Int. J. Environ. Res., 9(2):457-466, Spring 2015
ISSN: 1735-6865

Leachate and Ground Water Assessment at Kirkuk Sanitary Landfill Site in Zindana Village, Iraq

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Received 6 June 2014; Revised 23 Sep. 2014; Accepted 20 Oct. 2014

ABSTRACT: In Iraq, waste generation was increased after 2003 war events due to intense population development and economic growth. The limitation of designable system for Municipal Solid Waste (MSW) management led to serious problems regarding environment and human health. Sanitary landfill in the south of Kirkuk is the first kind of effective system for municipal solid waste management in Iraq. In the first effort to assess the pollution potential of leachate and its impact on ground water, leachate samples from pre-treatment basin, post treatment basin and leachate pond were analyzed for physico-chemical characteristics (pH, EC, TSS, TDS, BOD, COD, Cl^-, SO_4^{-2}, PO_4^{-3}, NO_3^- and NO_2^-) and heavy metals (Pb, Cu, Mn, Ni and Cd). Similar analysis was done on two monitoring wells around landfill site (MW1, directed leachate pond and MW2 directed landfill site). The leachate pollution index (LPI) was also determined. The results showed that the main concentrations of BOD, COD, SO_4^{-2}, PO_4^{-3}, and NO_3^- in the monitoring well samples are above the permissible limits of WHO standards regarding drinking water quality. It may particularly be due to the impact of leachate outflows on groundwater quality and surface drainage during rainy season. Analytical results of leachate samples indicate the early acidic biodegradation stage of Kirkuk landfill. The high LPI value of 6.651 was recorded for leachate before treatment indicating the role of leachate treatment to minimize the levels of pollutants.

Key words: Kirkuk Municipal Solid Waste, Sanitary Landfill, Ground water quality, Leachate, LPI

INTRODUCTION

Large quantities of solid waste are produced daily as a result of all human activities (fossil fuel combustion, solid wastes generated by municipal, agriculture, industrial and commercial activities). Lack of efficient management for disposal leads to accumulation of large quantities of solid waste in the cities and acts as pollutant since it has an adverse impact on ecosystem and human health (Jha *et al*., 2003; Yadav and Devi, 2000). The first step in waste management is to gain an understanding of waste type generated to facilitate its collection and disposal (Oyelola and Babatunde, 2008). The composition of solid waste is an important issue in waste management; it affects the density of the waste, proposes methodology of disposal and is necessary for examining reuse, reduction and recycle of waste (Al-Khatib *et al*., 2010). The Landfill is the common disposal system for municipal solid waste (MSW) all over the world. In municipal solid waste landfill, wastes both solid and semisolid are biodegraded an aerobically by microorganisms producing gas and soluble chemicals that combine with liquid in the waste to form leachate (USEPA, 2009). Several environmental problems may arise at municipal solid waste (MSW) landfill site causing hazards to human health. The level and quality of leachate and ground water within and around landfill site should be carefully monitored (Mahvi and Roodbari, 2011; Upadhyay *et al*., 2012). Waste degradation in MSW landfill is a complex process, which proceeds by the activity of microorganisms resulting leachate and landfill gas. The type of solid waste, physical, chemical, and biological activities may determine the quality of leachate (Warith, 2003). The composition of leachate is important in determining its potential effects on the quality of nearby surface water and ground water; it may be designed with liners, leachate collection systems, leak detection system and methane collection system (Škultétyová, 2009). Heavy metals are the most dangerous pollutant groups that are occur in leachates and they are able to contaminate water resources (ground water and surface water) close to the landfill sites, make this as one of the most serious environmental concerns. Although some of the heavy metals such as Zn, Mn, Ni and Cu act as micro-nutrients at lower concentrations, they become toxic

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at higher concentrations. In Iraq, large quantity of waste was generated after 2003 due to population expansion and economic growth. According to the Mineral Resources Data System (MRDS), about 0.8 kg of the waste is produced by one person per day in Kirkuk city; so the solid waste is expected to increase from 840,000 tonnes in 2008 to 1,156,445 tonnes in 2020 with high population expansion in Kirkuk city. Lack of effective method in MSW management led to raise serious problems regarding environment and human health. In Kirkuk, however the municipality discarded solid waste in two dump sites, one at east of city (2.5 km from the municipality boundary) and the second site located at the north of city (9 km from the municipality boundary). The waste was accumulated everywhere because these sites were uncontrolled. In an effort to reduce the health risks from accumulated waste in the city, Kirkuk governorate and municipality with the help of U.S. government started the construction of sanitary land fill in 2005 as the preferred way for solid waste management. In addition it is increasing employment and raising awareness of the inhabitants on waste disposal and hygiene. The collection, transfer station 1 and landfill operation were completely run in 2008. The main aim of this study is to get database for Kirkuk sanitary landfill site in terms of leachate characteristics and assess the impact of leachate on the ground water.

MATERIALS & METHODS

Kirkuk city is located in the north east of Iraq governorate, about 236 km away from the capital Baghdad. It is characterized by semi-arid climate with extremely hot and dry summer and cool rainy winter, with rainfall average of 250-320 mm annually. Kirkuk city is one of the rich–oil provinces with a more productive soil. According to the Kirkuk municipality, Kirkuk city may be divided into three regions: habitable region with high populated density, region with a few population densities and industrial and trading region. The population density of Kirkuk city is predicted to increase from 1,050,000 in 2008 to 1,445,556 in 2020 (Sameer *et al*., 2013). Sanitary landfill is the first kind of effective system of solid waste management in Iraq which accept about 1000 tons of waste daily, occupying about 192915 m^2 of area and situated in Zindana village about 18 km from the southern peripheral of Kirkuk city. It started operation in 2008 and estimated lifespan of 10 years based on the amount of waste produced by each person/day. About 10,000 m^3 of rubble and 15,000 m^3 of garbage were removed to landfill outside the city in addition to daily collection of domestic and commercial garbage (Brain, 2008a). Sanitary landfill in Kirkuk city accepts waste of domestic and market origin, rubber tires and consumables. In order to save time and make waste collection and transportation to landfill efficient, two transfer stations (T.S. 1 about 18 km away from landfill site and T.S. 2 about 37 km) are operating and acting as points of waste accumulation all over the city to be transported to landfill site after removing large pieces of metal from the trash for potential recycling (Fig. 1). In Kirkuk city sanitary landfill, the environmental controls include: a liner system composed of a clay layer (0.6m) with hydraulic conductivity of 1×10^{-7} cm/sec and 1.5mm high density polyethylene (HDPE) geomembrane liner. Leachate collection and treatment system comprising of: 0.52m gravel drainage layer, a series of 12 perforated PE leachate extraction pipelines with Non-woven geotextile wrap (gravity drained) and a leachate treatment system which including chemical dosing and aerobic digestion (Brian, 2008a). Environmental

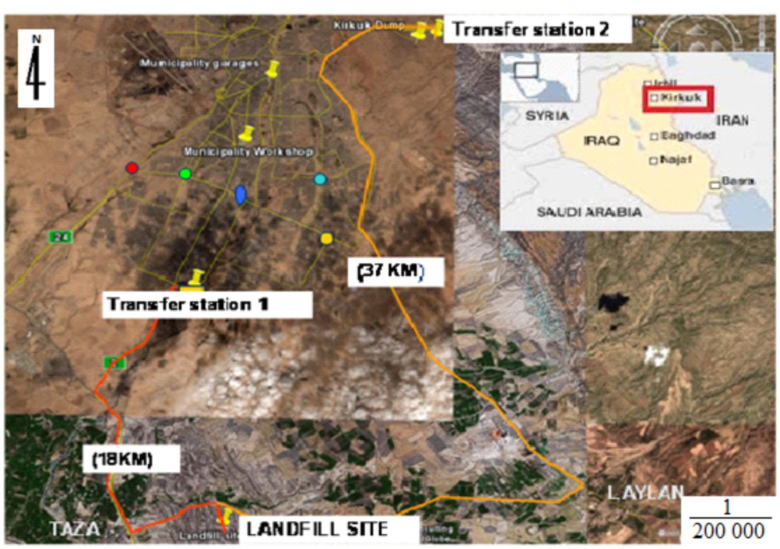


Fig. 1. Kirkuk landfill site and two transfer stations (TS 1 and TS 2)

monitoring should be investigated to find out whether the landfill operates as it designated (if ground water has deteriorated and to determine the degree of pollution occurred). The leachate produced during solid waste decomposition poses serious impact on the quality of surface and ground water near landfill site. In order to investigate ground water quality and efficiency of leachate treatment system, water sampling from leachate (Fig. 2) and monitoring wells (Fig. 3) around landfill site have been collected in 2010. The site specifications for leachate and groundwater samples are listed in Table 1. Samples were collected in pre-cleaned 1L Polyethylene bottles washed with non-ionic detergent and rinsed with de-ionized water before usage. Water quality in terms of parameters pH, Electrical Conductivity (EC), Total Dissolved solid (TDS), Total Suspended Solid (TSS), Biological Oxygen Demand(BOD_5), Chemical Oxygen Demand(COD), Chloride(Cl^-), Sulphate (SO_4^{-2}), Phosphate(PO_4^{-3}), Nitrate (NO_3^-) and Nitrite (NO_2^-) were carried out using the Standard Methods for the Examination of Water and Waste water (APHA, 2003). The pH, EC and TDS were recorded in the site at the time of sampling field with portable digital pH, EC, and TDS meter (HI 9813-6). For the analysis of biological oxygen demand (BOD_5), 300 ml capacity BOD bottles were used according to Azide-modification of Winkler method. Leachate and ground water samples were extracted for heavy metals using hydrochloric acid as digestion reagent and analyzed by atomic absorption spectrophotometer (AAS) (PYE UNICAM Model SP 191). All parameters were analyzed with three replications. All data were expressed as mean ± S.E. and statistical analysis was carried out using statistically available system (SPPS Version 11.5).

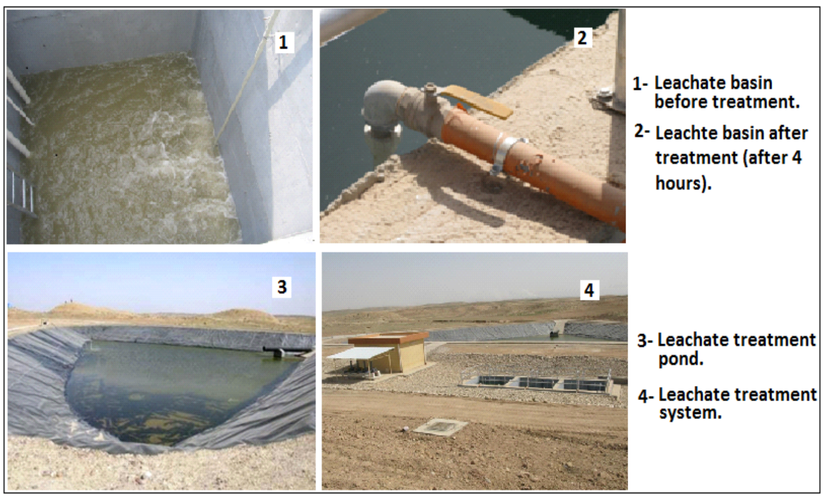


Fig. 2. Leachate treatment system at Kirkuk sanitary landfill

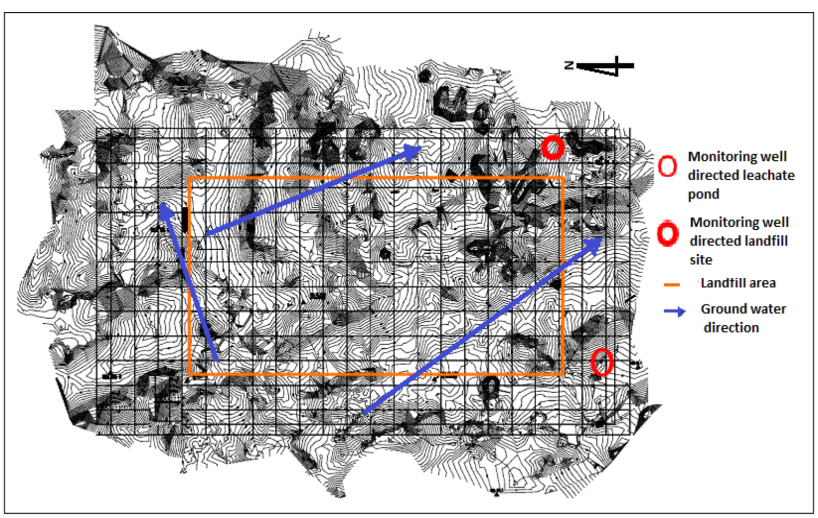


Fig. 3. Monitoring wells and direction of ground water at landfill area (Brian 2008b)

Table 1. Sites Specification for Leachate and Ground water Samples

	Monitoring wells	
sample	**Distance from landfill(m)**	**Depth to water level(m)**
MW1(Directed leachate pond)	120	100
MW2(Directed landfill site)	150	100
	Leachate treatment system	
Pre-treatment	Leachate basin pre treatment	
Post treatment	Leachate basin post treatment(after 4 hour)	
Leachate pond	Leachate treatment pond	
	Monitoring wells	
sample	**Distance from landfill(m)**	**Depth to water level(m)**
MW1(Directed leachate pond)	120	100
MW2(Directed landfill site)	150	100
	Leachate treatment system	
Pre-treatment	Leachate basin pre treatment	
Post treatment	Leachate basin post treatment(after 4 hour)	
Leachate pond	Leachate treatment pond	

The LPI can be calculated using Eqs. 1-3 as described by (Kumar and Alappat, 2005):

$$LPI = \sum_{i=1}^{n} WiPi \quad (1)$$

Where LPI = the weighted additive leachate pollution index, w_i = the weight for the i_{th} pollutant variable, P_i =the sub index value of the i_{th} leachate pollutant variable, n = number of leachate pollutant variables used in calculating LPI, and

$$\sum_{i=1}^{m} W_i \quad (2)$$

However, when the data for all the leachate pollutant variables included in LPI is not available, the LPI can be calculated using the data set of the available leachate pollutants. In that case, the LPI can be calculated by Eq. 3:

$$LPI = \frac{\sum_{i=1}^{n} WiPi}{\sum_{i=1}^{m} Wi} \quad (3)$$

RESULTS & DISCUSSION

Analytical results of Physico-chemical characteristics of leachate and ground water samples were shown in Tables 2-4 and Figs. 4-6, while table 5 shows descriptive statistics for characteristics of leachate and ground water samples in landfill site. The main values of leachate pH samples, ranging from 7.1 to 8.5, were recorded for pre-treatment leachate and post treatment respectively. While the values of 8.2 and 8.5 for monitoring well 1 and 2 (MW1 and MW2) respectively. The groundwater is alkaline in nature due to buffering capacity of Iraqi natural waters which is relatively high in its content of calcium bicarbonate and within the permissible level of WHO (WHO, 2004). However, leachate pH tend to be acidic before treatment due to complex chemical and biological reactions started with burial of waste and referred to aerobic and early anaerobic acid stages (Kjeldsen *et al.*, 2002). The high pH value of leachate post treatment and in leachate pond indicating the efficiency of leachate treatment system (addition of Sodium hydroxide). The electrical conductivity (EC) is an indicator of dissolved inorganic ions. The EC values of Leachate samples were varied from 1505 to 3191 µs/cm recorded for post treatment and pre-treatment respectively. The values of 1443 µs/cm and 1160 µs/cm were presented for MW2 and MW1, respectively. The values exceeding the WHO permissible limit for drinking water. The extremely high values for EC are attributable to high levels of anions and cations (Kale *et al.*, 2010). The Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) ranging from 754 to 2018 mg/l and from 263 to 4065mg/l were recorded for post and pr-treatment leachate samples respectively. The values of TDS and TSS for monitoring wells were within the permissible limit of WHO. The high values of BOD_5 and COD for all leachate samples and monitoring well samples were attributed to degradation of organic compounds of burial waste (Kale *et al.*, 2010; Fatta *et al.*, 1999) .The BOD_5/COD values of 0.37, 0.42, 0.41 were observed for leachate samples, while the values of 0.45 and 0.47 for MW1 and MW2, respectively. The leachate is characterized by high levels of BOD_5 and COD in the early acidic stage of landfill (Jones *et al.*, 2006). The BOD5/COD ratio provides a good estimate of the state of the leachate and this ratio for young leachate is generally between 0.4-0.5 (Kurniawan *et al.*, 2006). The ratio of BOD5/COD depends on the concentrations of acids produce in the early acidic stage, a low BOD5/COD ratio referred to consumption of carboxylic acid and accumulation of humic and fulvic-like compounds (Kjeldsen *et al*., 2002). The high values of BOD_5 and COD in monitoring wells indicate the migration of leachate to ground, contaminating the ground water. It is also possible that raw leachate from the landfills could have flowed directly into the wells through surface drainage during rainy season (Taha *et al*., 2011).

The acidic pH of leachate and high levels of BOD_5 and COD indicated the early acidic stage of landfill. Chloride concentrations in leachate samples were 104, 392, and 131 mg/l, while the values of 178, and 269 mg/l were recorded for MW2 and MW1, respectively. The levels of some inorganic macro components in leachate depend on the stabilization of landfill and the effects of sorption, complexation, and precipitation are minor for these macro components (Kjeldsen *et al*, 2002). The analytical results of Sulphate (SO_4^{-2}), Phosphate (PO_4^{-3}), nitrate (NO_3^-) in groundwater samples were above the WHO permissible limits. High levels indicated the impact of leachate on ground water in addition to the surface drainage during rainy periods (Jalali, 2005; Kale *et al*., 2010). The high values of SO_4^{-2} 366 mg/l and PO_4^{-3} 0.74 mg/l were occurred for leachate samples pre-treatment and leachate pond respectively. High levels of SO_4^{-2} could lead to dehydration and diarrhea. Children are often more sensitive to sulphate than adults (Longe and Balogun, 2010). The levels of Phosphate in the monitoring wells, MW1 and MW2 are 0.23 and 0.39 mg/l, respectively and exceeding the WHO level (0.004 mg/l) and the concentration of 0.25 mg/l was recorded for leachate post treatment indicated the efficiency of leachate treatment minimizing leachate pollutants. However, the level was raised in leachate pond. This may be due to the role of different weather factors as precipitation and surface run off or evaporation. The levels of NO_3^- in the leachate samples were 0.01, 0.11, and 0.14 mg/l for leachate pond, post treatment leachate and pr-treatment respectively, while in groundwater samples its levels is 0.002 and 0.17 mg/l in MW2 and MW1, respectively. In general, the major sources of NO_3^- in groundwater include domestic sewage, run off from agricultural fields, and leachate from landfill sites (kale *et al*., 2010; Jalali, 2005). High levels of NO_3^- in monitoring wells around the landfill indicated the contamination from leachate. High levels of NO_3^- may cause healthy problem related to blue baby disease. The values of Nitrite NO_2^- in monitoring wells around landfill are below the WHO limit.

The samples of leachate and ground water from monitoring wells were analyzed for heavy metals including (Lead (Pb), Nickel (Ni), Manganese (Mn), Copper (Cu), and Cadmium (Cd)). Analytical results of heavy metals are presented in Table 2 and Fig. 6. The values of 0.1, 0.048mg/l and 0.026 mg/l were recorded for Pb in pre-treatment leachate, post treatment leachate and pond leachate samples, respectively while no values were detected for monitoring well samples. For Ni, the highest value of 2.420 mg/l was occurred for pre-treatment leachate sample and the values of 0.138 and 0.152 mg/l were observed for Ni in MW1 and MW2, respectively. Therefore, exceeding WHO acceptable level of 0.02 mg/l. The high values of 2.178 mg/l, 1.250 mg/l, and 0.02 mg/l were presented for manganese (Mn) in leachate pond and for Cu and Cd in pre-treatment leachate samples respectively. For monitoring well samples the values of Mn, Cu and Cd were below WHO limits except for Mn in MW2. The

Table 2. Physico-chemical and heavy metals values in leachate and Monitoring wells samples at landfill site

Samples Parameters (mg/l)	Leachate Pre-treatment	Leachate Post treatment	Leachate pond	monitoring Well MW1	monitoring Well MW2	WHO level
pH	7.10	8.50	8.16	8.20	8.50	6.5-8.5
EC	3191	1505	2523	1160	1443	1350
TSS	4065	263	788	95.0	150.67	-
TDS	2018	754	1960	575.67	717.33	1000
BOD	371	201	352	10	15	3
COD	994	479	851	22	32	-
BOD/COD	0.37	0.42	0.41	0.45	0.47	-
Cl^-	104	392	131	269.0	178.0	250
SO_4^{-2}	366	287	270	605.0	673.0	250
PO_4^{-3}	0.48	0.25	0.74	0.23	0.39	0.004
NO_3^-	6.60	12.40	7.73	15.78	11.88	50
NO_2^-	0.14	0.11	0.01	0.17	0.002	1
Pb	0.10	0.048	0.026	0.000	0.000	0.01
Ni	2.420	0.704	0.605	0.138	0.152	0.02
Mn	1.985	1.374	2.178	0.405	0.579	0.5
Cu	1.250	0.069	0.054	0.040	0.013	2
Cd	0.020	0.003	0.002	0.002	0.002	0.003

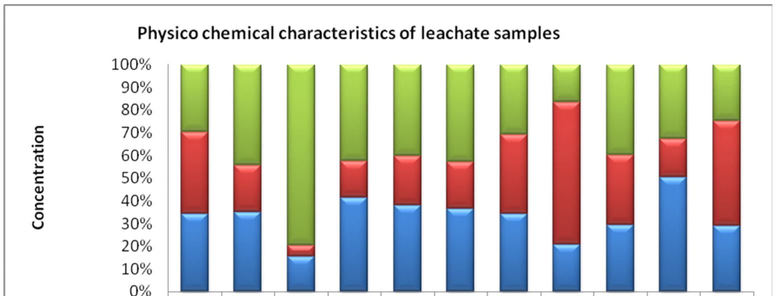
Table 3. characteristics of leachate and ground water samples in landfill site

Sample No	Leachate char.	Mean value			Individual pollution rating *pi*			Weight *Wi*	Overall pollution rating *WiPi*		
		Pre-treatment	Post treatment	Leachate pond	Pre-treatment	Post treatment	Leachate pond	Leachate Samples	Pre-treatment	Post treatment	Leachate pond
1	**pH**	7.1	8.5	8.16	5	5	5	0.055	0.027	0.027	0.027
2	**TDS**	2018	754	1960	7	3	7	0.05	0.35	0.15	0.35
3	**BOD**	371	201	352	12	7	11	0.061	0.732	0.427	0.671
4	**COD**	994	479	851	10	5	8	0.062	0.62	0.31	0.496
5	**Cl^-**	104	392	131	2	5	2	0.048	0.096	0.240	0.096
6	**Pb**	0.10	0.048	0.026	1	0.5	0.5	0.063	0.063	0.032	0.032
7	**Ni**	2.420	0.704	0.605	11	3	3	0.052	0.572	0.156	0.156
8	**Cu**	1.25	0.069	0.054	10	3	3	0.05	0.5	0.15	0.15
	Total							0.441	2.933	1.492	1.978
	$\mathbf{LPI = \sum_{i=1}^{m} W_i P_i / \sum_{i=1}^{m} W_i}$								6.651	3.383	4.485

Table 4. Comparison of Leachate characteristics with the results of other studies

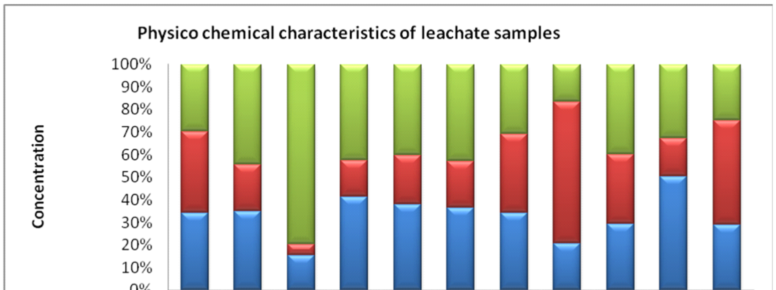
Parameter	**Present study (leachate)**	**Shahrood landfill,iran (Mahvi and Roodbari, 2011)**	**Nigeria, (Salami and Susu, 2013)**	**Pune landfill (India)(Kale *et al.*, 2010)**	**Pune landfill (India)(Kale *et al.*, 2010)**	**Pallikkarani Landfill (Manimekala & Vijayalakshmi, 2012)**	**Perria eria Landfill[(Manimekala & Vijayalakshmi, 2012)**
pH	7.10	7.5-8.5	-	8.33	7.32	7.5	8.08
EC	3191	-	-	99,510	685,400	-	-
TSS	4065	1350-2250	-	-	-	-	-
TDS	2018	1123-17500	-	-	-	16428	6341
BOD	371	-	-	4,122	6891	5193	313
COD	994	250-4852	-	6,834	9200	25975	1189
BOD/COD	0.37	-	-	0.6	0.75	-	
Cl^-	104	-	98	4,485	4764	3253	1987
SO_4^{-2}	366	100-1560	-	796	1024	-	-
PO_4^{-3}	0.48		-	188.6	312.5	-	-
NO_3^-	6.60	55-1211	-	115	55	-	-
NO_2^-	0.14	-	-	-	-	-	-
Pb	0.10	0-0.046	0.010	0.84	0.8	-	-
Ni	2.420	-	0.196	2.05	2.72	0.812	0.432
Mn	1.985	-	0.326	4.15	6.84	-	
Cu	1.250	0-4.98	0.189	0.9	1.47	0.401	0.432
Cd	0.020	0-0.05	0.006	0.93	1.24	-	
LPI	6.651	-	-	19.04	24.67	37.066	15.325

type of soil at Kirkuk city landfill consists of clay and silt that make waste land filling safety and little contamination of ground water as cleared from the results. Similar explanation was reported by (Salami and Susu, 2013; Adermi *et al.*, 2011). High levels of heavy metals in pre-treatment leachate samples indicate that the origin from dumped waste and have decreased post treatment due to the leachate treatment system allowing the heavy metals to be settled down. The traditional method used for leachate treatment in



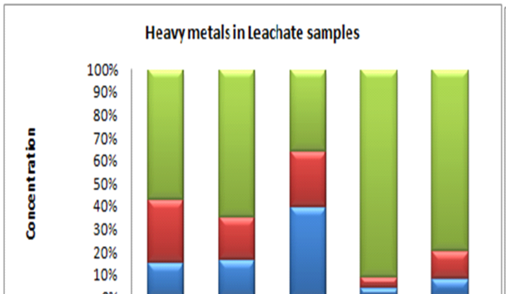
	pH	EC	TSS	TDS	BOD	COD	BOD/COD	Cl-	SO4-2	PO4-3	NO3-
Pre-treatment	7.1	3191	4065	2018	371	994	0.37	104	366	0.48	6.6
Post treatment	8.5	1505	263	754	201	479	0.42	392	287	0.25	12.4
Pond	8.16	2523	788	1960	352	851	0.41	131	270	0.74	7.73

Fig. 4. Physico-chemical characteristics of leachate samples

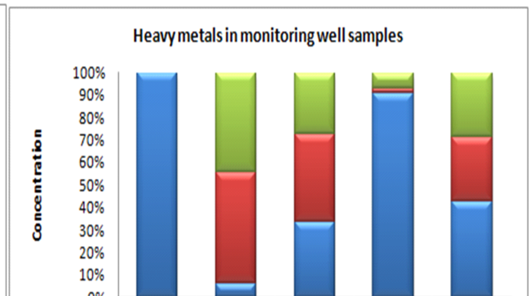


	pH	EC	TSS	TDS	BOD	COD	BOD/COD	Cl-	SO4-2	PO4-3	NO3-
Pre-treatment	7.1	3191	4065	2018	371	994	0.37	104	366	0.48	6.6
Post treatment	8.5	1505	263	754	201	479	0.42	392	287	0.25	12.4
Pond	8.16	2523	788	1960	352	851	0.41	131	270	0.74	7.73

Fig. 5. Physico-chemical characteristics of Monitoring well samples



	Pb	Ni	Mn	Cu	Cd
Pre-treatment	0.1	2.42	1.985	1.25	0.02
Post treatment	0.048	0.704	1.374	0.069	0.003
Pond	0.026	0.605	2.178	0.054	0.002



	Pb	Ni	Mn	Cu	Cd
MW1	0	0.138	0.405	0.04	0.002
MW2	0	0.152	0.579	0.013	0.002
WHO Level	0.01	0.02	0.5	0.5	0.003

Fig. 6. Levels of heavy metals in leachate and monitoring well samples

Kirkuk landfill site is through adding sodium hydroxide to arise leachate pH around 9.5, so that metallic hydroxide compounds precipitate. In order to reduce ammonia hindering the precipitation of metallic hydroxide compounds, ventilation step is done in leachate treatment system. Leachate can contaminate groundwater where landfills are not provided with liners and surface water if it is not collected and treated prior to its discharge. Successful treatment for leachate may decrease the level of contaminants. However, types of waste material and pre-treatment prior to landfilling strongly influenced the pollutant load

(Kumar and Alappat, 2005; Tränkler *et al.*, 2005). A lower levels of Pb (0.07 mg/l), Ni (0.13 mg/l), Cu (0.07 mg/ l), Cd (0.006 mg/l) were recorded in 106 Danish landfills by (Christensen *et al.*, 2001) and concluded that the heavy metals are not considered as a significant pollution problem at landfills, partly because of their low levels in the leachate, and partly because of strong attenuation by sorption and precipitation. In an effort to assess the pollution potential of leachate to contaminate ground water and to assess whether the leachate treatment system is efficient, leachate potential index LPI for leachate pre-treatment, post treatment and in leachate pond was calculated (Table 3). It is a quantitative and comparative measure for the leachate pollution potential and by which the leachate pollution data of the landfill sites can be reported uniformly (Kale *et al.*, 2010; Kumar and Alappat, 2005; Rafizul *et al.*, 2012). –The LPI values of leachate samples were calculated using eight leachate variables as reported in Table 3. The LPI values of 6.651, 3.383, and 4.485 were presented for pr-treatment leachate, post treatment leachate and leachate pond respectively. It was found that the high LPI value of the leachate before treatment was remarkably reduced after treatment. This leads to minimizing the levels of pollutants and the risk of pollution. The high LPI values of 36.48 and 39.04 were reported for the two active landfill sites, Pillar Point (PP) landfill and Shuen Wan (SW) landfill in Hong Kong respectively and indicate that the leachate should be treated. The comparatively lower values of LPI for the active landfill sites are attributable to low concentrations of heavy metals in the leachate. Landfill age also plays an important role in the leachate characteristics and hence, influences the LPI value (Kumar and Alappat, 2005). The LPI value of 37.006 was recorded for the Pallikkaranai landfill in India indicated highly contaminated leachate generated in comparison with the LPI value of 15.325 for Peiya eri

Table 5. Descriptive statistics for characteristics of leachate and groundwater samples in landfill site

Parameters	No.	Range	Minimum	Maximum	Mean	Standard Error	Standard Deviation	Variance
pH	9	1.70	7.00	8.70	7.92	0.22	0.66	0.44
	6	0.8	8.0	8.8	8.33	0.11	0.26	0.07
EC (µs/cm)	9	1731.00	1468.00	3199.00	2401.67	247.43	742.28	550980.25
	6	290.00	1160.00	1450.00	1301.66	63.38	155.26	24106.67
TSS	9	4106.00	240.00	4346.00	1705.33	596.37	1789.11	3200931.00
	6	62.00	94.00	156.00	122.83	12.52	30.66	940.17
TDS	9	1306.00	744.00	2050.00	1577.44	206.10	618.30	382296.03
	6	150.00	570.00	720.00	646.50	31.71	77.67	6033.50
BOD	9	237.00	188.00	425.00	308.22	28.95	86.86	7545.19
	6	5.00	10.00	15.00	12.50	0.45	1.09	1.200
COD	9	600.00	400.00	1000.00	774.89	78.07	234.21	54854.11
	6	10.00	22.00	32.00	27.00	1.15	2.83	8.00
Cl^-	9	385.00	100.00	485.00	220.22	52.24	156.72	24559.69
	6	166.00	154.00	320.00	223.17	28.13	68.90	4747.37
SO_4^{-2}	9	110.00	265.00	375.00	307.55	14.826	44.59	1989.03
	6	75.00	600.00	675.00	639.00	15.27	37.40	1398.80
PO_4^{-3}	9	0.58	0.22	0.80	0.49	0.07	0.22	0.05
	6	0.98	0.05	1.03	0.31	0.15	0.36	0.13
NO_3^-	9	6.00	6.50	12.50	8.89	0.88	2.65	7.03
	6	10.57	10.18	20.75	13.83	1.60	3.92	15.39
NO_2^-	9	0.14	0.01	0.15	0.08	0.02	0.06	0.00
	6	0.19	0.00	0.19	0.09	0.04	0.09	0.01
Pb	9	0.085	0.025	0.110	0.058	0.011	0.034	0.001
	6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ni	9	1.989	0.591	2.580	1.243	0.296	0.889	0.790
	6	0.019	0.136	0.155	0.145	.0033	0.0081	0.000
Mn	9	0.951	1.325	2.276	1.846	0.137	0.412	0.170
	6	0.218	0.400	0.618	0.492	0.043	0.105	0.011
Cu	9	1.290	0.050	1.340	0.457	0.198	0.594	0.353
	6	0.040	0.010	0.050	0.026	0.006	0.016	0.000
Cd	9	0.049	0.001	0.050	0.010	0.005	0.0156	0.000
	6	0.002	0.001	0.003	0.002	0.0003	0.001	0.000

landfill so proper treatment is required (Manimekalai and Vijayalakshmi, 2012). The results obtained by this study indicted clearly that the pollution potential of leachate in Kirkuk landfill site is not high and there is a low risk of leachate migration and contamination of ground water composition of waste, age of landfill site and number of variables included in LPI measure should be considered in comparison to the results for other landfill sites in other places (Table 4).

CONCLUSION

The results obtained from this study indicate that the monitoring that the monitoring wells are downstream directing the leachate treatment system and landfill site; therefore high levels of Sulphate (SO_4^{-2}), Phosphate (PO_4^{-3}), Nitrate (NO_3^{-}), BOD and COD are characteristic of monitoring wells indicating the migration of leachate in to ground water. It is also expected that the leachate could have flowed directly into the wells from the surface drainage during rainy season when the leachate pond is fully filled. According to the information from Kirkuk municipality, soil type of landfill site is dominated by clay and silt, therefore the low levels of heavy metals in the monitoring wells may be attributed to the characteristics of precipitation, complexation and sorption. Characteristics of leachate samples in the term of physic-chemical parameters and heavy metals indicated the early acidic biodegradation stage of landfill site. The difference in the levels of contaminants between the pre-treatment and post treatment leachate samples indicates the role of leachate treatment system in minimizing the levels of contaminants and lowering the risk of leachate contamination the ground water. The operation of leachate treatment system in terms of chemical dosing, ventilation and leachate collection should be controlled and more attention should be given to the land fill management.

REFERENCES

Aderemi, A.O, Oriaku, A.V., Adewumi, G.A. and Otitoloju, A.A. (2011). Assessment of groundwater contamination by leachate near a municipal solid waste landfill. African Journal of Environmental Science and Technology, **5 (11),** 933-940.

Al-Khatib, I.A., Monou, M., Abu Zahra, A.F., Shaheen, H.Q. and Kassinos, D. (2010). Solid waste characterization, quantification and management practices in developing countries. A case study: Nablus district – Palestine Journal of Environmental Management, **91,** 1131–1138.

APHA (American Public Health Association). (2003). Standard methods for examination of water and waste water, 20 th Ed.Washington DC, USA.

Brian, E.C. McCarthy. (2008a). Kirkuk city solid waste management program development, construction and operations.RTI International/Kirkuk Provincial Reconstruction Team, Iraq.

Brian, E.C. McCarty. (2008b). Kirkuk sanitary landfill, operation maintenance and management, local governance program.

Christensen, T.H., Kjeldsen, P. and Kjeldsen, P. (2001). Biogeochemistry of landfill leachate plumes. Applied Geochemistry, **16(7-8),** 659–718.

Fatta, D., Papadopoulos, A. and Loizidou, M. (1999). Astudy on the landfill leachate and its impact on the ground water quality of the greater area. Environmental Geochemistry and Health, **21 (2),** 175–90.

Jalali, M. (2005). Nitrate leaching from agricultural land in Hamadan, western Iran.Agriculture Ecosystems and Environment, **110 (3),** 210-218.

Jha, M.K., Sondhi, O.K. and Pansare, M. (2003). Solid waste management-a case study.Indian Journal of Environmental Protection, **23 (10),** 1153-1160.

Jones, D.L., Williamson, K.L. and Owen, A.G. (2006). Phytoremediation of landfill leachat. Journal of Waste Management, **26 (8),** 825–37.

Kale, S.S., Kadam, A.K.and Kumar, S. (2010). Pawar NJ. Evaluating pollution potential of leachate from landfill site, from the Pune metropolitan city and its impact on shallow basaltic aquifers. Environ Monit. Assess, **162,** 327–46.

Kjeldsen, P., Barlaz, M.A., Rooker, A.P., Baun, A., Ledin, A., Christensen, T.H.1. (2002) ‘ Present and Long-Term Composition of MSW Landfill Leachate: A Review’, Critical Reviews in Environmental Science and Technology, Vol.32 No.4 , pp. 297–336.

Kumar, D., and Alappat, B.J. (2005). Evaluating leachate contamination potential of landfill sites using leachate pollution index. Clean Technologies and Environmental Policy.**7 (3),** 190–197.

Kurniawan, T.A. and Lo, W.H. (2006). Chan GYS. Physico-chemical treatments for removal of recalcitrant contaminants from landfill leachate. Journal of Hazardous Materials, **129 (1-3),** 80–100.

Longe, E.O.and Balogun, M.R. (2010). Groundwater Quality Assessment near a Municipal Landfill, Lagos, Nigeria. Research Journal of Applied Sciences, Engineering and Technology, **2 (1),** 39-44.

Mahvi, A.H. and Roodbari, A.A. (2011). Survey on the effect of landfill leachate of shahrood city of iran on ground water quality. Journal of Applied Technology in Environmental Sanitation, **1(1),**17-25.

Manimekalai, M. B., and Vijayalakshmi, P.(2012) ‘ Analysis of Leachate Contamination Potential of a Municipal Landfill Using Leachate Pollution Index’, IOSR Journal Of Environmental Science, Toxicology And Food Technology (IOSR-JESTFT), Vol.2 No.1, pp.16-39.

Oyelola, O.T., Babatunde, A.I., (2008). Characterization of domestic and market solid wastes at source in Lagos metropolis, Lagos, Nigeria’,African Journal of Environmental Science and Technology, Vol.3 No.12, pp.430-37.

Rafizul, I.M., Alamgir, M., and Sharif, S.M.S. (2012) 'Analysis and Selection of Appropriate Aggregation Function for Calculating of Leachate Pollution Index of Landfill Lysimeter', Iranica Journal of Energy & Environment, Vol.3 No.4, pp.370-79.

Salami, L. and Susu, A.A.(2013) 'Leachate Characterisation and Assessment of Groundwater Quality: A Case of Soluos Dumpsite in Lagos State, Nigeria',Greener Journal of Science, Engineering and Technology Research, Vol.3 No.2 , pp.042-061.

Sameer, S.M., Sameerah, S.M., and Ali, H.M. (2013). Kirkuk municipal waste to electrical energy. Electrical Power and Energy Systems, **44,** 506–513.

Škultétyová, A. (2009). Water Source Protection from Landfills Leachate. International Symposium on Water Management and Hydraulic Engineering Ohrid/Macedonia, 523-532.

Taha, M.R. and Yaacob, W.Z.W. (2011). Samsudin AR, Yaakob J. Groundwater quality at two landfill sites in Selangor, Malaysia. Bulletin of the Geological Society of Malaysia, **57,** 13-18.

Tränkler, J., Visvanathan, C., Kuruparan, P. and Tubtimthai, O. (2005). Influence of tropical seasonal variations on landfill leachate characteristics—results from lysimeter studies. Waste Management, **25 (10),** 1013–20.

U.S. Environment Protection Agency. (2009). Municipal Solid Waste Generation, Recycling and Disposal in the United States Detailed Tables and Figures for 2008, Available from http://www.epa.gov/nscep .

Upadhyay, V., Jethoo, A.S. and Poonia, M.P. (2012). Solid Waste Collection and Segregation: A Case Study of MNIT Campus, Jaipur. International Journal of Engineering and Innovative Technology, **1 (3),** 144-149.

Warith, M.A. (2003). Solid Waste management: New Trends In landfill Design. Emirates Journal for Engineering Research, **8 (1),** 61-70.

WHO (2004). Guidelines for Drinking Water Quality. 3rd Edn. Recommendation, Geneva. 1, pp 515.

Yadav, I.C. and Devi, N.L.(2000). Studies on Municipal Solid Waste Management in Mysore City- A case study. Journal of Report and Opinion, **1 (3),** 21-24.