had a Cr concentration in the surface layer (0-25 cm) ranging from 9.66 ± 0.56 to 28.3 ± 0.05 mg/kg and in the depth layer (25 - 50 cm) ranging from 22.5 ± 1.40 to 32.5 ± 0 mg/kg.

4. Conclusion

The analysis results of the heavy metals in both layers had the appearance of Fe, Mn, Zn, Cr, Cu, Pb, Ni and were within the allowable limits of QCVN 03: MT/BTNMT- agricultural land. Most of the heavy metal concentrations in the surface layer (0-20 cm) was higher than those in the depth layer (60 - 80 cm). The concentration of heavy metals in the surface layer (0-20 cm) at the locations around the closed landfill site were higher than that of the reference position S3 (except Pb, Zn, Cu), indicating the presence of metals of Fe, Mn, Ni, Cr was from the closed landfill site. The presence of all heavy metals in the depth layer (60 - 80 cm) indicated a continuous movement of leachate and penetration through the soil layer, which after a certain period of time can contaminate in groundwater system if no action is taken to prevent this phenomenon. The study results also showed that the land far from the landfill was still suitable for agricultural purposes, but it is still necessary to have appropriate soil management measures and appropriate fertilization to avoid affecting the environment. The results of this study indicated that there are signs of

leachate movement from the closed landfill to surrrounding environment. The movement of heavy metals in the soil could pose potentially risk to groundwater quality and this pollution is more serious as heavy metals accumulate in the soil. Continuous environmental monitoring should be ensured to minimize the impact of the movement of leachate from a closed landfill and to minimize its impact on surrounding communities.

References

[1] Ministry of Natural Resources and Environment. Vietnam state of environment report for the period 2011 – 2015.
[2] Daabes, M, Qdais, H.A, Alsyouri, H. (2013). Assessment of Heavy Metals and Organics in Municipal Solid Waste Leachates from Landfills with Different Ages in Jordan. Journal of Environmental Protection, 2013, 4, 344-352.
[3] Toufexi, E., Tsarpali, V., Efthimiou, I., Vidali, M.S., Vlastos, D., Dailianis, S. (2013). Environmental and human risk assessment of landfill leachate: an integrated approach with the use of cytotoxic and genotoxic stress indices in mussel and human cells. Journal of Hazardous Materials, 2013, 260, 593-601.
[4] Klinsawathom, T., Songsakunrungrueng, B., Pattanamahakul, P. (2018). Heavy metal concentration and risk assessment of soil and rice in and around an open dumpsite in Thai Lan. Enviroment Asia, 2017, 10(2), 53-64.
[5] Rashed, A.R.A. (2018). The Environmental Impacts of Kabd Landfill on the Soil and Groundwater in Kuwait: A Case Study. International Journal of Geosciences, 2018, 9, 255-271.
[6] Ministry of Natural Resources and Environment. QCVN 03-MT: 2015/BTNMT National technical regulation on the allowable limits of heavy metals in the soil. 2015
[7] Kanmani, S and Gandhimathi, R. (2013). Assessment of heavy metal contamination in soil due to leachate migration from an open dumping site. Applied Water Science, vol. 3, no. 1, pp. 193–205.
[8] Hoang Ngoc Ha (2018). Heavy metal pollution from landfill landfills to soil environment: Kieu Ky landfill - Gia Lam - Hanoi. Science Journal, Hanoi National University: Earth and Environment Sciences. 34 (2): 86-94.
[9] Huynh Thi Hong Nhien (2018). Assessment of the current status of soil and water around the landfill site in Dong Thang commune, Co Do district, Can Tho city. University Bachelor Thesis. Can Tho University.
[10] Makuleke, P and Ngole-Jeme, V.M. (2020). Soil Heavy Metal Distribution with Depth around a Closed Landfill and Their Uptake by Datura stramonium. Applied and Environmental Soil Science, vol. 2020, Article ID 8872475, 14 pages.
[11] Bongoua-Devisme A.J, Gueable, Y.K.D, Balland, B.N.C, Bolou, B.B.E, Kassin, K.E, Adiaffi, B, Yao-Kouame, A, Djagoua, E.M.V. (2018), Assessment of heavy metal contamination degree of municipal open-air dumpsite on surrounding soils: Case of dumpsite of Bonoua, Ivory Coast. International Journal Of Engineering Research and General Science 6(5):28-42.
[12] Mapanda, F, Mangwayana, E.N, Nyamangara, J, Giller, K.E (2005). The effect of long-term irrigation using wastewater on heavy metal concentrations of soils under vegetables in Harare, Zimbabwe. Agric. Ecosyst. Environ. 107, 151–165.
[13] Vo Thi Tuyet Kha and Nguyen Thi Yen Nhi (2019). Assessment of the Environmental Impact of Landfills in Dong Thang Commune, Co Do District, Can Tho City. University Bachelor Thesis. Can Tho University.
[14] Opaluwa, O.D, and Umar, M.A.(2010). Bulletin of pure and applied sciences, 29:1, 39-55.
[15] Rosen, C.J. (2002). Lead in the home garden and urban soil environment, Communication and Educational Technology Services, University of Minnesota Extension.