IOSR Journal of Applied Chemistry (IOSR-JAC)
e-ISSN: 2278-5736.Volume 9, Issue 9 Ver. II (September. 2016), PP 39-46
www.iosrjournals.org

Methane and heavy metals Levels from leachates at Dandora dumpsite, Nairobi County, Kenya

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Abstract: *Rate of urbanization in Kenya has increased, resulting to increased generation of solid and liquid wastes. This has increased the use of landfills and dumpsites to manage wastes as well to reduce pollution. Landfills and dumpsites are the contributing sources of methane into the atmosphere and heavy metals in the environment. This study was to quantify the levels of methane and heavy metals in leachates from Dandora dumpsite, in Nairobi County. Methane and leachates samples were collected from twenty and ten sampling sites representative of the Dandora dumpsite, in a period of six months from November 2012 to April 2013. The sampling periods presented the short, dry and wet rainy seasons. This was to determine the effect of seasons on the level of analytes. Leachates were scooped from ten sampling trenches in Dandora dumpsite to analyse level of heavy metals viz Zn, Cu, Cd, Cr, Ni and Pb. Methane was collected using head space chambers. The levels of zinc metal were highest, at $3.58x10^5$ µg/kg in November and lowest at $4.6x10^4$ µg/kg in April. Levels of lead were also considerably high, ranging from $4.65x10^4$ µg/kg in November to $9.58x10^3$ µg/kg in April. Copper metal levels ranged from $1.61x10^4$ µg/kg in November to $5.57x10^3$ µg/kg in April. Nickel metal levels ranged from $7.92x10^3$ µg/kg in November to $1.18x10^3$ µg/kg in April. Levels of chromium metal were between $7.04x10^3$ µg/kg in March to $1.43x10^3$ µg/kg in November.Cadmium was only found at three sampling sites in December with total mean concentration $9.0x10^1$ µg/kg. The part of dumpsite covered by vegetation, the inactive sites had lowest level of methane. The levels of methane ranged from below detectable level to as high as $3.78x10^6$ µg/kg. Methane flux ranged from $0 \leq 4.89x10^4$ µg C m^{-2} h^{-1}. It was found that the part of the dumpsite covered by vegetation, bear dry ground or/and the inactive site had lowest levels of methane or no methane was detected.*

Keywords: *Dandora dumpsite, selected heavy metals, Leachate. Methane levels*

I. Introduction

High rate of urbanization in Kenya has resulted to increased solid and liquid waste generation and management besides other environmental impacts [1]. Landfills are options employed by many countries in waste management and disposal. Kenya has no landfill in Nairobi, one of its cities [2]. The main municipal solid waste (MSW) dumpsite is located at Dandora. It serves Nairobi County in Kenya. An illegal dumpsite at Kibera manages MSW in that region [3]. Clean air for the ever growing number of residents in the city of Nairobi is scarce due to increased waste generation coupled by poor management which results to environmental impacts [4]. Well managed waste in a city reduces pollution and may be a source of income.

Dumpsite has many adverse effects from its operation. Effects include; off gassing of methane and other gasses like hydrogen sulphide, carbon dioxide, and ammonia which are generated by decaying of organic wastes; pollution of the local environment such as contamination of ground water or/and aquifers by leakage or sink holes [5] and residual soil; injuries to wild life; simple nuisance problems such as odour, dust, noise pollution or vermin; damage of access roads by heavy trucks to the site and harbouring of disease vectors such as rats and flies.

Methane has been found to be one of the air contaminants in landfills or/and dumpsites [6]. It is generated from various substrates due to both chemical and biological reactions in the dumpsite [7]. Methane is one of the landfill gases that are relatively potent greenhouse gas [8]. Other sources of methane are biomass combustion, agriculture [9], fossil fuel production, animal husbandry, rice cultivation [10]. Natural sources of methane are: wetlands, permafrost, oceans, gas hydrates, termites, non-wet land soils, wild fires and fresh water bodies [9]. Energy types and usage, climate, industrial and agricultural production characteristics and waste management practices are some of the factors that determine methane emission levels from the source [11]. Temperature and moisture have a great significant effect on the anaerobic digestion process that causes methane emission in both natural and human-related sources [12].

Global methane levels stayed mostly flat since 1998 and by 2008, it rose to 1800nmol/mol [8]. Methane levels in the Arctic were measured at 1850nmol/mol, in 2010. This level was over twice as high as at any time in the 400,000 years prior to the industrial revolution. Methane's global warming potential is 72 times that of carbon dioxide over 20 years, and 25 times over 100 years [13]. Methane from dumpsites and landfills also causes environmental pollution. At 7% concentration it reduces oxygen to 19.5%, while at 71% concentration oxygen is reduced to fatally low 6% [14].

Methane produces a lot of heat per mass unit (55.7kJ/g) as compared to other complex hydrocarbons. It produces less carbon dioxide for each unit of heat produced compared to other hydrocarbon fuels. Methane as a fuel is more environment friendly, a clean fuel, than fossil fuels such as gasoline, petrol and diesel [7]. Methane can be ignited by minimum spark energy of 0.30mJ [15]. A hot surface or an open flame can ignite methane over a narrow range of concentration (5-15%) in the air [16].

Organic compounds found in leachates are other environmental pollutants [17]. Landfill leachate is that liquid which passes through matter, extract solutes, suspended solids or/and any other component of the material through which it has passed [18]. Generated leachate in a dumpsite and a landfill is the result of the contact of water with solid waste [19]. Leachate from MSW landfills has varied strength as a result of the biological activity occurring when the solid waste degrades [20]. Landfill leachate consists of many heavy metals which may be in aqueous form resulting to water pollution. Mercury is more volatile than other metals [21] hence does not form aqueous solution.

Leachate may contain suspended material associated with waste disposed in the landfill, dissolved matter, as well as many by-products of both biological and chemical reactions [2]. Leachate from young landfills has both high concentrations of organic matter as well as high dissolved solids content relative to domestic waste water [20]. Leachate may contain a trace amount of hazardous constituents found in waste stream [18].

Environmental pollution associated with landfills cannot be overlooked. Inorganic environmental contaminants are mainly metal salts, which originate from various cationic and anionic Metal salts, consisting of various cationic and anionic components of the leachate [22]. Some of metals frequently found in dumpsites or/and landfills are lead (Pb), zinc (Zn), copper (Cu), cadmium (Cd), chromium (Cr) and nickel (Ni) which were assessed [23].

Effects of heavy metals to human health are known. Zinc shortage causes birth defects. Presence of zinc negatively influences the activity of microorganisms and earthworms. This slows down breakdown of organic matter, which lowers the level of methane to be generated [24].

Long term exposure to copper can cause irritation of the nose, vomiting and diarrhea. Effects of copper are manifested in low concentrations [25]. Copper also influences the activity of microorganism negatively [24].

Cadmium is one of the most toxic elements. It is toxic to kidney, can cause bone demineralization, and also cancer [26]. Inhalation of cadmium-contaminated air leads to shortness of breath, lung oedema and destruction of mucous membranes as part of Cd-induced pneumonities [27]. Low dosages of cadmium stimulate ovarian progesterone biosynthesis, while high dosages inhibit it [28].

Nickel is deposited in the kidneys, lungs, liver, heart and testes. The adverse health effects of nickel depend on the rout of exposure. Immediate symptoms are: headache, nausea, vomiting, irritability, vertigo and insomnia. Delayed symptoms include: non-productive cough, cyanosis, visual disturbances, tightness of the chest and sweating [29].

Lead accumulates in the bone, liver and kidney. It has gastrointestinal absorption of 10% and biological half-life of about 20 years. Higher levels of lead reduce haem synthesis and causes anaemia. It also affects nervous system and impairs renal system [27].

Chromium can cause allergic reactions such as skin rash, nose irritations and nose bleeds, kidney and liver damage, upset stomach and ulcers weaken immune systems and respiratory problems. Chromium ends up in air through coal combustion and in soils through waste disposal [25].

Leachates are a potential hazardous waste that should be treated and contained. Untreated leachate can cause pollution to ground water, health problems and greatly affect the environment [18]. Study by Kulikowska and Klimiuki, [2008], shows that effect of leachate composition of heavy metals, dissolved solids and/or liquids, phosphorus (P), chlorine (Cl), sulphates (SO_4^{-2}), magnesium (Mg) and calcium (Ca) depends on season of the year and not landfill age.

II. Methodology

2.1 Area of study

The study area was Dandora dumpsite. It has an irregular shape with an approximate area of about 265000 m^2. It lies between latitude $1^0$15.10'S to $1^0$14.40'S and longitude $36^0$53.30'E to $36^0$54.10'E. It is an open dumpsite surrounded by the estates: Dandora, Mathare, Kariobaghi, Luckysams and Huruma (Figure 1).

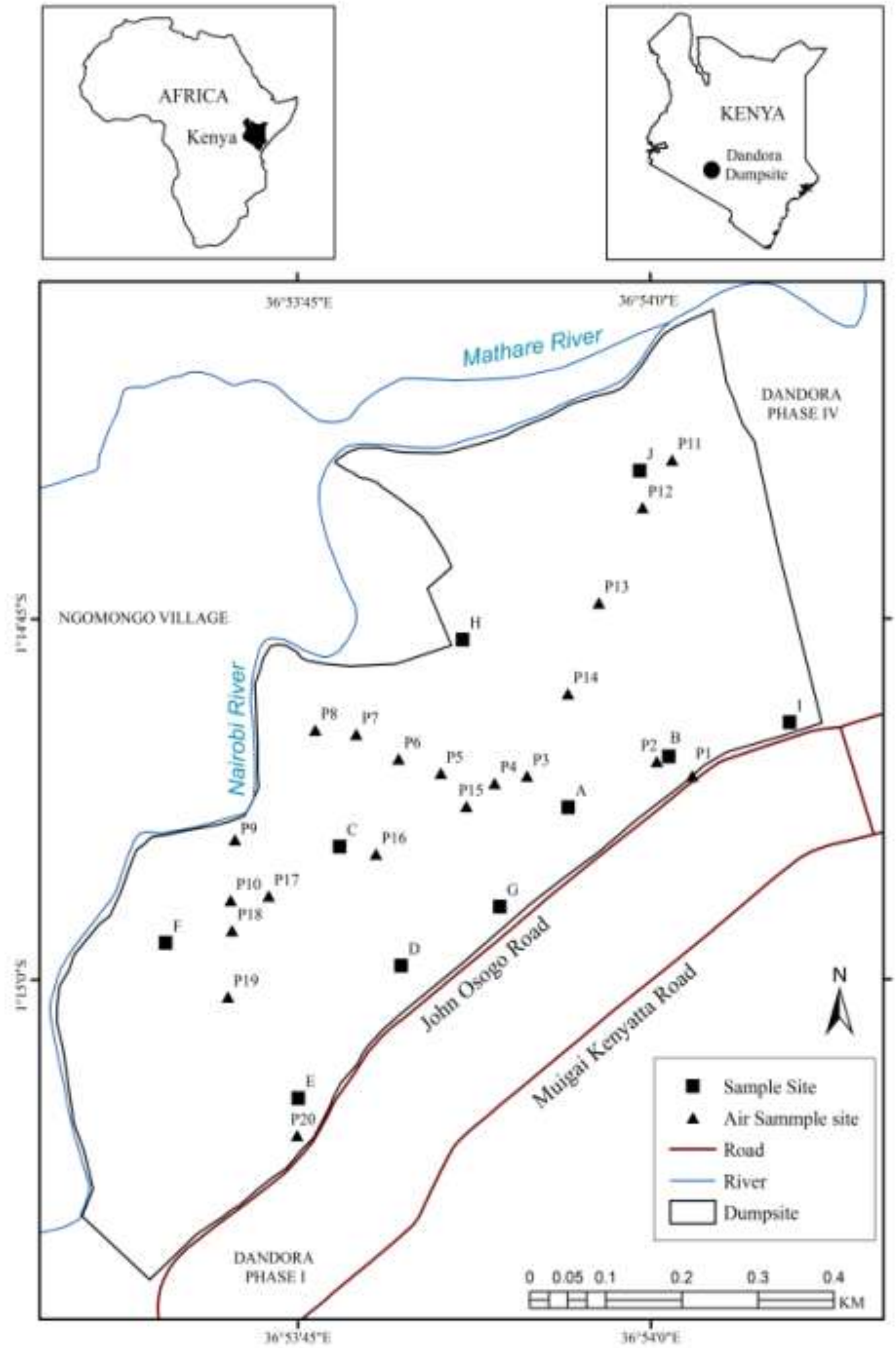

Figure 1: Map of Dandora dumpsite showing the sampling sites for leachates and the air-sample for methane

2.2 Leachate sampling, digestion and analysis

Ten sampling trenches were made and marked as A, B, C, D, E, F, G, H, J and K (Figure1). The trenches were 0.4 metre deep, 0.4 metre wide and 0.4 metre long. This gave leachate/0.064m^3. Leachates were collected from ten sampling points for six months, November 2012 to April 2013. Stainless shovel was used to scoop 50g leachate/0.064m^3 samples. The sample leachates were mixed well and placed in labelled self-seal polythene bags. The bags were placed into bigger labelled self-seal polythene bags for transport to the laboratory and kept into the freezer at University of Nairobi's Chiromo campus waiting for analysis. Samples collected in the months of November and December 2012, represented the short rain season. Samples collected in January and February 2013, was representing dry season while samples collected in March and April were for rain season.

The leachates were digested using concentrated nitric acid (69%), at a temperature of 105° C for 30 minutes. The digests were allowed to cool and filtered into a 50 ml volumetric flask, through double Whatman filter papers. Quantitative analysis of the heavy metal ions in the leachate was done by atomic absorption spectrometer technique. Heavy metals analyzed were: copper, zinc, chromium, cadmium, nickel and lead.

2.3 Methane sampling and analysis

Air in Dandora dumpsite was collected using head space chambers, at an interval of seven minutes for 21 minutes per sample for a period of fourteen days. There were twenty sample points, labelled P_1 to P_{20} (Figure1). The samples were collected between 9:00 and 17:20 hour local time in Kenya. T_1 is the time when the gas was collected at point one (P_1), etc. Head space chambers were installed into the ground to trap generated gas at points P. Three head space chambers were installed at a distance of five metres from each other, in triangular set up, in the dumpsite. Twenty cubic centimetres of air samples were drawn from each of the three chambers using a needle fitted onto a syringe. The samples collected in a pool had a volume of 60 cm^3 per point. A labelled vial was cleaned using 40 cm^3 of the collected sample while the remaining amount, 20 cm^3, in the syringe was transferred into the vial. Vials were placed in a box and transported to the laboratory at ILRI for analysis, within five days.

Samples were removed from vials using a needle fitted onto the syringe and injected into the Gas chromatograph machine. Analysis was done by Gas Chromatography with flame ionization detector.

III. Results and discussions

3.1 Selected heavy metal ions in the leachate

The lead metal ions in the leachate were detected in concentration range of BDL (below detectable limit) to 7.62x10^3 µg/kg (Table 1)

Table 1: Lead concentration (x10^3 µg/kg) metal ions in the leachates from Dandora dumpsite

Site/Month	November	December	January	February	March	April
A	4.20±0.196	5.24±0.243	1.72±0.721	2.55±0.55	1.01±0.014	0.80±0.799
B	5.86±0.859	5.30±0.96	2.88±0.875	3.26±0.257	1.04±0.04	0.95±0.947
C	3.95±0.947	4.93±0.927	2.12±0.115	2.34±0.336	2.79±0.785	0.96±0.964
D	4.20±0.204	7.62±0.616	3.28±0.284	2.96±0.958	1.52±0.516	1.14±0.14
E	4.97±0.966	5.37±0.366	2.04±0.044	2.40±0.387	1.14±0.14	1.39±0.391
F	4.33±0.327	4.90±0.885	1.60±0.585	3.09±0.085	0.99±0.99	1.06±0.062
G	4.67±0.67	6.39±0.391	1.90±0.895	2.43±0.434	096±0.962	0.48±0.483
H	4.70±0.696	BDL	1.03±0.03	BDL	0.50±0.502	0.22±0.216
J	4.79±0.786	2.98±0.977	1.63±0.632	3.47±0.471	0.89±0.887	0.96±0.957
K	4.06±0.064	3.76±0.759	1.02±0.024	0.53±0.527	0.49±0.491	1.62±0.623
∑ mean concentration	45.73±5.7	46.49±6.09	19.22±4.19	23.03±3.99	11.33±5.33	9.58±5.55

Concentration = mean ± S.D, BDL = below detection limit, N = 5

Mean concentration of lead metal ions per was highest in point in December (4.65x10^4 µg/kg) and lowest in April (9.58x10^3 µg/kg).

Major sources of lead in our environment are: lead paint, water distribution systems, food, gasoline and lead used in tableware such as toys, ceramic dishes, decorated drinking glasses, furniture and bean pots [27]. Maximum limit for lead in drinking water is 1.50x10^1 µg/kg (1.50x10^{-2} mg/L) according to maximum advisable limits set by International Organizations [30]. Results show higher concentration value because of wide use of lead resulting to very high exposure. The copper metal ions in the leachate were detected in the concentration range of BDL to 6.25x10^3 µg/kg (Table 2).

Table 2: Copper concentration (x10^3 µg/kg) in leachates from Dandora dumpsite

Site/Month	November	December	January	February	March	April
A	1.91±0.906	1.29±0.285	0.89±0.885	0.64±0.038	0.52±0.017	0.22±0.023
B	1.73±0.727	1.09±0.091	1.11±0.111	1.03±0.028	0.31±0.314	0.20±0.204
C	3.18±0.168	1.21±0.206	0.79±0.792	0.59±0.592	0.91±0.905	0.16±0.164
D	1.33±0.329	2.59±0.087	1.92±0.919	1.94±0.937	0.47±0.474	0.90±0.901
E	1.66±0.662	1.19±0.187	0.86±0.863	0.62±o.622	0.36±0.363	0.45±0.449
F	1.16±0.111	1.50±0.501	0.61±0.614	0.75±0.751	0.32±0.457	0.66±0.712
G	1.40±0.001	1.75±0.754	0.57±0.579	0.61±0.624	1.42±0.423	0.21±0.312
H	1.42±0.423	BDL	0.50±0.504	BDL	0.17±0.173	0.10±0.114
J	1.21±0.207	0.87±1.873	0.74±0.004	6.25±0.165	0.21±0.551	0.22±0.221
K	1.05±0.006	1.47±0.003	0.45±0.446	0.77±0.774	0.97±0.932	2.45±0.448
∑mean concentration	16.05±0.62	12.96±0.66	8.44±0.43	13.2±1.80	5.66±0.40	5.57±0.71

Concentration = mean ± S.D, BDL = below detection limit, N = 5

Mean concentration of metal ions per point in the six months were: November had the highest level 1.61x10^4 µg/kg and lowest level in March 5.66x10^3 µg/kg. Sources of copper to environment include copper pipes, copper wires for connections, brass and bronze faucets [25]. Results show higher level of copper in the leachate due to its wide use in industries and in homes. Some of the uses of copper are: making coins and ornaments, making German silver and bronze, making brass, making electrical wires and contacts in switches, soldering instruments, making plugs and sockets. The zinc metal ions were generally the highest in the six months. They were detected in the range from BDL to 6.48x10^4 µg/kg (Table 3).

Table 3: Zinc concentration (x10^3 µg/kg) in leachates from Dandora dumpsite

Site/Month	November	December	January	February	March	April
A	31.7±0.171	32.4±0.433	12.4±0.426	19.6±0.611	3.10±0.124	2.90±0.912
B	36.6±0.643	28.8±0.844	25.0±0.001	21.2±0.224	4.5±0.543	4.4±0.441
C	31.0±0.002	29.0±0.032	22.3±0.333	11.4±0.441	23.2±0.211	1.3±0.258
D	29.2±0.203	64.8±0.822	27.0±0.004	17.5±0.481	10.5±0.544	2.8±0.811
E	26.5±0.501	28.4±0.395	17.1±0.111	10.4±0.444	4.9±0.912	4.0±0.003
F	41.2±0.212	31.8±0.801	17.9±0.933	19.3±0.303	6.5±0.521	2.4±0.413
G	51.4±0.403	31.6±0.622	17.7±0.732	15.4±0.356	5.0±0.044	2.2±0.222
H	32.6±0.622	BDL	4.7±0.721	BDL	4.5±0.491	1.8±0.764
J	45.8±0.811	38.6±0.603	16.6±0.582	33.0±0.002	7.5±0.452	8.0±0.004
K	32.4±0.402	55.2±0.204	4.1±0.095	4.1±0.134	2.8±0.823	16.2±0.174
∑ Zinc	358.4±7.92	340.6±17.23	164.8±7.67	151.9±9.35	72.5±6.04	46±4.50

Concentration = mean ± S.D, BDL = below detection limit, N = 5

Their mean level for six months were: November 3.58x10^3 µg/kg, December 3.41x10^3 µg/kg, January 1.65x10^4 µg/kg, February 1.52x10^4 µg/kg, March 7.26x10^3 µg/kg and April 4.60x10^3 µg/kg. Zinc is used widely as a protective coating to prevent corrosion, for electrical apparatus, household utensils, castings, printing plates, building materials, car-lining and many others [21]. Old items are disposed which results to the highest concentration in the leachate. The nickel metal ions concentration in the leachate was found in the range of 3.00x10^0 µg/kg to 1.25x10^3 µg/kg (Table 4).

Table 4: Nickel concentration (x10^3 µg/kg) in leachates from Dandora dumpsite

Site	**November**	**December**	**January**	**February**	**March**	**April**
A	1.25±0.246	0.67±0.073	0.52±0.024	0.31±0.012	0.42±0.024	0.10±0.009
B	0.87±0.072	0.32±0.015	0.58±0.076	0.28±0.079	0.36±0.055	0.03±0.031
C	0.66±0.058	0.52±0.021	0.50±0.003	0.14±0.041	0.53±0.026	0.10±0.001
D	0.87±0.069	0.45±0.048	0.84±0.037	0.22±0.018	0.59±0.088	0.03±0.025
E	0.78±0.084	0.33±0.029	0.40±0.004	0.10±0.003	0.38±0.076	0.12±0.016
F	0.71±0.008	0.47±0.071	0.59±0.088	0.30±0.001	0.20±0.004	0.03±0.026
G	0.79±0.093	0.54±0.043	0.33±0.034	0.26±0.056	0.25±0.053	0.15±0.052
H	0.79±0.085	0.18±0.077	0.30±0.002	0.12±0.017	0.27±0.067	0.18±0.081
J	0.62±0.022	0.65±0.047	0.45±0.046	0.64±0.035	0.28±0.075	0.15±0.053
K	0.58±0.076	0.76±0.062	0.29±0.091	0.11±0.014	0.13±0.028	0.29±0.092
∑ **Nickel**	7.92±0.19	4.89±0.18	4.8±0.17	2.48±0.16	3.41±0.14	1.18±0.08

Concentration = mean ± S.D, BDL = below detection limit, N = 5

Mean concentration per point for six month were: November 7.92x10^2 µg/kg, December 4.89x10^2 µg/kg, January 4.80x10^2 µg/kg, February 2.48x10^2 µg/kg, March 3.41x10^2 µg/kg and April 1.18x10^2 µg/kg. Maximum advisable limit for exposure set by USEPA (2008) is 1.00x10^2 µg/kg which is lower than the level in the leachate. The chromium metal ions level in the leachate were found in the range of 8.00x10^0 µg/kg to 2.97x10^2 µg/kg (Table 5).

Table 5: Chromium concentration (x10^3 µg/kg) in leachates from Dandora dumpsite

Site/Month	**November**	**December**	**January**	**February**	**March**	**April**
A	0.79±0.085	1.09±0.094	0.80±0.004	1.04±0.04	0.56±0.062	0.89±0.088
B	1.16±0.161	1.22±0.222	1.02±0.024	1.47±0.471	0.75±0.048	1.0±0.005
C	1.13±0.129	1.47±0.465	1.36±0.355	0.92±0.017	1.15±0.154	0.77±0.072
D	1.52±0.524	1.65±0.649	1.27±0.266	0.94±0.036	1.16±0.163	0.74±0.041
E	1.59±0.588	1.23±0.234	1.33±0.332	0.89±0.087	1.23±0.233	0.77±0.071
F	2.97±0.971	0.51±0.005	1.43±0.431	0.96±0.064	1.40±0.403	0.77±0.069
G	2.25±0.253	1.16±0.162	0.41±0.006	0.88±0.075	0.30±0.006	0.75±0.48
H	1.31±0.311	0.64±0.038	0.88±0.84	0.66±0.056	0.25±0.053	0.74±0.044
J	0.97±0.65	0.90±0.004	0.46±0.057	0.87±0.073	0.16±0.056	0.72±0.024
K	0.58±0.082	0.86±0.063	0.32±0.21	0.66±0.064	0.08±0.075	0.74±0.043
∑**Chromium**	14.27±0.71	10.73±0.35	9.28±0.42	9.29±0.22	7.04±0.50	7.89±0.09

Concentration = mean ± S.D, BDL = below detection limit, N = 5

The highest concentration was at site F during the months of November, followed by site G with mean concentration of 2.25x10^2 µg/kg. Maximum advisable limit set by USEPA is 1.00x10^2 µg/kg, which is lower than the level in the leachate.

The cadmium metal ions in the leachate were detected in the concentration range of BDL to 7.00x10^0 µg/kg (Table 6).

Table 6: Cadmium concentration (x10^3 µg/kg) in leachates from Dandora dumpsite

Site/Month	November	December	January	February	March	April
A	BDL	0.07±0.065	BDL	BDL	BDL	BDL
B	BDL	0.01±0.006	BDL	BDL	BDL	BDL
C	BDL	BDL	BDL	BDL	BDL	BDL
D	BDL	0.01±0.002	BDL	BDL	BDL	BDL
E	BDL	BDL	BDL	BDL	BDL	BDL
F	BDL	BDL	BDL	BDL	BDL	BDL
G	BDL	BDL	BDL	BDL	BDL	BDL
H	BDL	BDL	BDL	BDL	BDL	BDL
J	BDL	BDL	BDL	BDL	BDL	BDL
K	BDL	BDL	BDL	BDL	BDL	BDL
∑Cadmium	BDL	0.09±0.073	BDL	BDL	BDL	BDL

Concentration = mean ± S.D, BDL = below detection limit, N = 5

The metal ions were only detected during the month of December with total mean concentration of 9.00x10^0 µg/kg. Cadmium is emitted into the air from incineration of municipal waste materials [31]. The study analyzed leachate and not air. This might have been the reason why many sample sites did not contain cadmium. Metal ion levels in the leachate was relatively high in all sampling seasons. MSW is continually disposed throughout the year. More waste is disposed as the population increase.

Results of the levels of methane from the dumpsite are in the table below (Table 7).

Table 7a: Methane level at the Dandora dumpsite in week 1

Sampling point	Duration (minutes)	CH_4 Concentration (x10^{3}µg/kg)	CH_4 fluxes (µgCm^{-2}h^{-1})		Sampling point	Duration (minutes)	CH_4 Concentration (x10^{3}µg/kg)	CH_4 fluxes (µgCm^{-2}h^{-1})
P_1	0	196.86			P_6	0	27.30	
	7	203.70				7	79.54	
	14	277.07				14	113.01	
	21	280.65	1744.03			21	174.07	2544.47
P_2	0	244.29			P_7	0	BDL	
	7	1634.41				7	BDL	
	14	1309.24				14	BDL	
	21	1685.49	21473.75			21	BDL	0
P_3	0	75.58			P_8	0	BDL	
	7	228.64				7	BDL	
	14	94.51				14	BDL	
	21	74.73	0			21	BDL	65.51
P_4	0	BDL			P_9	0	1953.52	
	7	36.61				7	2411.31	
	14	15.54				14	2279.82	
	21	25.47	319.21			21	1343.64	0
P_5	0	BDL			P_{10}	0	987.69	
	7	BDL				7	1666.63	
	14	BDL				14	618.73	
	21	BDL	57.72			21	BDL	0

Table 7b: Methane level at the Dandora dumpsite in week 2

Sampling point	Duration (minutes)	CH_4 Concentration (x10^3 µg/kg)	CH_4 fluxes (µgCm^{-2}h^{-1})		Sampling point	Duration (minutes)	CH_4 Concentration (x10^3 µg/kg)	CH_4 fluxes (µgCm^{-2}h^{-1})
P_{11}	0	730.42			P_{16}	0	BDL	
	7	2184.90				7	BDL	
	14	2700.07				14	BDL	
	21	2829.56	36587.28			21	BDL	0
P_{12}	0	544.17			P_{17}	0	1242.80	
	7	1630.19				7	817.19	
	14	1890.17				14	795.32	
	21	3490.66	48869.05			21	3779.87	40758.99
P_{13}	0	1423.12			P_{18}	0	649.65	
	7	2662.92				7	648.54	
	14	658.74				14	966.40	

	21	2742.10	10487.33			21	1411.26	13977.94
P_{14}	0	80.96			P_{19}	0	114.16	
	7	327.25				7	250.66	
	14	277.27				14	154.46	
	21	319.52	3575.12			21	166.07	319.67
P_{15}	0	BDL			P_{20}	0	1031.30	
	7	BDL				7	436.06	
	14	BDL				14	2978.57	
	21	BDL	0			21	1781.25	25737.57

Methane concentration was highest at Site P_{12}, with flux of $4.89\text{x}10^3$ µg C m^{-2} h^{-1}, followed by P_{17}, with flux of $4.08\text{x}10^3$ µg C m^{-2} h^{-1}. Five Sites P_5, P_7, P_8, P_{15} and P_{16} had below detectable level (BDL) concentration. This could have been the sites where the soils are net sinks for flux of CH_4 into the soil. Morning and afternoon timings did not affect the concentration of methane.

Comparing methane emission from Dandora dumpsite with estimates of global methane flux from mud volcanoes (MVs) (In the year 2002, $8.0\text{x}10^{-2}$-$1.4\text{x}10^{0}$ µgCm^{-2} h^{-1}, were from Kopf, $3.3\text{x}10^{0}$ µgCm^{-2} h^{-1} were from Milkov in the year 2003 and $2.0\text{x}10^{-1}$ -$1.23\text{x}10^{1}$ µgCm^{-2} h^{-1} were from Kopf in the year 2003) to the atmosphere, it is found that more emissions are made by the dumpsite than the MVs.

IV. Conclusion and Recommendations

This study has established baseline data regarding the levels of heavy metals and methane from leachate and air at Dandora dump site respectively. Better management of the dump site is required before it reaches the point of no return in terms of environmental pollution. The results of this study can form the basis for the study of the other dump site in other counties in Kenya

The study found out that the level of zinc metal ions was highest in the leachate from Dandora dumpsite and in all seasons. The levels of metals were lowest during rainy season (in March and April 2013).

The level of heavy metals analysed was above the recommended level in drinking water by the USEPA (32). There is need to treat leachate from the dumpsite in case farmers use it as manure and examine the level of metal ions in water from boreholes in that area.

The level of methane was highest where there were no methane sinks (absence of OH). Methane is generated within fourteen days of waste decomposition under anaerobic conditions. The gas can be trapped if it is in a closed dumpsite and be used as clean fuel.

The findings of this study enable to recommend restriction of residence closer to the dumpsite. This will reduce effects of metals such as chromium and cadmium which end up in air. Generated methane be trapped and used as fuel. This will reduce dependence on charcoal and/or kerosene. In case there are boreholes in the area, water to be examined before being used.

Acknowledgement

Professor Klaus and Mr Wanyama, from The ILIRI, Mines and geology department, Nairobi City county, for their assistance in the sample analysis.

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