HEAVY METALS CONCENTRATION IN GROUNDWATER AROUND THE OLD LANDFILL OF UDON THANI, THAILAND

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Abstract

The aim of this study was to determine the contamination of heavy metals from groundwater in the surroundings of the old landfill site in Udon Thani, Thailand. The sampling points were four wells on different locations of the old landfill. The groundwater was collected during dry season of 2019 to 2021. All the samples were analyzed for three physicochemical parameters, such as conductivity (EC), pH and Total Dissolved Solids (TDS), and were measured on-site using HQ40D multi meter. The results of this study were within the allowable limit: The concentration of heavy metals includes Cd, Pb, Zn, Cu, Mn and Fe using the Perkin Elmer Optima 8000 Series Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES). The analysis indicated that concentration of the heavy metals was mostly below studies detection limit and far below the WHO international best standards. Most of the sites among those showed low enough levels of heavy metal contamination in the groundwater that it would not affect the health of humans and the environment around the landfill.

Keywords: Open Dumpsite, Leachate, Municipal Waste, Heavy Metals

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Introduction

Concerning the situation of community solid waste in Thailand (2020), the amount of waste was approximately 25.4 million tons. From the municipal solid waste (MSW), 10.85 million tons (39%) were disposed of properly according to academic principles and the rest, 7.32 million tons (26%) were incorrectly disposed (Pollution Control Department, 2021). In Thailand, a local government organization is responsible for comprehensive waste management. Most of them are able to provide lots of solid waste collection services which still leave the problem of reducing the garbage. However, there is still a problem of not being very hygienic such as open dumping or open burning (Tanjira et al., 2017), and water resources being drained directly into the seawater (Baun & Christensen, 2004). According to the solid waste disposal, if it was not properly managed, it could lead to various effects such as soil pollution, water pollution, air pollution and health impacts. The major groundwater pollution problem of the landfill is the contamination of heavy metals in leachate. These heavy metals are transported and compartmentalized in the human body through various processes that lead to human diseases (Jarup, 2003; Florea & Busselberg, 2006). Leaching of heavy metals from the landfills have been extensively studied and continuously monitored for a long time. (Aluko et.al, 2003; Looser et al.,1999; Critto et al., 2003; Mitra et al., 2003; Frascari et al., 2004).

Udon Thani province is the third largest city in North East of Thailand and has an estimated population of 1.58 million (2017). The study was conducted at the old landfill called the Banmain Landfill in Naka District. The site is located at 19 km north from the city of Udon Thani. The old landfill is covered a land area of 19.7 acre with open dumpsites technology for MSW disposal. The old landfill was commissioned for use from 1993 to 2003 before it closed and moved to a new location with sanitary landfill technology in 2004. This landfill is an old landfill, which is not designed with a lining and collection system for leachate management. The old and usually uninsulated landfills contain household hazardous waste, the most obvious being processed metals and electronics. From the above properties, leachate in landfills constitute was a major source of contaminants which can contain heavy metals. The liners are important to prevent the heavy metals in leachate from the landfill from contaminating the groundwater aquifer or environment (Sarabian & Rayhani, 2013; Baumann et al., 2006).

The aim of this study was to determine the contamination of heavy metals from the leachate and water quality in groundwater in the surroundings of the old landfill site in Udon Thani, Thailand. This study can be helpful in developing effective treatment technology to stop the contamination of groundwater and to protect human health living nearby the landfills and environment.

Materials and Methods

1. Sample collection

The old landfill site in this study with geographical coordinates 48Q 266878 and 1944257 is located in Naka District of Udon Thani province, N.E. Thailand. (Fig.1). The site is located in the about 19 km north from Udon Thani city, along the 12 Asian Highway, and comprise an area of 19.7 acre. The old landfill was in operation from 1993 to 2003, and has been used as an uncontrolled open system without any engineering operations in the area. Sampling points were collected from 4 wells (ST1-ST4) near the landfill site during the rainy season (July) of 2019 to 2021 (Table 1).

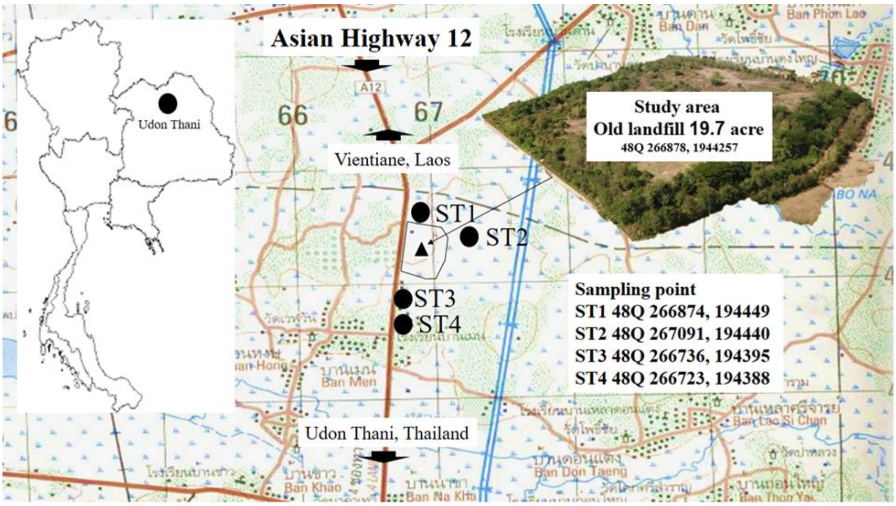

Fig. 1 Position of the studied area and sampling point

Table 1 Sampling point of groundwater well

Sampling point	Distance from landfills (meters)	Coordinates	Depth (meters)
ST1	20	48Q 266874, 194449	75
ST2	77	48Q 267091, 194440	75
ST3	155	48Q 266736, 194395	65
ST4	244	48Q 266723, 194388	65

2. Sample analysis

The field and laboratory procedures were conducted according to APHA et al. (1998). All the chemicals were analytical grade. Groundwater samples were collected in a pre-cleaned polyethylene sample bottle, which were washed using liquid detergent and soaked in 1% nitric acid and then were rinsed with deionized water three times. Groundwater samples were fetched after a pumping period of at least 30 minutes to eliminate immobile water. The samples were collected into polyethylene bottles and fixed with nitric acid conc to a pH < 2.0. The samples were transported to the laboratory and were conserved at 4°C until further analysis. The samples were tested for the occurrence of physicochemical parameters such as conductivity, pH and TDS, and were measured in-site using a HQ40D multi meter.

Each 100 mL groundwater sample was transferred into beakers containing 10 mL of conc.HNO_3. The samples were heated slowly on a hot plate until the volume was reduced to 20 mL. The samples were allowed to cool and 5 mL of conc.HNO_3 was added. Heating was continued with the addition of conc.HNO_3 as necessary until dry. Then 5 ml of HCl solution (1:1 v/v) was added. The samples were warmed and 5 ml of 5 M NaOH was added. The samples were filtered through filter paper to 100 mL volumetric flasks and diluted to the mark with deionized distilled water. After preparation of samples, heavy metal concentrations Cd, Pb, Zn, Cu, Mn and Fe in the groundwater samples were measured using Perkin Elmer Optima8000 Series Inductively Coupled Plasma-Optical Emission Spectrometer (ICP-OES).

Results and Discussion

The physicochemical analysis and heavy metals results in the groundwater sample in the old landfill site during dry season of 2019 to 2021 is presented in Table 2.

pH values of groundwater samples from each of the sample areas obtained for ST1, ST2, ST3 and ST4 ranged from 6.58±0.03 to 7.57±0.04, which clearly indicated that the groundwater in the study area was good water quality, and values were within the permissible range by the Pollution Control Department of Thailand best standards for water quality (Pollution Control Department, 2021). A slightly alkaline value of pH is normally leachate met at old domestic landfills (El-Fadel et al., 2002; Kanmani & Gandhimath, 2013). The pH value of the groundwater sample may be attributed to the presence of some chemical and the biological stabilization of the organism over a period of time, and lost into the soil as carbonates, bicarbonates and anaerobic decomposition, while percolated into the underground soil through rain water (Esmail et al., 2009; Lekanet al., 2019).

EC levels in the groundwater samples varied from 4.62±0.07 to 9.36± 0.02 µs/cm. EC is a valuable indicator of the abundance of dissolved total concentration ions and inorganic species in groundwater (Banar et al., 2006; Yilmaz & Koc, 2014). Low concentration of EC was found in the groundwater samples. The concentration of EC with a lower inorganics component may be due to very little solute dissolution into groundwater.

The concentrations of TDS did not show different values between four groundwater samples sites which obtained ranges of 227±29 to 470±16 mg/l. The TDS could be used as indicators of the total dissolved salt content of water. All the sample sites exhibited values much below the allowable value of 1000 mg/l by the WHO for drinking water. The concentration of TDS indicates the groundwater in the study area is fresh water and clearly not saline (Oyem et al., 2014).

The results of heavy metals for groundwater of old landfill samples site including Cd, Pb, Zn, Cu, Mn and Fe are shown in Table 2. The concentration of heavy metals for all groundwater samples were too low to be detected by the instrument of analysis. Zn concentration at ST1 to ST4 showed low concentration. Each showed levels from 0.11±0.05 to 0.48±0.02mg/l. Meanwhile Fe concentration appeared almost below detection limit with a low concentration at 0.09±0.02 mg/l and 0.01±0.00 mg/l for ST1 and ST2, respectively. Although Zn and Mn contaminations occurred in groundwater, both are below the standard acceptable levels of drinking water determined by international standards. The WHO has a guideline value for Zn and Mn of 3.0 mg/l and 0.4 mg/l, respectively. Apart from them, Cd, Pb, Cu and Fe in the groundwater samples site of the study area were all below detection limit.

Table 2 Analysis of heavy metals in groundwater samples in the studies site during the year: 2019 – 2021

Sample location/ coordinate		Years	parameters			Heavy metal concentration (mg/l)					
			EC (µs/cm)	pH	TDS (mg/l)	Cd	Pb	Zn	Cu	Mn	Fe
ST1	48Q 266874, 194449	2019	8.85±0.12	6.95±0.01	445±16	BDL	BDL	BDL	BDL	0.11±0.02	BDL
		2020	5.87±0.01	6.94±0.02	445±5	BDL	BDL	0.19±0.00	BDL	0.09±0.02	BDL
		2021	8.96±0.01	7.57±0.04	442±23	BDL	BDL	0.11±0.05	BDL	BDL	BDL
ST2	48Q 267091, 194440	2019	5.87±0.01	7.56±0.04	317±15	BDL	BDL	BDL	BDL	BDL	BDL
		2020	6.02±0.01	7.41±0.01	332±11	BDL	BDL	0.20±0.13	BDL	0.01±0.00	BDL
		2021	9.36±0.02	7.43±0.04	470±16	BDL	BDL	0.18±0.00	BDL	BDL	BDL
ST3	48Q 266736, 194395	2019	7.13±0.05	7.35±0.02	442±59	BDL	BDL	0.24±0.16	BDL	BDL	BDL
		2020	7.32±0.01	7.29±0.03	358±19	BDL	BDL	0.16±0.12	BDL	BDL	BDL
		2021	7.54±0.26	7.53±0.05	444±9	BDL	BDL	0.21±0.02	BDL	BDL	BDL
ST4	48Q 266723, 194388	2019	5.22±0.01	6.99±0.04	227±29	BDL	BDL	0.26±0.86	BDL	BDL	BDL
		2020	4.62±0.07	6.58±0.03	247±14	BDL	BDL	0.48±0.02	BDL	BDL	BDL
		2021	5.58±0.12	6.89±0.06	303±7	BDL	BDL	0.29±0.15	BDL	BDL	BDL
WHO (2011)standard			NA	6.5-8.0	500	0.003	0.01	3.0	2.0	0.4	0.3

Note: BDL = below detectable level
NA = No guideline available

ST1, ST2, ST3 and ST4 were located approximately 20 m, 77 m, 155 m and 244 m, away from the old landfill site, respectively. The depth of the groundwater wells varied from 65 m to 75 m. The pattern of sampling points depicting different well depths is presented in Fig. 2. The low concentration of heavy metals in the groundwater samples may be attributed to different depths of wells (Elwali et al., 2008; Othman et al., 2019). The height or depth of the well and the low depth of the groundwater well was another factor/reason enhancing the contamination, because the contamination was into the groundwater of heavy metals through the soil occurs more slowly. (Abhishek et al., 2017).

However, the liner system is installed as a barrier preventing any leachate migrating to the environment and groundwater around the landfill (Farquhar, 1989; Mochamad et al., 2014). In this study, the old landfills do not have the initial design of the landfill site for leachate management, but instead uses clay which as a type of lining systems in the landfill (Salim et al., 1996). This is probably the reason for the low concentration of heavy metals in the groundwater.

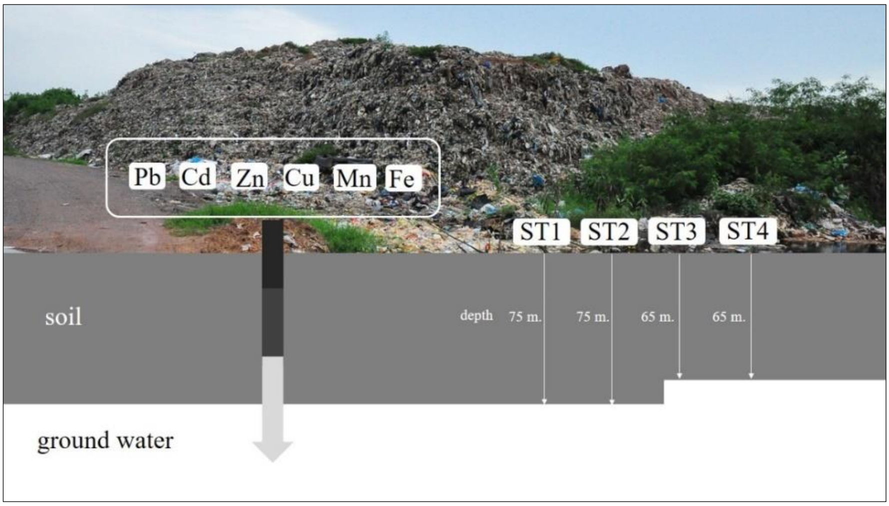

Fig. 2 The pattern of old landfill depicted sampling point at different well depths

Conclusions

The main goal of this study was to assess the physicochemical and heavy metals concentration in groundwater around the old landfill of Udon Thani, Thailand. The samples were collected from four stations around the landfills during the rainy season of 2019 to 2021. The parameters measured were EC, pH and TDS. The results showed that the groundwater samples at this landfill had a low level of contamination, where the concentration of parameters was under the standard acceptable levels by WHO standard. The heavy metals, Cd, Pb, Cu and Fe were below detection limit in all the sampling sites. Zn and Mn were found to be very low as per WHO standard. From these results, the groundwater of the old landfill is still safe for the health of the population and environment. However, the government should continue monitoring the groundwater of this landfill to prevent further contamination to the groundwater.

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