NU Science Journal 2013; 10(1): 18 - 29

Assessment of Heavy Metal Distribution in Soil and Groundwater Surrounding Municipal Solid Waste Dumpsite in Nai Muang Sub-district Administrative Organization, Amphur Phichai, Uttaradit

Piyada Wachirawongsakorn and Suksaman Sangyoka

Environmental Science, Faculty of Science and Technology,
Rajabhat Pibulsongkarm University, Phitsanulok, 65000, Thailand
* Corresponding author. E-mail: piyada333@hotmail.com

ABSTRACT

The open dumpsite of Nai Muang Phichai Sub-district Administrative Organization, Amphur Phichai, Uttaradit Province is the one of words disposal site in Thailand that becomes to the sources of environmental pollution. The leachate from dumpsite usually contains high concentration of heavy metals that effect to environment and human health. The study was determined the heavy metals in the soil and groundwater at dumpsite surrounding areas for assessment the heavy metal contents and distributions. The results obtained indicated the following ranges for the metal in the dumpsite soil: 0.51-0.98 mg/kg of Cd, 1.22-8.78 mg/kg of Pb, 8.33-22.40 mg/kg of Cu, 25.14-75.75 mg/kg of Zn and 869.04-948.83 mg/kg of Fe. For the heavy metal content at surrounding soils ranged between 0.13-0.73 mg/kg of Cd, 1.22-12.69 mg/kg of Pb, 2.27-17.35 mg/kg of Cu, 11.16-34.15 mg/kg of Zn and 782.47-938.28 mg/kg of Fe. These values were found to be below the critical permissible concentration of soil quality standard. The groundwater resources, the results indicated that they are suitable for domestic purposes but it is not suitable for drinking purpose. Each heavy metal is classified into portable, within permissible limits. Except for iron concentration which is detected to be above the maximum permissible range, this is generally not suitable for consumption. The concentration of Cd, Pb, Cu, Zn and Fe in groundwater ranged between BDL-0.01, BDL-0.01, BDL-0.08, 0.03-2.38 and 0.53-9.36 mg/L, respectively.

Keywords: municipal solid waste, open dumpsite, heavy metal, soil, groundwater

INTRODUCTION

The global problem concerning the environmental pollution problem from solid waste as a consequence of human activities is increasing. The practice of landfill system as a method of waste disposal in many developing countries is usually far from standard recommendations (Mull, 2005). In Thailand, solid waste has seriously increased, especially in capital city. Most waste disposal sites are open dump type without proper management control cause adverse impact to the environment. Hazardous waste such as used batteries, electronic goods, pesticide bottles, electro plating waste and household hazardous waste, etc. are always mixed with municipal solid waste that can cause of heavy metal contamination in the dumpsite. The leachate from open dumpsite usually has high content of pollutants.

Since leachates are one of the potential source of groundwater pollution (Oyeku and Eludoyin, 2010). Zurbrugg et al. (2003) referred to it as 'dumps' which receive solid wastes in a more or less uncontrolled quantity, asking a very uneconomical use of the available space and that which allows free access to waste pickers, animals and flies, and often produce unpleasant and hazardous smoke from slow-burning fires. Besides, instances have been shown that even the lined (protected) landfills have been inadequate in the prevention of groundwater contamination (Lee and Lee, 2005). Therefore, the assessment of heavy metal content in dumpsite, surrounding area and groundwater is necessary to provide the guidance of environmental protecting before the critical environmental damaged situation is occurred.

Open dumpsite in Nai Muang Phichai Sub-district Administrative Organization, Amphur Phichai, Uttaradit Province is also one of many predominant unorganized open dumpsites of solid waste in Thailand. Three local administrative organizations which are Nai Muang Phichai Municipality, Nai Muang Sub-district Administrative Organization and BanMorh Sub-district Administrative Organizations jointly dispose municipal solid waste in this open dumpsite which is located in area of Nai Muang Phichai sub-district administrative organization for 25 years ago. All unsegregated wastes were dumped in the old reservoir without sufficient protection from the leachate. That may cause toxic contamination in surrounding area where is the agriculture land located and also groundwater resource for drinking and consumptions in the surrounded villages. There has been growing concern the environmental problem from surrounding community especially bad odor, fly nuisance, and blowing of light materials like plastics, paper etc., due to winds. Solid waste disposal system consulting indicated that it carries risks to harm environmental surrounding by toxic contamination in agriculture soil and groundwater because of an operation and location of open dump are not proper to the standards of sanitary landfill. People who live around this open dumpsite feel as are living in bad place and lacked of self-care. (Kriengsit, 2009)

All above these observations prompted the present study that aim to investigate the heavy metal contents and distribution in soil where the agriculture lands are located and groundwater use to supply daily consumption at the point of tubewell pump and hand dug well near dumpsite areas. The heavy metals investigated in this study have been implicated for various human health problems which are cadmium (Cd), copper (Cu), lead (Pb), zinc (Zn) and iron (Fe). This would be a basic data help to overcome the environmental impact of improper disposal practices and may provide a solution to the crisis in solid waste management due to exhaustion of available space for landfilling.

Material and Methods

The study site

The present study was carried out in surrounding area of open dumpsite in Nai Muang Sub-district Administrative Organization, Amphur Phichai, Uttaradit Province.

Sample collection and analyses procedure

Soil samples

Soil samples were collected at difference depths up to soil profile classification. Drilling process was terminated at about 100-150 cm depth due to the blocking by compact soil and stone. Two holes of soil collection were collected at each point at 3 and 5 m from the edge of the dumpsite towards the border fence and another 5 holes of soil collection were point at 15 and 30 m from the border fence towards the area where is vegetation area located (Figure 1). For each horizon in soil profile, four soil samples were thoroughly mixed and one composite soil sample derived for laboratory analysis. A total of 29 samples were collected from seven holes. Texture analysis was performed by the hydrometer method (Palmer and Troeh, 1980). pH was measured in a slurry (shaking 5 parts of distilled water and 1 part of soil during 15 min). Heavy metals determined from the soils included cadmium (Cd), copper (Cu), lead (Pb), Iron (Fe) and zinc (Zn). The soil samples were air dried for 30 days, crushed and passed through a 2 mm sieve. 1g each of the sieved soil sample was digested in a 1:1 mixture of concentrated HNO_3 and $HClO_4$ acids by heating a mixture of the acids and sample in a water bath in a fume cupboard. The solution was heated to dryness while the residue was re-dissolved in 5 mL of 2.0M HCl. The concentrations of heavy metals were determined by using atomic absorption spectrophotometer (AAS).

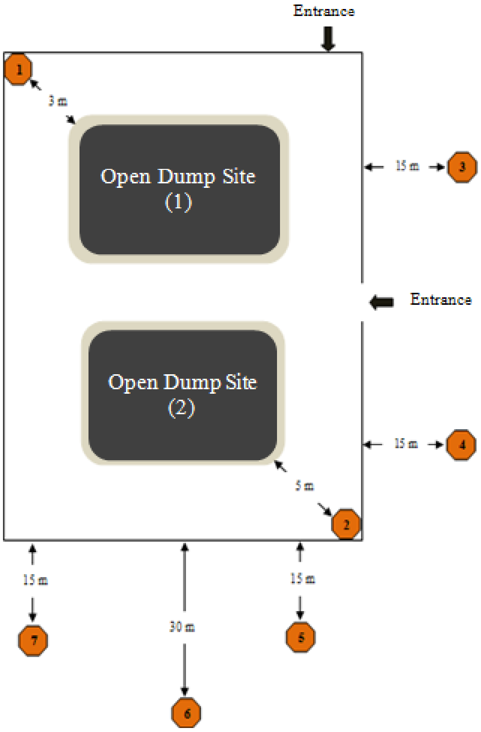

Figure 1 The positions of drilling holes for soil sample collection.

Groundwater samples

For the present study, water samples were collected 8 points in the dumpsite area surrounding of Nai Muang Sub-district Administrative in November, 2009 and April, 2010. (Figure 2) Most of the fresh water samples were collected from tubewell pump station and just only one point from hand pump drawn water. (Table 1) Water samples were collected in clean and sterile one litter polythene cans rinsed with diluted HCl to set a representative sample and stored in an ice box. Samples were protected from direct sun light during transportation to the laboratory and metals were analyzed as per the standard procedures. All the metals were determined by using atomic absorption spectrophotometer. The instrument was used in the limit of precised accuracy and chemicals used were of analytical grade. Double-distilled water was used for all purposes.

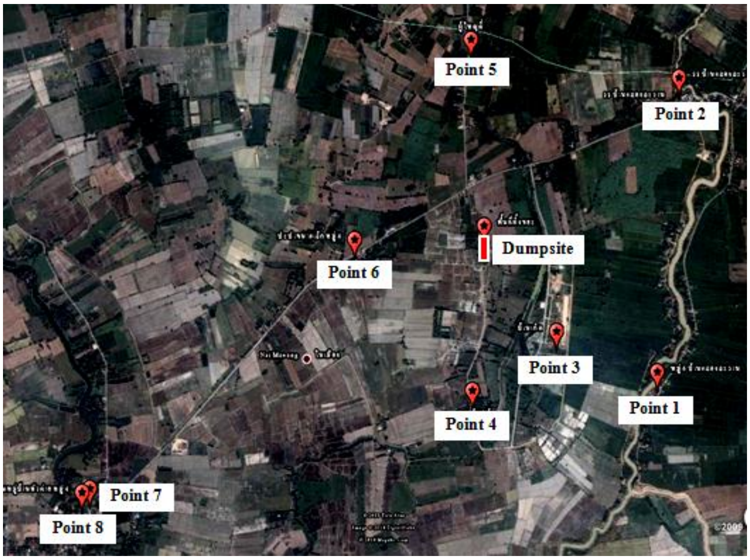

Figure 2 The positions of water sample collection surrounding dumpsite area.

Table 1 Water sampling locations and sources.

Sample no.	Sampling station	Source
P.1	Village water supply of Moo 6	Tube well pump station
P.2	Village water supply at Ban Clong Rawan School	Tube well pump station
P.3	Hometown of Phraya Phichai Dabhak	Tube well pump station
P.4	Water supply for small community in Moo 9	Hand dug well
P.5	Village water supply of Moo 9	Tube well pump station
P.6	Village water supply of Moo 4	Tube well pump station
P.7	Village water supply of Moo 4	Tube well pump station
P.8	Village water supply at Village fund and Urban Community Office	Tube well pump station

Results and Discussion

Content of heavy metals on soils from different distances from the dumpsite

The textural class of the soils was observed to be a mixture of sand, clay and loam in all the sites investigated. Soil in the dumpsite area are loamy clay-clay with the varied mean composition of 34-47% sand, 26-36% silt and 20-42% clay while the top soils surrounding where is the vegetation area are clay loam, silt loam, sandy clay loam and loam with varied mean composition of sand, silt and clay as showed in Table 2. The mean pH values in 1:1 soil: water suspension exhibited slightly acidic with a varied mean pH ranged from 6.41-7.05 of soil in dumpsite area and 5.58-7.45 of soil surrounding area. Mineral and organic soils can bind metals to different extent. (Maria *et al*., 2003) Organic matter, iron and manganese hydrous oxides, and clay content are significant soil properties influencing sorption reactions (Bolan and Duraisamy, 2003). Additionally, soil pH, cation exchange capacity (CEC) and redox potential can also regulate the mobility of metals in soils (Lombi and Gerzabek, 1998). Soil pH, for instance is very important for most heavy metals, since metal availability is relatively low when pH is around 6.5 to 7 (Maria *et al*., 2003)

Table 2 Texture class of soils in each depth soil profile at different locations

Position	Soil profile	Soil layer	pH	Soil particle distribution			Soil type
				%sand	%silt	%clay	
Point 1	Backfill soil	0-50	6.82	34	26	40	clay loam
	Backfill soil	>50-100	6.41	44	36	20	loam
	Backfill soil	>100-150	6.99	47	33	20	loam
Point 2	Backfill soil	0-50	7.05	42	32	26	loam
	Backfill soil	>50-100	6.50	38	32	30	clay loam
	Backfill soil	>100-150	6.98	30	28	42	clay
Point 3	AB	0-25	6.57	34	28	38	clay loam
	B1	>25-55	7.12	27	35	38	clay loam
	B2	>55-95	6.76	26	32	42	clay
	B3	>95-140	7.45	27	32	41	clay
Point 4	AB	0-25	6.48	24	41	35	clay loam
	B1	>25-35	6.45	26	38	36	clay loam
	B2	>35-80	5.58	30	30	40	clay loam
	B3	>80-100	6.42	34	36	30	clay loam
Point 5	AB	0-20	6.26	1.8	52.2	46	silty loam
	B1	>20-55	6.98	20	24	56	clay
	B2	>55-90	6.86	1.4	38.6	60	clay
	B3	>90-135	5.89	28	31	41	clay
	BC	>135-200	6.40	12	26	62	clay
Point 6	AB	0-20	6.50	32	32	36	clay loam
	B1	>20-50	7.05	34	26	40	clay loam
	B2	>50-100	7.09	28	26	46	clay
	B3	>100-135	7.27	20	26	54	clay
	BC	>135-200	6.72	16	29	55	clay
Point 7	AB	0-20	7.09	28	38	34	clay loam
	B1	>20-50	6.90	28	33	39	clay loam
	B2	>50-100	6.51	28	34	38	clay loam
	B3	>100-140	6.98	25	36	39	clay loam
	BC	>140-200	7.17	16	38	46	clay

The heavy metal content obtained from different soil depth and distance from capped landfill varied with different types of heavy mental constituent. (Table 3) The pronounced presence of heavy metals was noticed between 5 m away from the refuse dump indicating toxic pollution, while the heavy metals recorded of landfill surrounding areas were below the Land Development Department Standard (LDDS). Results obtained showed that soils from dumpsite area were higher heavy metal concentration than surrounding area where some vegetable fields were located. The heavy metal concentration at capped dumpsite ranged between 0.51-0.98, 1.22-8.78, 8.33-22.40, 25.14-75.75 and 869.04-948.83 mg/kg for cadmium, lead, copper, zinc and iron, respectively. Soils at surrounding areas showed ranged between 0.13-0.73, 1.22-12.69, 2.27-17.35, 11.16-34.15 and 782.47-938.28 mg/kg, respectively. This may be because soil in capped landfill was protected by concrete wall; therefore the heavy metal was hardly distributed to surrounding area. However, it could be attributed to the availability of heavy metal containing wastes at dumpsites which are eventually leached into the underlying and surrounding soils. The average abundance order of heavy metal contents in each sampling point based on soil depths are iron>zinc>copper>lead>cadmium. This order was similar trend that found both in the capped dumpsite and surrounding area. Iron recording was the highest concentration of 938.28 mg/kg, while cadmium was recorded the lowest concentration of 0.13 mg/kg. Soil samples analyzed for heavy metals at different depths indicated different concentration levels. Furthermore, results indicated concentration levels of heavy metals decreased with distance. The different range of heavy metal contamination in the different depth or distance of the soil samples is highly dependent on the chemical composition of the soil. The effect of perturbation depends on the buffering capacity, chemical characteristics and specific compound of the soil, and the soil organic matter. Heavy metal binding properties of these soil constituents differ with the charges of the soil material and the ionic valency (Agamuthu and Fauziah, 2010). Specifically, the cadmium concentrations of top soils were found to be below the Land Development Department (LDD) soil quality standard which indicated not exceed 0.5 mg/kg for agriculture purpose, except the soils in dumpsite area (Point 1 and 2) which exceed the LDD values. However, these values were below Dutch Intervention and USDDA NRCS soil quality standards. Moreover, the results revealed that cadmium concentrations of banana plantation soils (Point 3 and 4) were higher compared with rice field soils (Point 5, 6 and 7). This was probably due to rice field soil was clay loam to clay texture with high content of clay particles distribution that has more capability to absorb cation than other soil particles. The electrical charge associated with clay and soil pH influence pollutant transport. Clay normally carries a negative charge because it high organic content maintains an overall negative charge. Clay also consists of silicon and aluminum oxide, which can precipitate metals (Sullivan and Kreiger, 2001). Therefore, the removal of cadmium was more effective for clay loam soil than for clay soil. Cadmium contaminated soil in banana plantation area and rice field may not only influence by the leachate of waste dumpsite, pesticide and fertilizer applications on the crop can also be affected.

For lead concentration of soil in the dumpsite and surrounding areas showed varied quantities below LDD soil quality standard ranges which allowed lead contaminated in soil not exceed 55 mg/kg. The lead was enriched at the surface as compared with the soil beneath for all sampling points. Lead concentration at the 50 cm depth of dumpsite area is between 3.61 and 8.78 mg/kg higher than in the 100 and 150 cm depths. The higher organic content in the topsoil may affect the lead concentration. Panichsakpattana (1997) indicated that lead content increase following the amount of organic matter content. The negative charges on humus and dissociation of carboxyl and phenolic hydroxyl groups have high capability to absorb lead and other cation in soil. Therefore, there is enriched lead in the top soil. Moreover, lead moves more rapidly and very slowly into the deeper soil because of the low solubility characteristic and hardy degradation by microorganism.

The copper concentrations did not show a large variation between soil profiles of each sampling position. The copper content was found to be below the critical permissible concentration of 45 mg/kg LDD soil quality standard for agriculture purpose. The soils in dumpsite area had copper concentration between 9.84-12.61 mg/kg, while copper contents in soil ranged 5.41-15.02 mg/kg of banana field and 2-27-13.30 mg/kg of rice field.

The total zinc concentration in soil samples had higher concentration through the whole soil profile than cadmium, lead and copper with ranged 25.06-76.75 mg/kg of dumpsite area, 13.78-32.35 mg/kg of banana plantation area and 11.16-30.18 mg/kg of rice field. Also, zinc enrichment in the topsoil and zinc distribution showed the same tendency with respect to their downward movement within the soil profile. Zinc is normally considered to be quite mobile in soils (Bride, 1989), although soil organic matter is known to have a high potential in storing heavy metals (Chulin *et al*, 1995). For the maximum zinc concentration found in this study, 66.76 mg/kg does not reach the allowance of LDD soil quality standard for agriculture purpose (not exceed 100 mg/kg).

For the level of iron concentration ranged between 810.23-946.71 mg/kg. In the top soil, the highest average concentration of iron was found at capped dumpsite area. These values fell within the permissible level standard of iron for soil. Eddy et al. (2004) suggested that the pollution of the environment by iron cannot be conclusively linked to waste materials alone but other natural sources of iron must be taken into consideration. Although, the high concentration of iron in soil solutions were found in these soils but it may not be toxic to plants, these usually occur because the iron is in a form that cannot be taken up by plants. Doberman and Fairhurst (2000) explained that the iron toxicity in soil is occurred due to the soil consist of high available form of iron that causes excessive uptake by plant and toxic to plants. Mathias and Folkard (2005) suggested that critical level for iron toxicity in the plant tissues is 300-2000 mg/kg, depending on plant age and general nutritional status. In addition, much heavy metals such as zinc and copper, inhibits the plant uptake of iron. This may be a reason causing iron does not toxic to plant (Wallace Labs, 2009).

Table 3 Heavy metal distribution in each depth soil profile at different location

Position	Soil profile	Soil layer	Heavy metal content (mg/kg)				
			Cd	Pb	Cu	Zn	Fe
Point 1	Backfill soil	0-50	0.82	8.78	22.40	66.76	941.29
	Backfill soil	>50-100	0.82	1.51	8.33	25.09	869.04
	Backfill soil	>100-150	0.98	1.75	28.21	75.75	945.14
Point 2	Backfill soil	0-50	0.51	3.61	12.61	29.12	948.83
	Backfill soil	>50-100	0.54	1.40	9.84	25.14	899.76
	Backfill soil	>100-150	0.62	1.22	11.07	28.90	918.92
Point 3	AB	0-25	0.36	5.27	10.50	22.09	887.06
	B1	>25-55	0.25	9.00	14.36	30.97	916.16
	B2	>55-95	0.57	9.41	17.35	34.15	929.73
	B3	>95-140	0.60	6.61	11.54	26.27	885.20
Point 4	AB	0-25	0.34	3.14	15.02	22.17	855.00
	B1	>25-35	0.25	1.49	5.41	14.13	832.82
	B2	>35-80	0.16	2.17	6.70	13.78	806.99
	B3	>80-100	0.46	4.68	13.79	32.35	938.28
Point 5	AB	0-20	0.15	6.38	3.36	15.60	808.33
	B1	>20-55	0.30	5.56	3.44	13.29	810.23
	B2	>55-90	0.42	5.29	2.27	11.16	782.47
	B3	>90-135	0.65	7.17	5.02	14.50	876.13
	BC	>135-200	0.13	10.71	10.06	23.93	932.57
Point 6	AB	0-20	0.18	6.73	4.18	14.21	814.17
	B1	>20-50	0.28	5.86	5.09	15.45	832.76
	B2	>50-100	0.45	5.39	5.97	16.56	873.13
	B3	>100-135	0.61	7.89	6.82	18.14	880.03
	BC	>135-200	0.17	7.99	8.94	20.25	918.16
Point 7	AB	0-20	0.13	6.16	3.78	15.15	788.42
	B1	>20-50	0.51	8.53	5.83	18.05	838.35
	B2	>50-100	0.53	12.69	13.01	30.58	946.71
	B3	>100-140	0.73	11.83	13.30	30.18	931.00
	BC	>140-200	0.40	7.33	7.56	18.57	885.02
Land Development Department Standard			≤0.5	≤55	≤45	≤100	-
Dutch Intervention Standard*			≤12	≤530	≤190	≤720	-
USDDA NRCS Standard**			≤85	≤420	≤4300	≤7500	≤20,000-550,000

Remark: * Fauziah et al., 2011,

** USDA NRCS, 2000

Heavy metal in Groundwater

The heavy metals detected in the groundwater samples from the tubewell pump stations and hand dug well are lead, cadmium, zinc, iron and copper. The results of laboratory analyses conducted on the samples are in Table 3. It shows the concentration and distribution of heavy metals in the groundwater surrounding the capped dumpsites and was also been compared with groundwater standards for drinking purpose. This provides the comprehensive picture of the heavy metals characteristics of groundwater in this area. The results indicated that the groundwater resource was suitable for domestic purposes but it was not suitable for drinking purpose. Each heavy metal is classified into portable, within PCD's permissible limits. Except for iron concentration which was detected to be above the maximum permissible range that were generally not suitable for consumption. Specifically, the groundwater containing lead was within a range of BDL-0.1 mg/L. The study revealed that the concentration of lead was below the detectable level in most of water collection stations. However, the concentration of lead observed is within the safe limit of PCD. For cadmium concentration, groundwater in tubewell pump stations number 6 and 7 collected in November, 2009 were detected to be above the maximum acceptable concentration but it was not over the maximum allowable concentration. However, the cadmium concentration collected in April, 2010 turned to below detectable limit. Nevertheless, cadmium in low concentration is quite toxic to human health (Chopra and Choudhary, 1998). Normally, cadmium is not an essential non-beneficial element know to have a toxic potential. The concentration of cadmium in lithosphere is low. It normally ranges from $1x10^{-4}$ to $2x10^{-4}$ mg/L (Chopra and Choudhary, 1998; Rajappa *et al*., 2010). The main sources of cadmium are industrial activities. Cadmium is highly toxic and responsible for several cases of poisoning through food. Small quantities of cadmium cause adverse changes in the arteries of human kidney. It replaces zinc biochemically and causes high blood pressures kidney damage and etc. It interferes with enzymes and causes a painful disease called Itai-itai (Chopra and Choudhary, 1998; Rajappa *et al*., 2010). Zinc is one of the important trace elements that play a vital role in the physiological and metabolic process of many organisms (Stephen *et al*., 2012).Nevertheless, at higher concentration, zinc can be toxic to the organisms. It plays an important role in protein synthesis. Zinc is a metal which shows fairly low concentration in surface water, which is due to its restricted mobility from the place of rock weathering or from the natural sources (Rajgopal, 1984). In this study, 0.02-2.28 mg/L of zinc was detected in groundwater surrounded dumpsite area. These values were with in the maximum acceptable concentration that is not exceeded 5.0 mg/L of PCD's permissible limit. Copper similarly varied from BDL-0.04 mg/L that the copper observed was within the maximum acceptable concentration that is not exceeded 1.0 mg/L. The iron concentration in the study area is higher than the desirable limit with a wide range of 0.53-9.36 mg/L. Rajgopal (1984) said that the ferrous level was observed in abnormally high concentration in most groundwater sources. Regularly, iron is an essential and non-conservative trace element found in significant concentration in drinking water because of its abundance in the earth's crust. Usually iron occurring in groundwater is in the form of ferric hydroxide, in concentration less than 0.5 mg/l. The shortage of iron causes a disease called "anemia" and prolonged consumption of drinking water with high concentration of iron may lead to liver disease called as haermosiderosis. In order to, the people who use this groundwater as drinking purpose could find the proper water treatment method for iron.

Table 3 Heavy metal concentration of groundwater in the study site

Collection Station	Pb		Cd		Zn		Fe		Cu	
	Nov.	Apr.	Nov.	Apr.	Nov.	Apr.	Nov.	Apr.	Nov.	Apr.
Point 1	BDL	0.01	BDL	BDL	0.03	0.04	1.20	1.02	0.01	BDL
Point 2	BDL	0.01	BDL	BDL	0.07	0.03	2.57	2.55	0.01	BDL
Point 3	BDL	0.01	BDL	BDL	0.27	0.16	2.75	1.90	0.01	BDL
Point 4	BDL	0.01	BDL	BDL	0.14	0.64	9.36	2.43	0.01	BDL
Point 5	BDL	0.01	BDL	BDL	0.13	0.03	1.57	3.93	0.01	BDL
Point 6	BDL	BDL	0.01	BDL	0.10	0.02	0.53	1.24	0.02	BDL
Point 7	BDL	0.01	0.01	BDL	0.28	0.04	1.33	3.84	0.08	BDL
Point 8	BDL	0.01	BDL	BDL	2.38	0.05	5.29	3.81	0.04	0.04
Maximum Acceptable Concentration*	≤0.01		≤0.003		≤5.0		≤0.5		≤1.0	
Maximum Allowable Concentration*	≤0.05		≤0.01		≤15.0		≤1.0		≤1.5	

Note: BDL = below detectable level
*Groundwater Quality Standard for drinking by Pollution Control Department (PCD), Ministry of Natural Resources and Environment

CONCLUSIONS

This research work has investigated environmental pollution that may impact on human health. Soil samples analyzed from locations adjacent and within the dumpsite. Results from the soil samples analysis indicated that heavy metal distribution vary with different depths and distance of the sampling holes from dumpsite. The results showed high levels of heavy metals emanating from the site in particular iron>zinc>copper>lead>cadmium. In dumpsites soils can accumulate more of the heavy metals than surrounding soils where the agriculture lands were located. The values obtained for heavy metal concentrations of soil in this experiment do not exceed the limits for soil quality standards normally stated in LDD’s standard limits. For groundwater resources, the results indicated that they are suitable for domestic purposes which it is presently used this study area but it is not suitable for drinking purpose. Each heavy metal was in permissible levels and each heavy metal was classified as low contamination. Except for iron concentration which was detected to be above the maximum permissible range that were generally not suitable for consumption. Although, the existing concentration of investigated heavy metals in soil and groundwater were below the allowance standards but the open dumpsite may lead to a major risks and impacts on the environment in the future, if the local administrative organization still keeps continue dispose municipal solid waste with open dumpsite type. Therefore, it is necessary actions should be taken as to ensure that future activities not posing environmental contamination and risks to human health.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to the Office of National Research Council of Thailand for financial support. The Faculty of Science and Technology, Rajabhat Pibulsongkarm University is acknowledged for supplying all of the chemicals and equipment needed in this work.

REFERENCES

Agamuthu, P. and Fauziah, S.H. (2010). Heavy metal pollution in landfill environment: A Malaysian case study. 4th International Conference on Bioinformatics and Biomedical Engineering (iCBBE). P 1-4.

Bolan, N.S. and Duraisamy, V.P. (2003). Role of inorganic and organic soil amendments on immobilization and phytoavailability of heavy metals: a review involving specific case studies. *Australian Journal of Soil Research, 41,* 533-555.

Bride, M.B. (1989). Reactions controlling heavy metals solubility in soils. *Advances in Soil Science, 10*, 51-56.

Chulin, R., Geiger, G. and Furrer, G. (1995). Heavy metal retention by soil organic matter under changing environmental conditions in A. Salomons and W.M. Stigliani (ed.) Biogeodynamics of pollutants in soils and sediments. Springer. Berlin. 53–85.

Doberman, A. and Fairhurst, T. (2000). Rice: Nutrient disorders and nutrient management. Potash&Phosphate Institute (PPI). Potash&Phosphate Institute of Canada (PPIC), and International Rice Research Institute (IRRI). Singapore and Los Banos.

Eddy, N.O, Ndibuke, M.O. and Ndibuke, E.O. (2004). Heavy metals in sediment from CrossRiver at Oron. *African Journal of Environmental Pollution and Health, 3*(5), 21-26.

Fauziah, S H., Wan Siti Nurhajar, W I. and Agamuthu, P. (2011). Heavy metal accumulation in Ipomoea reptans and Helianthus anuus. *Malaysian Journal of Science, 30*(1):36-44.

Kriengsit, U. (2009). Municipal solid waste management, public opinion and community participation in municipal solid waste management: A case study of Nai Muang Phichai Municipality, Nai Muang Phichai Sub-district Administrative Organization and Ban Morh Sub-district Administrative Organization, Amphoe Phichai, Uttaradit Province. Bacchelor of Science Degree in Environmental Science, Pibulsongkarm Rajabhat University.

Lee, G.F. and Lee, J.A. (2005). Municipal solid waste landfills - water quality issues. Water Encyclopaedia: Water Quality and Resource Development, John Wiley. NJ, 163-169.

Lombi, E. and Gerzabek, M.H. (1998). Determination of mobile heavy metal fraction in soil. Result of a plot experiment with sewage sludge. Communications in Soil Science and Plant Analysis, *29*, 2545-2556.

Maria, L.A.S., Luís R.F.A. and Luiz R.G.G. (2003). Biosolids and heavy metals in soils. *Scientia Agricola, 60*(4). 793-806.

Mathias, B. and Folkard, A. (2005). Iron toxicity in rice-conditions and management concepts. *Journal of Plant Nutrition and Soil Science, 168*. 558–573.

Mohan, R.N., Chopra, R. and Choudhary, G.C.. (1998). Heavy metals in the groundwater of non-industrial area. *Pollution Research, 17*(2), 167-168.

Mull, E.J. (2005). Approaches toward Sustainable Urban Solid Waste Management: Sahakaranagar Layout. Unpublished M.Sc. Int. Environ. Sci., Lund University. Sweden, 37.

Oyeku, O.T. and Eludoyin, A.O. (2010). Heavy Metal Contamination of Groundwater Resources in a Nigerian Urban Settlement, *African Journal of Environmental Science and Technology*, *4*(4). 201-214.

Palmer, R.G. and Troeh, F.R. (1980). Introductory Soil Science Laboratory Manual, Iowa State University Press, Ames, Iowa.

Panichsakpattana, S. (1997). Soil Pollution from Toxic Use. Kasetsart. 2nd. Bangkok.

Rajappa, P., Manjappa, S. and Puttaiah, E.T. (2010). Monitoring of Heavy Metal Concentration in Groundwater of Hakinaka Taluk, India. *Contemporary Engineering Sciences, 3*(4). 183-190.

Rajgopal, Groundwater quality assessment for public policy in India. (1984). 1st Annual report. Department of geography, IOWA University, IOWA., 10-11.

Stephen A.M., Alex N. and Mark, M. (2012). Zinc Transporters, Mechanisms of Action and Therapeutic Utility: Implications for Type 2 Diabetes Mellitus. *Journal of Nutrition and Metabolism. 10*. 155-167.

Sullivan, J.B. and Kreiger, G.R. (2001). Pollutant fate and transport in the environment. Clinical environmental health and toxic exposures. Lippincott: Williams & Wilkins.

USDA NRCS. (2000). Heavy Metal Soil Contamination. 334-844-4741 X-177, Soil Quality Urban Technical Note No. 3. Soil Quality Institute, United States Department of Agriculture, Natural Resources Conservation Service. Auburn, AL. [cite 2012 Oct 23]. Available from: http://www.aiswcd.org/ IUMPDF/appendix/u03.pdf.

Wallace Labs. (2009). Soil testing offers multiple advantages. [cite 2012 Oct 23]. Available from: http://us.wlabs.com/services/

Zurbrugg, C. (2003). Solid Waste Management in Developing Countries, SWM. [cite 2012 Oct 23]. Available from: www.sanicon.net