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Geo-visualization of the distribution and properties of landfill gases at Al-Qurain Landfill, Kuwait

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Abstract

The public can benefit when landfills are treated and the potential energy embedded in the landfill gas (LFG) emissions is used or harnessed. This is the situation in Al-Qurain closed landfill, which has been designated as a national park after rehabilitation, treatment and gas utilization. Methane produced by organic decomposition of landfill wastes can be used to produce combustion energy. Methane, hydrogen sulfide, carbon dioxide, oxygen, and hexane are also common pollutants produced by landfill areas that can pollute groundwater, air, and soil, especially when these landfills are close to residential areas. For these reasons, it is very crucial that proper and periodic monitoring of such gases should take place. The sample and readings of LFGs from 25 boreholes in Al-Qurain closed landfill in the State of Kuwait were taken. Measured LFG quantities, velocity, temperatures and GIS mapping of these gases will help shape future efforts to minimize LFG impact on the environment and maximize potential energy production

Keywords: GIS; ground water; landfill gas; Methane; organic waste.

1. Introduction

The State of Kuwait occupies an area of 17,818 km^2 at the northern part of Arabian Peninsula between latitude of 28.30° and 30.05° north and longitudes of 46.33° and 48.30° east. Al-Qurain (Figure 1) closed landfill site (the study area) is at a radial distance of about 20 km south-east of Kuwait City and about 3.5 km from the coastline. The total area of the site is approximately 1 km^2. It contains about 5 million cubic meters (m^3) of buried waste. Prior to the 1970s, the site was natural source for the extraction of impermeable natural soil locally known as gatch. During the 1970s, the site was extensively used for the dumping of municipal solid waste (MSW), demolition and non-categorized waste. This practice continued until 1985.

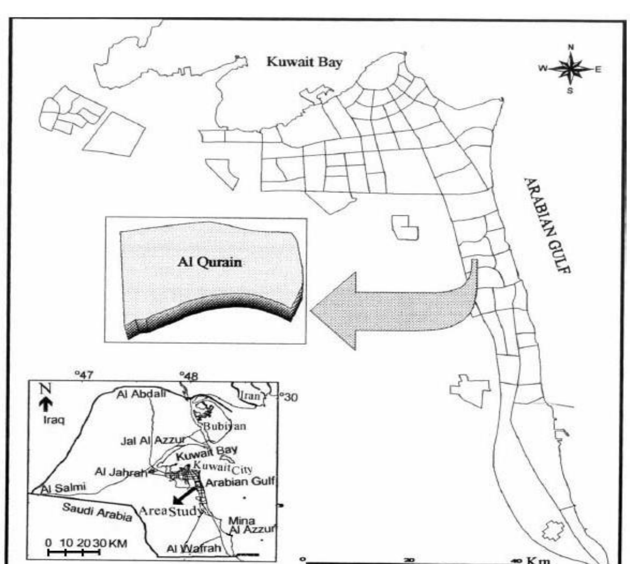


Fig. 1. Location map of Al-Qurain landfill site

The landfill site was utilized without any engineering measures to stop leaching. There was no monitoring of the decomposed gases nor was there any system to collect the gases. Using soil profile computational data from boreholes drilled at the site to depths exceeding 24 m, it was estimated that the volume of dumped waste was approximately 5 million m^3.

By 1989, the residential area of 12,000 houses encroached the edge of the site. The landfill became a nuisance to the inhabitants. The main issue was foul odor from the biodegradation of organic matter, i.e. landfill gases (LFG) composed of methane gas (CH_4) (ranging from 50- 60%) and carbon dioxide (CO_2) (ranging from 3540%-). The data were dependent on the percent by weight of organic matter content (OMC) in the waste. Gas production rates varied from location to location and from time to time. This was due to the a number of variables. First, the composition and thickness of the waste body at the landfill differed in certain areas. Second, water pooled and drained from the site at different rates. These variables affected the rate of maturity of the fermentation process. At Al-Qurain landfill site, the Lower Explosive Limit (LEL) exceeded the flammable and explosive limits of methane when the air mixture was between 5 -15% volume, when it reached the housing area due to lateral ground water migrations.

There are 310 vertical gas wells drilled and housed with PVC pipes down to different depths from 6- 25 m and connected horizontally to one active degassing system. The degassing system consisted of high density polyethylene (HDPE) plastic pipes extending a length of 17 km with vacuum blowers and flare 12 m high at initial stage and later it was connected to electrical generator to produce electricity.

This paper map landfill gases (CH_4, C_6H_{14}, H_2S, CO_2, and O_2) and flow rate in Al-Qurain landfill. Electronic maps were generated representing the distribution of the gases by using Geographical Information System software (GIS). The purpose was to understand contributing factors affecting LFG distribution.

GIS software utilizing Inverse Distance Weighted (IDW) methods was used to map the flow rates of LFGs, the relative composition of LFGs and LFG temperature across the study area. Types of wastes disposes and how were they distributed was not a part of study.

1.1 Landfills in Kuwait and waste management

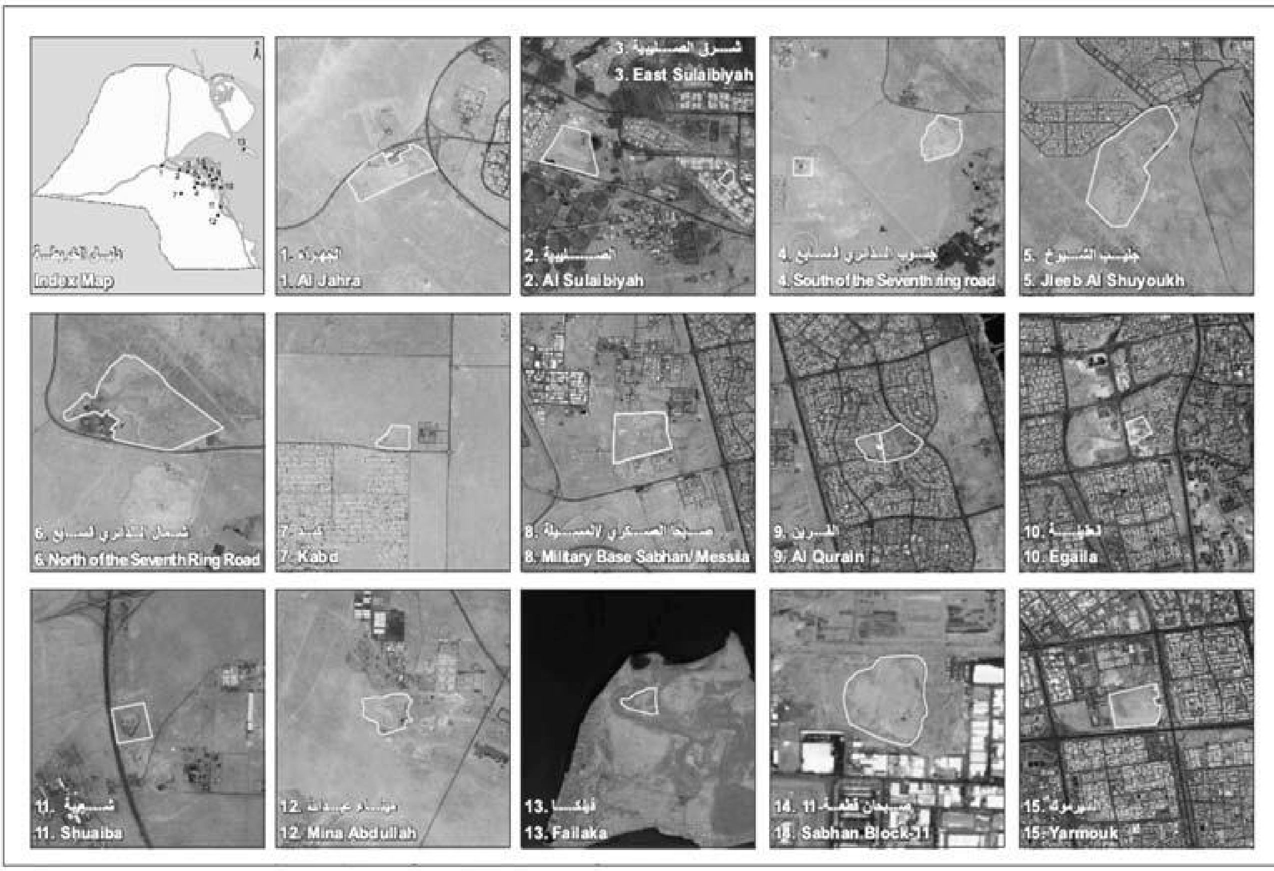
Presently municipal solid waste in Kuwait is disposed of in landfills where gravel and sand queries exist. Unfortunately, the waste is a mixture of household, organic, medical, industrial and construction refuse. There are 18 landfills, of which 14 sites are closed. The four sites still in operation are causing various environmental issues (Figure 2). Landfill sites that are currently in operation are in Mina Abdullah, Al-Jahra, and on Seventh Ring Road (Table 1). Besides the physical trash, landfill sites generate a huge amount of toxic gases (methane, carbon dioxide, hydrogen sulfide, hexane and volatile organic hydrocarbons, etc.) and is plagued by gas emission and spontaneous fires. The closed landfill produced 75- 85% landfill gas, while the open landfill areas produced 67%. This gas outfall contributes to air pollution and groundwater contamination. Severe public health issues are the result. Due to fast urban development, residential areas have expanded to the edges of landfill sites thus causing even more danger to the public. The Al-Qurain landfill (closed landfill), with an area of 1 km^2, was used for dumping of municipal solid waste with total volume of dumped waste being 5 million m^3.

Table 1. List of all landfill sites in Kuwait (Source: Kuwait Municipality 2010)

S. No	Site Name	Waste Type	Filling Period		Status	Depth (m)	Area(km^2)
			From	To			
1	Al Jahra	HH+CD (Stopped) +WW(Stopped)	1986	Till date	Open	>15	1.72
2	Mina Abdullah	HH+CD(Stopped)	1992	Till date	Open	>15	1.15
3	Seventh Road (S)	HH	1992	Till date	Open	>15	4.21
4	Rajem Khashman (South 7th Ring Road)	Medical	1992	Till date	Open	Upto 10	1.00
5	Sabhan Block 11	CD	1980	1986	Closed	Upto 13	0.12
6	Al Shuaiba	HH+CD	1986	1992	Closed	Upto 10	0.13
7	Seventh Road (N)	CD+WW	1986	2005	Closed	Upto 15	4.18
8	East Sulaibiyah	CD	1986	1987	Closed	Upto 5	0.17
9	Araifjan	CD	NA	2009	Closed	Upto 6	0.20
10	Al Yarmouk	CD	2009	2004	Closed	Upto 10	0.42
11	Jleeb Al Shuyoukh	HH+CD	NA	1993	Closed	Upto 27	5.50
12	Al Qurain	HH+CD	1970	1985	Closed	Upto 20	0.71
13	Sulaibiyah	HH+CD	1975	2005	Closed	Upto 15	2.76
14	Sabhan Military	HH+CD	1982	1991	Closed	Upto 20	1.80
15	Failaka	HH+CD	1984	1990	Closed	NA	0.39
16	Al Egaila	HH+CD	NA	NA	Closed	NA	0.11
17	Al Wafra	HH+CD	NA	NA	Closed	NA	0.20
18	Kabd	Poulitry and Cattle Waste	1999	2001	Closed	NA	0.37

Generally, the operating dumpsites are not lined, causing severe contamination to the subsurface geology. Several publications have shown that the water table is affected by leachate. Beside the illegal dumping of solid waste, there are also problems with odor and fire (Al-Sarawi et al. 2006b; Al-Faraj 2005).

Fig. 2. The location of landfill sites in Kuwait (Source: Kuwait Environmental Public Authority)



2. Literature review

Al-Yaqout & Hamoda (2004) conducted a pollutant migration study at Al-Qurain landfill site. Their study suggested that the vertical decay velocity had the greatest impact on migration behavior of the contaminants. Al-Yaqout et al. (2007) studied the characteristics of waste, leachate and gas at landfills in Kuwait. A total of 14 liquid waste samples were collected from different sources at five landfill sites. Al-Sarawi et al. (2006a) discussed the rehabilitation process of the closed landfill in Al-Qurain. This 1 km^2 landfill had a depth of 15 m. The study discussed dangers of uncontrolled gas emissions, contamination and pollution of groundwater and soil that open landfills have on the environment.

Al-Sarawi et al. (2001 & 2006b) discussed the process of waste management in Kuwait. The environmental pollution evident in the groundwater samples and uncontrolled gas fires illustrate the improper handling processes of waste management in Kuwait over the past decade.

Al-Yaqout & Hamoda (2006) examined the solid waste movement at Al-Quran landfill in Kuwait, field experiments were conducted for 6 months to measure soil and water behavior within the landfill using two settlement plates with a level survey access.

Al-Muzaini & Muslamani (1994) conducted an analysis for Landfill leachates at Al-Qurain, Sulaibiya and Jaleeb AI-Shuyoukh solid waste disposal sites. The analysis of samples showed high concentrations of all the chemicals parameters measured, though the levels of heavy metals were low. Al-Tal & Al-Sarawi (2002) wrote the environmental strategy for Kuwait after studying the country's waste management problems. Biotto et al. (2009) studied the illegality of landfills using multiple characteristics and multi factors spatial analysis by using GIS. Hamoda & Zafar (2005) studied the characteristic of waste, leachate and gases in the arid land.

Generally, municipal waste landfill sites works like bio-reactors. Landfill gas (LFG) is a natural byproduct of the decomposition of organic material. Most of the gases are colorless and odorless yet flammable (Table 2). Methane is a potent greenhouse gas with a global warming potential that is about 25 times greater than that of CO_2.

Table 2. Typical Landfill Gas Components

Typical Landfill Gas Components

Component	Percent by Volume	Characteristics
methane	45–60	Methane is a naturally occurring gas. It is colorless andodorless. Landfills are the single largest source of U.S. man-made methane emissions
carbon dioxide	40–60	Carbon dioxide is naturally found at small concentrations in the atmosphere (0.03%). It is colorless, odorless, and slightly acidic.
nitrogen	2–5	Nitrogen comprises approximately 79% of the atmosphere. It is odorless, tasteless, and colorless.
oxygen	0.1–1	Oxygen comprises approximately 21% of the atmosphere. It is odorless, tasteless, and colorless.
ammonia	0.1–1	Ammonia is a colorless gas with a pungent odor.
NMOCs (non-methane organic compounds)	0.01–0.6	NMOCs are organic compounds (i.e., compounds that contain carbon). (Methane is an organic compound but is not considered an NMOC.) NMOCs may occur naturally or be formed by synthetic chemical processes. NMOCs most commonly found in landfills include acrylonitrile, benzene, 1,1-dichloroethane, 1,2-cis dichloroethylene, dichloromethane, carbonyl sulfide, ethyl-benzene, hexane, methyl ethyl ketone, tetrachloroethylene, toluene, trichloroethylene, vinyl chloride, and xylenes.
sulfides	0–1	Sulfides (e.g., hydrogen sulfide, dimethyl sulfide, mercaptans) are naturally occurring gases that give the landfill gas mixture its rotten-egg smell. Sulfides can cause unpleasant odors even at very low concentrations.
hydrogen	0–0.2	Hydrogen is an odorless, colorless gas.
carbon monoxide	0–0.2	Carbon monoxide is an odorless, colorless gas.

Source: Tchobanoglous, Theisen, and Vigil 1993; EPA 1995

3. Methodology

3.1 Determining GPS location

Twenty-five boreholes were randomly selected from over 300 available boreholes in the study area. Using a GPS spectrum device, latitude and longitude information was gathered to locate the boreholes (Figure 3).

Fig. 3. Using GPS to log latitude and longitude data of boreholes

3.2 Measurements of chemical parameters

A gas flow meter was utilized to measure the gas flow. A handheld gas analyzer (GFM) was used to detect the gas types from the randomly selected boreholes. Data collection occurred during the summer of 2015. GFM analysis detected oxygen, carbon dioxide, hydrogen sulfide, methane, and hexane.

3.3 Processing of satellite images

Satellite images were used to identify the study area. The images were taken in 2011 (Figure 4) from a worldview satellite with a spatial resolution of 50cm.

(a) Image displays false color. (b) Image displays true color

Fig. 4. Satellite images of Al-Qurain Landfill Site

The data were analyzed and mapped on the study area map. Utilizing ERDAS processing these near-IR satellite images, the change detection was performed based on the vegetation channeled to red so that it is easy to define the vegetation area and the possible impacts it may have.

3.4 GIS processing and mapping

Arc GIS 10.1 (GIS mapping software) was used to map the study area. The borehole location data gathered by GPS were superimposed on the created map image to build a geo-database.

The large amounts of quantitative data were organized for visual and computer-aided interpretation by representing gases in bar/column/pie charts. The IDW method was selected for geo-visualizing the measured points into an area estimation.

4. Results and discussion

The following is a detailed analysis and interpretation of the data which were collected along the study area. There are 25 boreholes as shown in Table 3.

Table 3. Boreholes locations

N_NAME	Boreholes	Latitude	Longitude
1	55B	48°4'14.76"E	29°13'29.22"N
2	52B	48°4'16.38"E	29°13'28.74"N
3	49B	48°4'14.141"E	29°13'24.458"N
4	82B	48°4'17.58"E	29°13'23.76"N
5	70B	48°4'15.24"E	29°13'26.7"N
6	111B	48°4'17.143"E	29°13'26.71"N
7	91B	48°4'16.14"E	29°13'22.8"N
8	67B	48°4'18.36"E	29°13'20.7"N
9	42.B	48°4'15.66"E	29°13'32.1"N
10	13B	48°4'14.58"E	29°13'33.84"N
11	25B	48°4'13.2"E	29°13'35.52"N
12	1B	48°4'14.94"E	29°13'38.52"N
15	19B	48°4'11.58"E	29°13'37.8"N
13	40B	48°4'13.44"E	29°13'34.8"N
14	26B	48°4'14.014"E	29°13'37.855"N
16	15A	48°4'9.9"E	29°13'31.62"N
17	77A	48°4'9.412"E	29°13'32.64"N
18	NEAR_BOAT	48°4'9.781"E	29°13'34.38"N
19	A33	48°4'7.14"E	29°13'34.32"N
20	PIGEONHOLE	48°4'3.658"E	29°13'33.36"N
21	NEAR_KW_TOWER	48°4'3.666"E	29°13'30.654"N
22	NEAR_THE_PLAY_GROUND	48°4'9.361"E	29°13'29.52"N
23	NEAR_THE_PLAY_GROUND	48°4'9.3"E	29°13'26.4"N
24	13A	48°4'11.52"E	29°13'27.18"N
25	KOC	48°4'11.76"E	29°13'29.22"N

4.1 Distribution of methane gas

There were some main factors responsible for methane generation. First was the total amount of waste (richness in organic matter). Second, was the age of the waste, which is related to the amount of waste landfill annually. In addition, the characteristics of the MSW, including the biodegradability of the waste, also caused methane gas to form.

Methane emissions from landfills are a function of methane generation, as discussed above. The amount of CH_4 that is recovered and either flared or used for energy purposes, and the amount of CH_4 that leaks out of the landfill cover were some of which is oxidized.

The lowest CH_4 gas concentration point at the site was 4.1% located at borehole no. 17. The lowest concentrations were clustered in the southeastern areas of the landfill (Figure 5a and b). While the highest concentration of CH_4 gas was 75% located at borehole no. 16. Higher concentrations of CH_4 gas were clustered more towards the western part of the landfill study area.

This map image was produced in ArcMap using the IDW method. The image shows the distribution of CH_4 in Al-Qurain landfill from the collected data samples. Yellow areas represent the least amount of gas concentration, while dark red areas represent higher gas concentrations. The concentration of the gas was more within the deepest part of the landfill area. It has been affected by the subsurface groundwater flow.

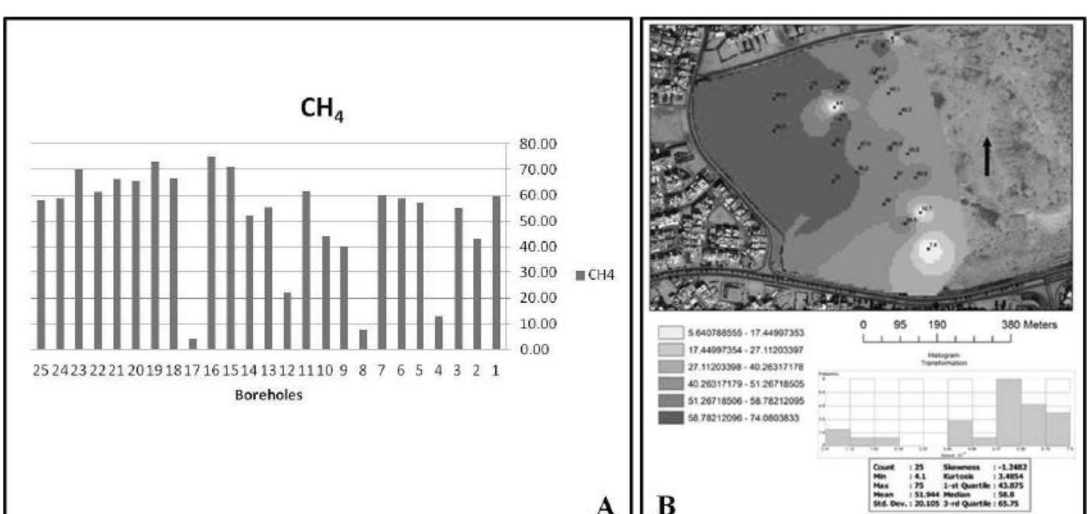


Fig. 5 (a). Values of CH_4 gas for the boreholes in Al-Qurain landfill

(b) Map of estimation of CH_4 gas in Al-Qurain landfill using IDW method

4.2 Distribution of carbon dioxide

Carbon dioxide (CO_2) gas was detected in all samples collected from the 25 boreholes. The highest concentration point was 31% located at borehole no. 5, while the lowest concentration of CO_2 gas was 4.8% at borehole no. 17 (Figures 6a and 6b).

This map shows the distribution of CO_2 in Al-Qurain landfill from the collected data samples. Light blue represents the least amount of gas concentration, while dark blue represents higher gas concentrations. Higher concentrations of CO_2 gas were clustered more towards the eastern part of the landfill study area.

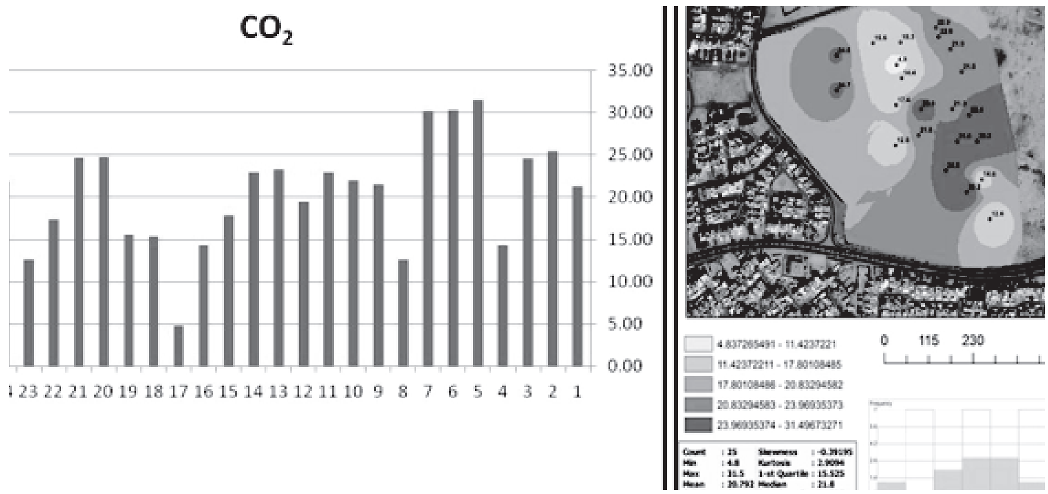


Fig. 6 (a). Values of CO_2 gas for the boreholes in Al-Qurain landfill

(b) Map of estimation of CO_2 gas in Al-Qurain landfill using IDW method

4.3 Distribution of hydrogen sulfide

Hydrogen sulfide gas occurs in some natural gas formations. It is a colorless, highly flammable and explosive gas. It has a rotten egg odor at low concentrations. Hydrogen sulfide (H_2S) may be released during venting, incomplete combustion of flared gas or fugitive emissions from equipment. The latter can be defined as emissions not caught by a capture system.

Hydrogen sulfide gas was detected in all samples collected from the 25 boreholes. The highest concentration point was 100% at borehole no.19, while the lowest concentration was 0% at borehole nos. 1, 2, 3, 4, 8, 9, 10, 17, and 18 (Figures 7a and b).

Figure 7(b) was produced in ArcMap using IDW method. It shows the distribution of H_2S in Al-Qurain landfill from the collected data samples. Light colored areas represent the lowest gas concentrations, while darker colors represent higher gas concentrations. Higher concentrations of H_2S gas were clustered more towards the northern part of the landfill study area.

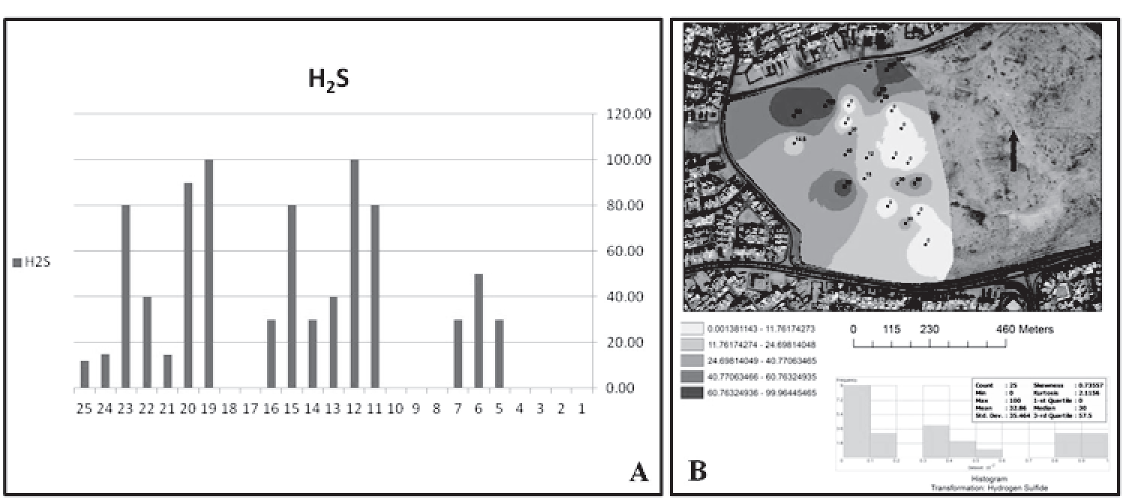


Fig. 7 (a). Values of H_2S gas for the boreholes in Al-Qurain landfill

(b) Map of estimation of H_2S gas in Al-Qurain landfill using IDW method

4.4 Distribution of oxygen

Oxygen gas was detected in all samples collected from the 25 boreholes. The highest concentration point was 13.5% located at borehole no. 17 (Figure 8a and b), while the lowest concentration of hexane gas was 0.0% and located at borehole no.'s(1,2,5,6,9,10,11,12,13,14,15,16,18,19,20,21,22,24, 25).

This map image was produced in ArcMap using IDW method to show the distribution of O_2 in Al-Qurain landfill from the collected data samples. Light colored areas represent the least amount of gas concentration, while darker colors represent higher gas concentrations. Higher concentrations of O_2 gas were clustered more towards the southern part of the landfill study area.

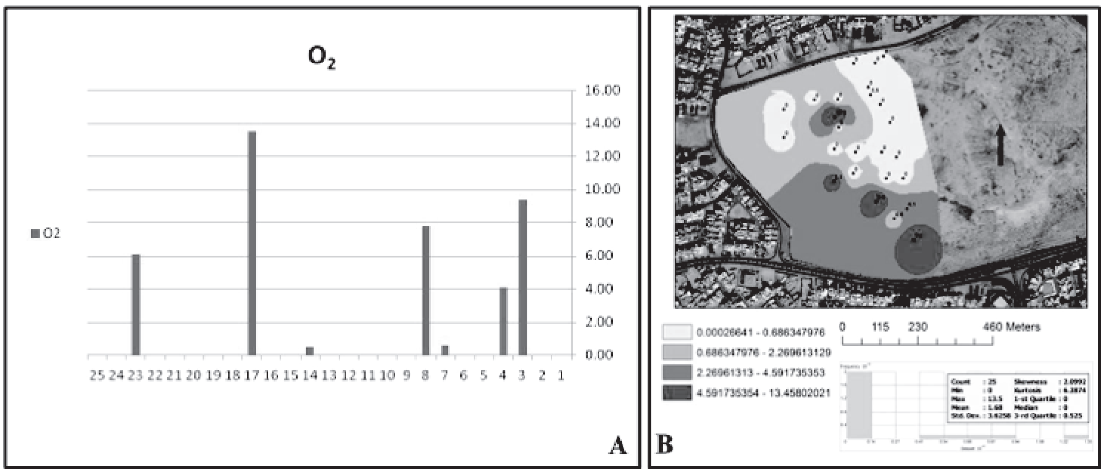


Fig. 8 (a). Values of O_2 gas for boreholes in Al-Qurain landfill

(b) Map of estimation of O_2 gas in Al-Qurain landfill using IDW method

4.5 Distribution of hexane

Hexane gas is released from the landfill with some other hydrocarbons in small portions. However, this gas still has a harmful impact on the environment and people. Van Engelen et. al. (1997) studied the effect of exposure to hexane from a landfill.

Hexane gas was detected in all the borehole samples. The concentrations of this gas were very similar across all areas and never exceeded 1%. The highest concentration point was 0.99% located at borehole no. 16, while the lowest concentration of hexane gas was 0.20% from borehole no. 17 (Figure 9).

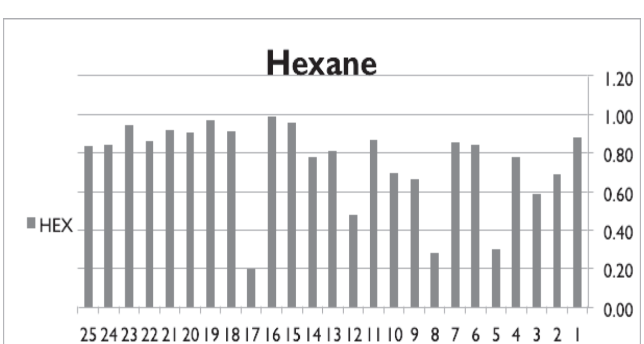


Fig. 9. Values of hexane of gas flow gas for boreholes in Al-Qurain landfill

4.6 Distribution of temperature

Temperature gas was detected in all samples collected from the 25 boreholes. The highest concentration point was 43.5° C located at boreholes 22 and 23. On the other hand, the lowest concentration of temperature gas was 35° C at borehole 1 and 2 (Figure 10a and b).

This map image was produced in ArcMap using IDW method. It shows the distribution of temperature in Al-Qurain landfill from the collected data samples. Light colored areas represent the lowest temperatures, while darker colors represent higher temperatures. Higher temperatures were clustered more towards the northwestern part of the landfill study area.

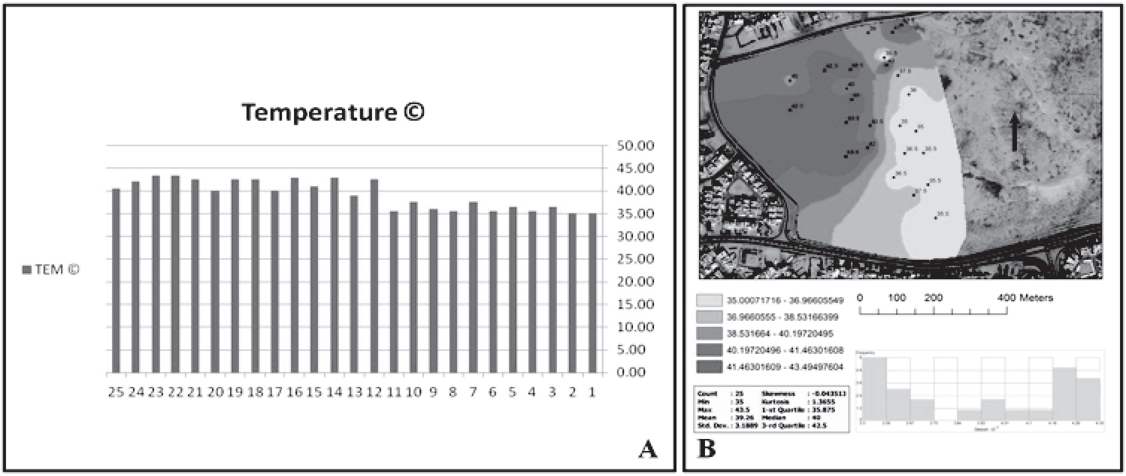


Fig. 10 (a). Values of temperature for the boreholes in Al-Qurain landfill

(b) Map of estimation of temperature gasses in Al-Qurain landfill using IDW method

4.7 Distribution of the velocity of gas flow

Figure 11 illustrates the velocity of the gas flow rate in meters per second (m/s). The highest velocity of gas flow was 5.3 m/s located at borehole no. 18. The lowest velocity of gas flow was 1.0 m/s at borehole no. 1.

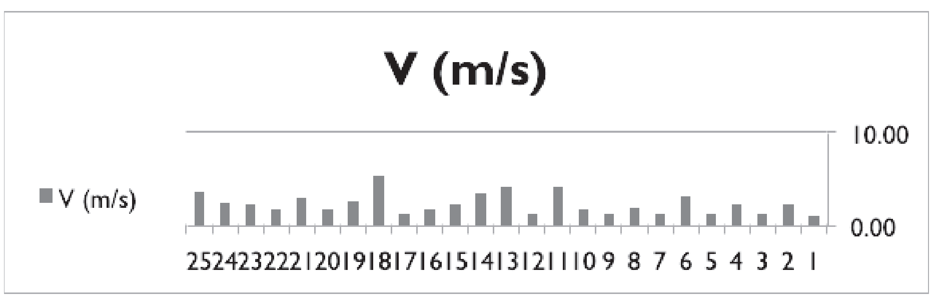


Fig. 11. Values of velocity of gas flow for boreholes in Al-Qurain landfill

The LFG data is illustrated on GIS maps and graphs. Gas velocity, composition, distribution, and temperature were analyzed. Methane gas, the most flammable of the identified LFGs, was most abundant in the northwestern corner of the landfill, which is near residential areas to the north and west sides of the study location.

Hydrogen sulfide gas, the most odorous of the identified LFGs, was clearly more abundant in the northern part of the landfill, which is also very close to the residential areas. Oxygen gas, the most corrosively oxidizing LFG, was most abundant in the southern part of the landfill, also near a residential neighborhood. Figure 4a, the false color satellite image, shows vegetation to be more abundant in the southern the study area, where oxygen is most abundant. Carbon dioxide, a common pollutant and greenhouse gas, was mostly abundant in the eastern part of the landfill, away from neighborhoods but closer to the municipality-controlled area of the landfill.

Gas temperatures were highest in the northwestern part of the landfill near main roads and houses in the area. Hexane gas was produced in minute amounts from the LFG samples. These amounts do not pose an immediate combustion threat.

4.8 Other findings

Blueprints of the old treated landfill show that boreholes still exist outside the borders of the currently identified landfill. These boreholes extend into the western residential zone. This means that there is a risk to residents. Migration of gases might cause further problems to the local residents. In fact, methane gas was detected in some houses, in bathrooms and kitchen areas near sewer outlets.

Table 4. List of chemical parameters observed from boreholes in Al-Qurain landfill

Number	Sample	V (m/s)	TEM ©	ELE	HEX	O_2	CO_2	H_2S	CH_4
1	55 B	1.00	35.00	max	0.88	0.00	21.30	0.00	59.50
2	52 B	2.20	35.00	max	0.69	0.00	25.40	0.00	43.20
3	49 B	1.30	36.50	max	0.59	9.40	24.60	0.00	55.00
4	82 B	2.30	35.50	max	0.78	4.10	14.40	0.00	12.70
5	70 B	1.20	36.50	max	0.30	0.00	31.50	30.00	57.00
6	111 B	3.20	35.50	max	0.84	0.00	30.30	50.00	58.80
7	91 B	1.30	37.50	max	0.86	0.60	30.20	30.00	59.90
8	67 B	1.90	35.50	max	0.28	7.80	12.60	0.00	7.80
9	42 B	1.30	36.00	max	0.66	0.00	21.50	0.00	40.30
10	13 B	1.70	37.50	max	0.69	0.00	21.90	0.00	44.10
11	25 B	4.20	35.50	max	0.87	0.00	22.90	80.00	61.40
12	1 B	1.30	42.50	max	0.48	0.00	19.50	100.00	22.00
13	19 B	4.20	39.00	max	0.81	0.00	23.30	40.00	55.10
14	40 B	3.40	43.00	max	0.78	0.50	22.90	30.00	52.10
15	26 B	2.20	41.00	max	0.96	0.00	17.80	80.00	71.30
16	15 A	1.70	43.00	max	0.99	0.00	14.40	30.00	75.00
17	77 A	1.20	40.00	max	0.20	13.50	4.80	0.00	4.10
18	NEARBOAT	5.30	42.50	max	0.91	0.00	15.30	0.00	66.60
19	33 A	2.60	42.50	max	0.97	0.00	15.60	100.00	73.00
20	pigeonhole	1.80	40.00	max	0.91	0.00	24.80	90.00	65.50
21	near kw tower	2.90	42.50	max	0.92	0.00	24.70	14.50	66.50
22	near the play ground	1.70	43.50	max	0.86	0.00	17.40	40.00	61.10
23	near the play ground	2.20	43.50	max	0.94	6.10	12.60	80.00	70.00
24	13 A	2.50	42.00	max	0.84	0.00	21.80	15.00	58.80
25	KOC	3.60	40.50	max	0.84	0.00	28.30	12.00	57.80

4.8 Relative comparison of chemical parameters

The section presents a comparison between the most abundant gases in the present landfill. First, it was found that the most dominant gases in the landfill were CH_4, CO_2, H_2O, and O_2, small amounts of non-methane volatile organic compounds, polycyclic aromatic hydrocarbons, polychlorinated dibenzodioxins, and dibenzofurans (Figure 12a). These gases were found proportionate to each other and were controlled by the number of organic compounds in the area, moisture content, fermentation rates, and the composition of other waste. Second, it was found that the ratio of CH_4 to CO_2 averaged 3:1. This figure is in agreement with landfills around the world. It indicates that the fermentation process is performing as it should (Figure 12b). The presence of methane gas is a function of the richness of organic matter. Third, the presence of H_2S is related to high moisture with a high sulfate content. It was mostly detected at the boundary of the landfill and the residential area. Hydrogen sulfide is generated faster than methane (Figure 12c). Fourth, oxygen levels were low at this site. It is surmised that this is due to the low permeability of the waste contact and compaction (Figure 12d).

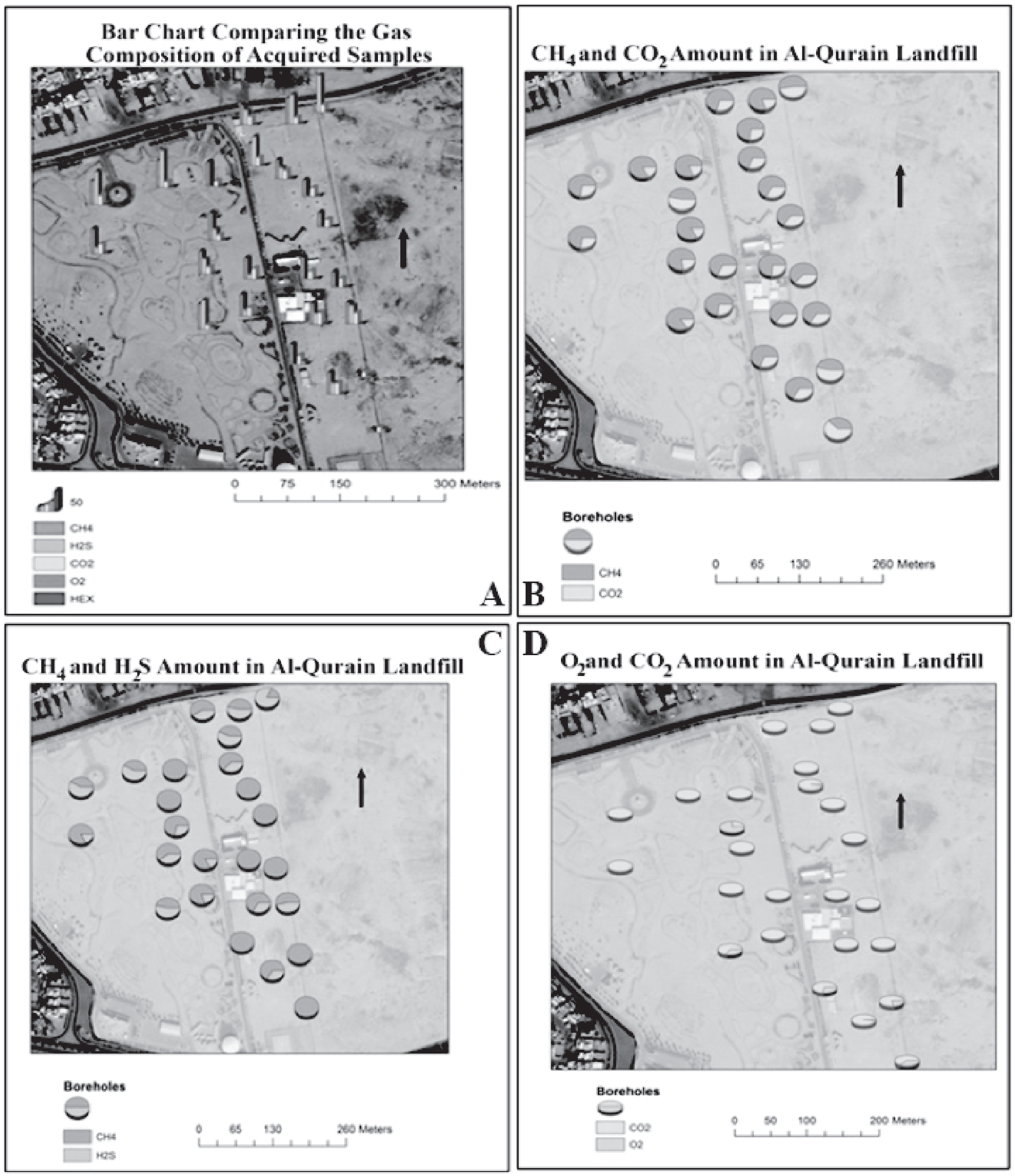


Fig. 12. All gases amount in Al-Qurain Landfill

5. Conclusion

The CH_4 by average volume ranged from 40% to 60% and that of CO_2 ranged from 30% to 40%. The ratio of CH_4:CO_2 averaged 3:1, which is similar to most landfills in the world. It indicates that the fermentation processes is performing as it should. This volume and ratio were adequate and consummate for utilization of landfill gas for the purpose of combustion. The recovery of landfill methane gas from the Al-Qurain landfill is used to generate energy. It is an example of how to lower risks posed from such closed landfill sites near the residential area to people.

From the field survey and data collection of boreholes, continuous monitoring is recommended. Waste to energy is a must. If electricity is not generated, then burning the gas through flaring should be carried out. In addition, gas migration must be controlled as to protect the inhabitants of the area.

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استخدام الأنظمة الجغرافية في التعرف على انتشار وحركة غازات المرادم البلدية في الكويت

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الملخص

تم في الآونة الأخيرة الاستفادة من غاز الميثان المتصاعد من مرادم النفايات البلدية وتحويله إلى طاقة كهربائية. وبالفعل فقد تم تطبيق هذه التقنية في مردم القرين المغلق والاستفادة من الغاز وتحويله إلى طاقة كهربائية وتحويل الموقع إلى حديقة عامة للجمهور. وغاز الميثان ينتج من التفاعلات العضوية المتواجدة في المردم. وهناك غازات أخرى تنتج مع غاز الميثان مثل ثاني اكسيد الكربون وكبريتيد الهيدروجين والاكسجين والهيكسين وكثير من الغازات العطرية الأخرى. ومعظم هذه الغازات تلوث المياه الجوفية والهواء الخارجي والتربة بالإضافة الى أن تلك الغازات تؤثر على المناطق المحيطة بها. وهنا يجب عمل المراقبة الدورية للمرادم المغلقة للحد من تصاعد الغازات السامة والخطرة. وقد تم أخذ (25 عينة) من مردم القرين المغلق لدراسة أنواع الغازات المتصاعدة والحرارة وسرعة الانتقال كما تم عمل مجموعة من الخرائط بالاعتماد على أنظمة المعلومات الجغرافية للتعرف مستقبلاً على حركة الغازات وانتشارها بالموقع .