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Environment

Characteristics of leachate at the Qurain dumping site

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Abstract

Levels of physicochemical parameters and heavy metals were determined in landfill leachate samples from Qurain landfill site. Over twelve month study period (January to December 2003), levels at the Qurain landfill site were: pH 7.8-9.40; total dissolved solids (TDS) 3.59-21.90 mg/l; conductivity 1.83 to 36.50 µs/cm; salinity 1-22.30‰; Cl 0.5-13.63 mg/l ; S 0.1-2.31 mg/l; N 0-6.8 mg/l; P 0.13 to 6.88 mg/l; total carbon 212-4376 mg/l; Ca 14.5-437 mg/l; Cd < 0.05-0.05 mg/l; Co <0.05-0.05 mg/l; Cr 0.05-0.7 mg/l; Cu < 0.05- 0.05 mg/l; Fe 0.1- 9.4 mg/l; Hg 0.1-1.2 mg/l; Mg 0.05-0.17 mg/l; Na 361-4450 mg/l; Ni 0.05-0.28 mg/l; Pb 0.05-0.12 mg/l; Zn 0.05-0.9 mg/l. The study helped to understand the behavior of various pollutants present in the landfill leachate and the extent of pollution. At present, the leachate site may not exhibit any significant accumulation of contamination. However, the results of the study indicate that further long-term monitoring program should be implemented for the Qurain site.

Key words: Heavy metals, leachate, pollution, landfill site, waste.

Introduction

The Qurain landfill site is located about 15 km southeast of Kuwait City, about 1 km from the shoreline (Fig. 1). The total area of the site is approximately 1 km². The site was used as a quarry for natural low-permeability soil locally known as '*gatch'* prior to 1975. Then, the site was used for the dumping of municipal solid waste and demolition and construction materials from 1975 until 1985. The total volume of the waste dumped in 5 million m³ of non-homogenous waste [3]. The hydrogeology of the site indicates that groundwater is located at a 40-m depth. Leachate water is in a discontinuous phase and within the shale between the landfill materials and the lower unlined layer. No information is available on the groundwater quality at the Qurain Landfill [10]. Recently, Kuwait's Environmental Public Authority (KEPA) initiated regulatory action on complaints from residents of Qurain's surrounding residential areas. The leachates draining from the site has possibly impacted the surrounding areas by contaminating both groundwater and the lower aquifer at the site [11]. Contamination of groundwater by landfill is recognized a serious problem in many countries in the world. In Kuwait the problem has not received sufficient attention mainly because the groundwater available at shallow depth is not utilized for drinking purpose [2]. However, the recent strategic master plan now being prepared to utilize the shallow groundwater for landscaping purposes.

In Kuwait, landfilling is the main disposal method for domestic waste. About 90% of all domestic wastes is disposed to landfill and the remaining fraction is recycled [11]. Thus, the problem of waste disposal will continue since the bulk of it disposed in landfills. Most of the landfill sites were used as a quarry for sand and gravels. They have not been properly selected and have no engineering design or planning [3]. It has been reported that a large quality of leachate is produced in the landfill sites due to the domestic waste [1, 4]. Leachate emitted by the landfill is likely to contain various types of pollutants that may enter the groundwater aquifiers in the surrounding areas [13].

The complex chemical and biological reactions that take place in a landfill site make it very difficult to predict the quality of leachate at any given landfill site. Bolton and Evans [6] have shown that the composition of the landfill leachate from the same source as well as from different sources is extremely variable. Landfill leachates often contain high concentrations of toxic heavy metals, and many of these metals can form strong biomolecular complexes. Their presence in even small amounts can have deleterious consequences for both plants and animals. Al-Muzaini and Muslamani [2] investigated environmental pollution from landfill site receiving solid wastes at Sulaibiya, North of Kuwait city, and observed that concentrations of heavy metals, Cd, Fe, Ni, Pd, V and Zn, were higher in downstream wells than in upstream wells. The leachates from the same sites were also found to have genotoxic effect in test systems [5].

An analysis of leachate samples for trace heavy metals (Cd, Cu, Fe, Mn, Ni, Pb, and Zn) from four southern Ontario municipal solid waste landfills led to the conclusion that leachate samples contain high concentrations of alkali and alkaline earth metals as well as chloride ions. Also, the elemental composition and speciation of landfill leachates is affected by high concentrations of Cl and DOC [6]. The subsurface geologic materials, physical and chemical properties of soil, such as humic materials and type of clay minerals, are the most important factors in determining leachate quality [12, 17]. Therefore, determination of the quantity and the characteristics of the leachate is essentially required for designing landfill site suitable control system for the treatment

of the leachate. It is important to find out the chemical characteristics of the leachate, since Qurain landfill site is not equipped with a leachate collection and treatment system.

The objective of the present study was to investigate the level of various pollutants in the Qurain landfill leachate, monitored for one year, and to determine any potential environmental impact. The information obtained from this indicated current situation at the Qurain site and helped the local regulatory agency to develop management program.

Materials and Methods

The Qurain landfill site was chosen for the study. The geology of the site is dominated by sand and limestone which vary in grain size. The moisture content is less than 10% and the content of organic matter comes to about 1% [11].

Fourteen monitoring wells (Nos. 1 through 14) were selected, distributed evenly at the site. The locations of the monitoring wells were chosen to monitor the potential impact of leachate on the groundwater quality and surrounding areas, as shown in Fig 2. Bore holes were installed at fourteen sites for leachate sampling. The pipes used were of PVC and a cemented platform was built at each site. The sampling unit was fabricated using Teflon and stainless steel rope.

Temperature and pH were measured immediately after the collection. The samples were brought to the laboratory and a portion was acidified to be used for the analysis of heavy metals.

Unpreserved samples were analyzed immediately for total dissolved solids, salinity, total organic carbon, chlorine, phosphorus and sulfide. The acidified samples were analyzed for heavy metals using atomic absorption spectrophotometry. The analyses were done according to the standard methods for water and waster [18].

Results and Discussion

The results of physical and chemical parameters are shown in Table 1. The data are reported average values of 14 monitoring wells (borehole) at the Qurain landfill site of samples taken between January to December 2003. The pH ranged between 7.8 and 9.40, highest value being 9.40 at the Bh 3 site. The observed high pH values in the present study are in contrast to the generally reported low pH value for leachates [7, 8, 16]. The observed high pH values of the leachates may be due to the high alkalinity of the Qurain soil. The lowest pH was found at Bh 13 site. This is due to the formation of acetic acid and other organic acids by the acetogenic microorganisms under anaerobic conditions [8, 9].

The concentrations of TDs were 3.54-21.9 g/l. The TDs values were high at sites Bh 3 and Bh 4 and low at site Bh 9. The specific conductivity was extremely high at sites Bh 3 and Bh 4 compared to other sites, indicating the high total concentrations of ionic solutes in leachate samples. The salinity concentrations were high at sites Bh 3 and 4, reflecting the high concentration of elements in leachate samples. The total chlorine concentrations were 0.5-13.63 mg/l. The highest value was observed at site Bh 4 and the lowest one at sites Bh 6, 9 and 13. The observed high chlorine values of the leachates may be because the sampling site has not been subject to reactive transport processes or decay overtime [15]. Sulfide, nitrate and phosphorus values were high also at the Bh 4 site.

Total organic carbon content, 231-4376 mg/l, was high in samples. The variations in the concentration of organic matter may be due to various stages of biodegradation processes [14, 15]. The total organic carbon at site Bh 4 was highest and contributed by inorganic and organic carbon.

The metal concentrations are presented in Table 2. The analysis showed high values for almost all metals analyzed. The values of calcium and sodium were high but were close at the Bh 6 and Bh 12 sites and lower at the Bh 3 and Bh 4 sites compared to other sites. Iron and zinc were found in high concentration at sites Bh 1 and Bh 4. Chromium and manganese were also found in high concentration at site Bh 4. Nickel was found in high concentration at site Bh 1 as compared to other sites. Lead was found at comparable levels at the fourteen sites studied. Cadmium and Cobalt were found at almost the same concentration at all boreholes sites studied. Mercury was found in high concentration at site Bh 13 compared to other sites.

The results show that the leachate of the Qurain site has the presence of conventional pollutants and heavy metals. There are difference in the levels of various parameters at the fourteen sites due to the sluggish movement of the groundwater and water quality. The source of the pollutants can be directly traced to the dumping municipal and industrial wastes. The mismanagement of the site has led to cumulate disposal of all types of wastes, including debris material from building and industrial wastes. Therefore, this study needs to be expanded in winter months when Kuwait experiences rains. Secondly, with only 14 boreholes it was not possible to locate the leachate plume rather it was not sure that all the boreholes intercepted the contaminated water. Therefore, more boreholes are required to be installed at the site as well as at adjoining areas. Thus, our results also suggest that extensive groundwater monitoring and the building of a treatment facility are required to avoid further pollution.

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Table 1. Physical and chemical parameters of Qurain leachate.

Borehole	Parameter								
	pH unit	TDS mg/l	Conductivity µs/cm	Salinity ‰	Chlorine mg/l	Sulfide mg/l	Nitrate mg/l	Phosphorus mg/l	Total organic matter mg/l
1	9.17	16.58	27.60	15.10	3.38	0.33	ND	2.75	1676
2	9.00	8.03	13.39	6.10	0.75	0.10	ND	1.38	652
3	9.40	21.9	36.50	22.30	1.75	0.14	ND	5.50	1445
4	8.91	21.5	36.80	22.60	13.63	2.31	6.88	6.88	4376
5	8.82	14.42	24.90	13.10	3.00	0.25	ND	1.50	1358
6	8.72	10.72	1.83	1.0	0.38	0.03	3.0	0.13	231
7	9.05	8.40	14.03	6.4	3.25	0.29	ND	2.13	1390
8	9.01	13.39	22.30	11.4	1.75	0.15	ND	4.00	1522
9	8.70	3.54	5.99	2.6	0.50	0.10	ND	0.25	212
10	9.01	5.27	8.78	3.8	0.88	0.08	ND	0.38	342
11	8.82	7.05	11.75	5.20	1.38	0.16	ND	1.75	810
12	9.12	9.61	16.01	7.5	0.88	0.10	ND	1.88	315
13	7.80	11.74	19.45	9.6	0.50	0.14	ND	0.38	294
14	9.07	5.36	8.94	3.9	0.75	0.13	ND	0.50	370
Average	8.90	11.29	18.99	9.99	2.34	0.31	0.71	2.10	1071

Table 2. Heavy metals concentration in leachate samples from the Qurain monitoring wells.

Constituent	Monitoring wells No.														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Average
Ca	39.7	38.3	31.7	14.5	30.7	425	376	37	615	1179	38.8	452	155	437	276
Cd	<0.05	<0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Co	<0.05	<0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cr	0.6	<0.05	0.1	0.7	0.38	0.05	0.3	0.14	0.05	0.05	0.1	0.05	0.05	0.05	0.15
Cu	<0.05	<0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Fe	7.4	2.4	2.0	9.4	4.3	0.2	7.1	1.3	3.1	0.1	2.5	0.8	0.7	5.2	2.4
Hg	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	0.4	0.4	0.4	1.2	0.1	0.25
Mg	<0.05	<0.05	0.06	0.05	0.05	0.17	0.1	0.05	0.05	0.05	0.05	0.13	0.1	0.05	0.06
Mn	<0.05	<0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Na	4450	2072	857	1760	3275	361	1965	3172	1002	1634	1860	2872	3242	453	2070
Ni	0.28	<0.05	0.05	0.27	0.2	0.05	0.17	0.12	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Pb	0.12	<0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.1	0.05	0.05	0.05	0.05	0.05
Zn	0.9	<0.05	0.05	0.32	0.4	0.05	0.4	0.4	0.05	0.1	0.05	0.05	0.05	0.05	0.2

NB: All amounts are given in milligrams per litre.

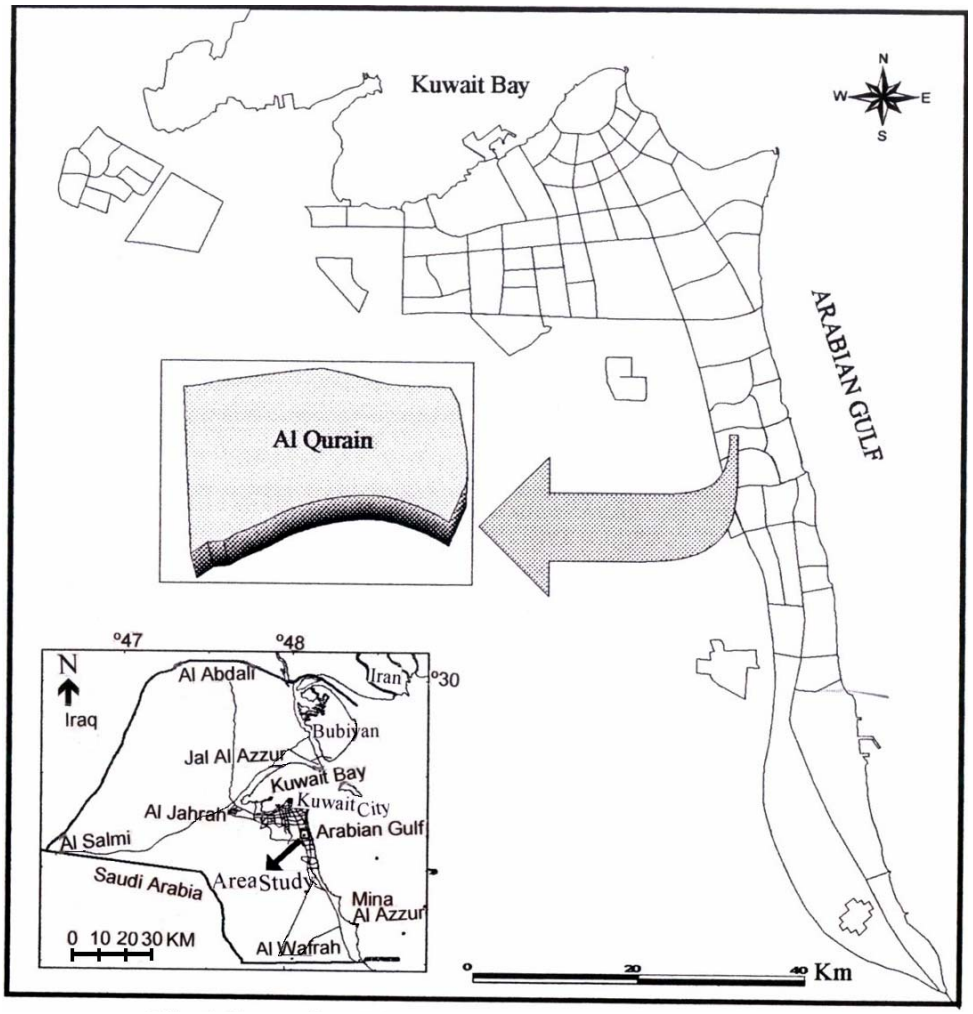

Figure 1. Location Map of the Al Ourain Landfill Site

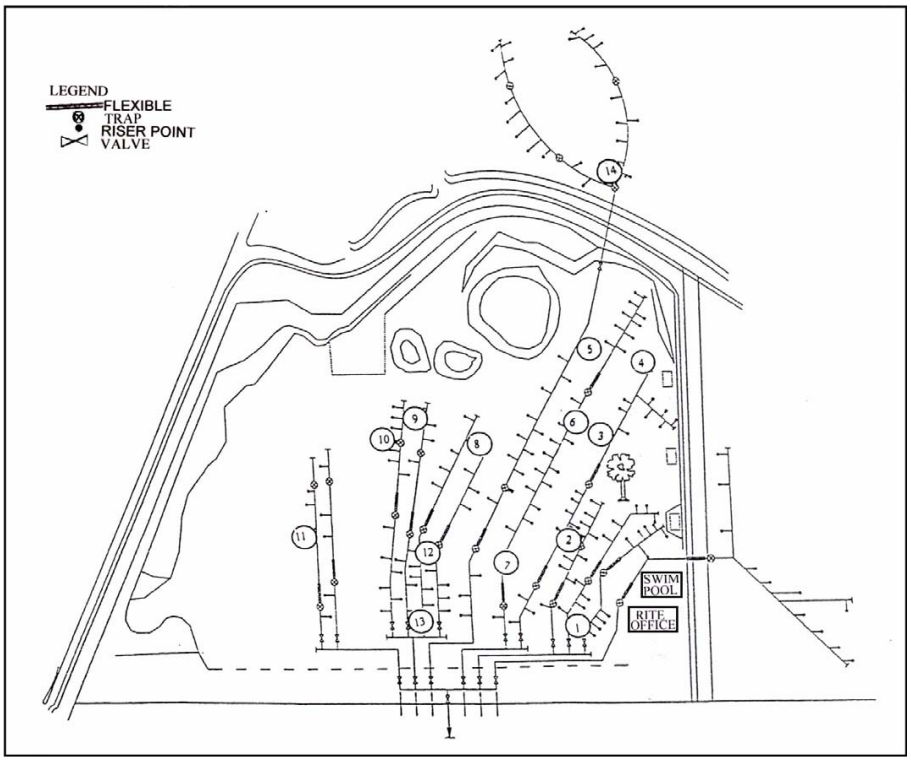

Figure 2. Sampling points