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EFFECT OF SOLID WASTE LANDFILL ON UNDERGROUND AND SURFACE WATER QUALITY AT RING ROAD, IBADAN, NIGERIA

O. O. ODUKOYA, T. A. AROWOLO and O. BAMGBOSE

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ABSTRACT

The effect of the municipal solid waste landfill at Ring Road Ibadan on the quality of the underground water in the surrounding area and adjacent surface water was investigated. Samples of water from these sources were analyzed for the following physico-chemical parameters: pH, conductivity, total solid, dissolved solid, suspended solid, total hardness, chloride, phosphate, sulphate phenol and the metals, Na, K, Zn, Pb, Cd, Cr, Cu, Fe and Al.

Results showed the landfill to be a source of inorganic and organic pollution since most of these parameters showed increased concentrations over those from control sites. Comparison with WHO guidelines (1991) indicate that most of the water samples are not suitable for human consumption.

Keywords: landfill, groundwater, surface-water, pollution.

INTRODUCTION

Ground water is an important source of water for domestic use especially in developing countries. As a result of the long retention time and natural filtering capacity of aquifiers, ground water is often unpolluted. However, leachate from municipal solid-waste landfills are potential sources of contamination of both ground water and surface water. Many workers have detected elevated levels of both organic and inorganic pollutants in surface groundwater and water in the vicinity of solid-waste landfills (Van der Broek and Kirov 1971; Baedecker and Back 1979; Murray 1981; Reinhard, et. al. 1984; Albaiges 1986; Borden and Yanoschak, 1990; Mirecki and parks 1994). However, solid-waste disposal in landfills still remains the most convenient and most economic form of disposal in most cases (Thomson and Zandi, 1975; Rushbrook, 1983; Carra and Cossu 1990). Investigations have shown that in non-arid regions, *infilteration* of water through landfill has caused water table mounding. This causes leachate to flow downward and outward from the landfill. Downward flow pollutes ground -water while outward flow causes leachate springs at the periphery of the landfill or seepage into streams or other surface-water (Khanbilvardi, et. al. 1992).

The city of Ibadan in Oyo State of Nigeria is a densely populated city with an estimated population of over 4 million (Onianwa, 1995). The waste generated by this vast population were dumped in two solid-waste landfill sites at Ring Road and Aperin. The Ring Road landfill site was closed down in 1991 after being in use for over 20 years. It covers an area of about 800 x 250 m^2. During its use, it received both domestic and industrial wastes. The wastes sometimes attained heights of up to 60 meters and was

O. O. ODUKOYA, Department of Chemical Sciences, University of Agriculture, Abeokuta, Nigeria
T. A. AROWOLO, Department of Environmental Management & Toxicology, University of Agriculture, Abeokuta, Nigeria
O. BAMGBOSE, Department of Environmental Management & Toxicology, University of Agriculture, Abeokuta, Nigeria

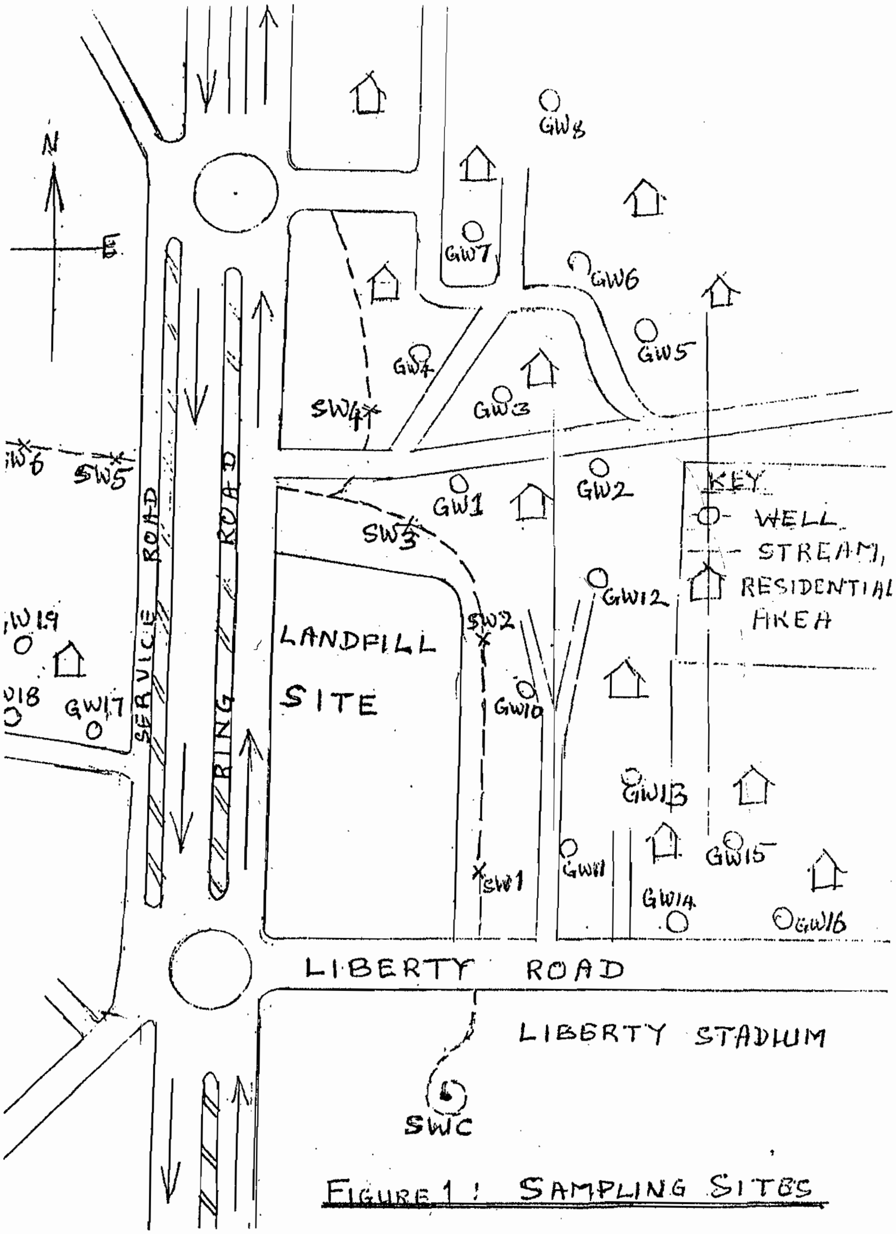

FIGURE 1 : SAMPLING SITES

periodically burnt, a process which generated a lot of ash from combustible materials and also converts metals to their oxides. This process increases the solubility of the various substances in the water percolating into the soil. The immediate vicinity of the landfill site is a highly populated residential area. This population depend mostly on underground well water without treatment for cooking, drinking and other domestic use due to inadequate supply of potable tap water – a common problem in Ibadan. Contamination of this water would result in

Table 1: Some physicochemical parameters in groundwater and surface water at Ring Road Landfill, Ibadan

	Site	Distance from landfill (m)	pH	Conductivity (μs/cm)	Total hardness (mg/L)	Total solid (mg/L)	Dissolved solid	Suspended solid (mg/L)	Chloride (mg/L)	Phosphate mg/L	Sulphate mg/L	Phenol mg/L
Northern Direction	GW1	25	6.94	524	428	1180	1100	85	35.0	1040	700	0.2
	GW2	50	8.14	406	321	480	459	21	32.5	674	336	0.2
	GW3	75	6.52	450	307	1620	1550	68	37.0	669	334	0.5
	GW4	150	7.41	391	156	760	741	19	52.5	543	310	0.5
	GW5	180	5.66	449	207	510	490	20	69.0	471	296	0.3
	GW6	200	5.56	345	121	320	306	14	61.0	520	286	0.8
	GW7	280	6.81	868	130	740	709	31	118	497	264	1.0
	GW8	720	8.22	373	214	800	768	32	37.5	674	224	1.0
	GW9	820	5.50	340	194	760	742	18	36.0	629	170	0.5
Eastern Direction	GW10	5	6.81	380	327	600	583	17	24.0	994	166	1.8
	GW11	200	7.94	269	160	360	346	14	28.5	564	120	1.2
	GW12	250	6.69	237	149	500	481	19	21.0	428	128	1.5
	GW13	300	7.33	243	140	300	288	12	20.0	471	116	1.0
	GW14	450	5.99	197	96.0	160	147	13	22.0	443	120	1.0
	GW15	550	6.10	172	78.8	600	583	17	26.0	443	130	0.5
	GW16	900	7.29	614	271	720	689	31	75.0	257	116	0.5
Western Direction	GW17	200	6.26	268	141	180	159	21	50.0	486	114	0.5
	GW18	300	6.47	345	169	520	502	18	40.0	443	125	0.5
	GW19	350	6.21	402	192	760	711	49	30.0	407	118	0.5
	*GWC	4000	7.06	276	195	280	260	20	17.5	397	161	0.2
Surface Water	+SWC		6.59	411	71.6	460	392	68	30.5	497	436	1.0
	SW1		6.74	366	129	460	408	52	45.0	1129	480	1.2
	SW2		7.02	611	181	2160	2054	106	70.0	1086	430	1.5
	SW3		6.75	610	317	720	646	74	67.0	994	456	1.5
	SW4		6.79	470	299	460	422	38	45.0	943	386	1.5
	SW5		6.75	602	320	2000	1896	104	62.5	971	454	2.0
	SW6		6.81	596	311	1700	630	170	65.5	700	470	1.8
WHO Standard			6.50-8.50		500	1000			200	0.5	200	0.001

GWC - groundwater Control Site + SWC - Surfacewater control site (source of the stream)

These values are within less than 10.0% coefficient of variation.

serious health problems. The aim of this study is to assess the effect of the solid waste landfill site on the quality of the underground water, and the suitability of the water for drinking and other domestic purposes. The surface water (stream) flowing around the landfill site will also be assessed to determine its level of contamination.

MATERIALS AND METHOD

Water samples were collected from twenty wells at various distances from the dis-used refuse landfill site at Ring Road Ibadan in three different directions (Fig. 1). Samples were also collected along a shallow stream flowing round the landfill site. Two sets of samples were collected at each sampling event from the wells and the stream; one for metal analysis and the other for determination of non-metallic parameters. The sample for metal analysis was collected into previously acid-washed 2 litre plastic containers with 10ml HNO_3 being added at the point of collection. This is to prevent surface adsorption of metals. The sample for other parameters was collected into 10 litre plastic containers after rinsing with the water sample.

The samples for metal analysis were subjected to a concentration treatment step (in the laboratory) to improve instrumental signal. This was done by passing 500ml of each sample through a column of Dowex 50 strongly acidic cation exchanger in the hydrogen form and eluting with 25ml 2M HNO_3. This results in a 20 fold concentration (Vernon and Wani 1993). The metals, zinc, lead cadmium, chromium, copper and iron were determined with an Atomic Absorption Spectrophotomer Model 2000A. Sodium and potassium were determined by Flame Photometer Corning 410, pH by pH meter Jenway Model 3015, conductivity by conductivity meter model CMD 80 WPA, total hardness by EDTA titration, chloride by Mohr's method. Aluminium was determined colorimetrically using aluminon method, sulphate by turbidimetry, phosphate by vanadomolybdophosphoric acid

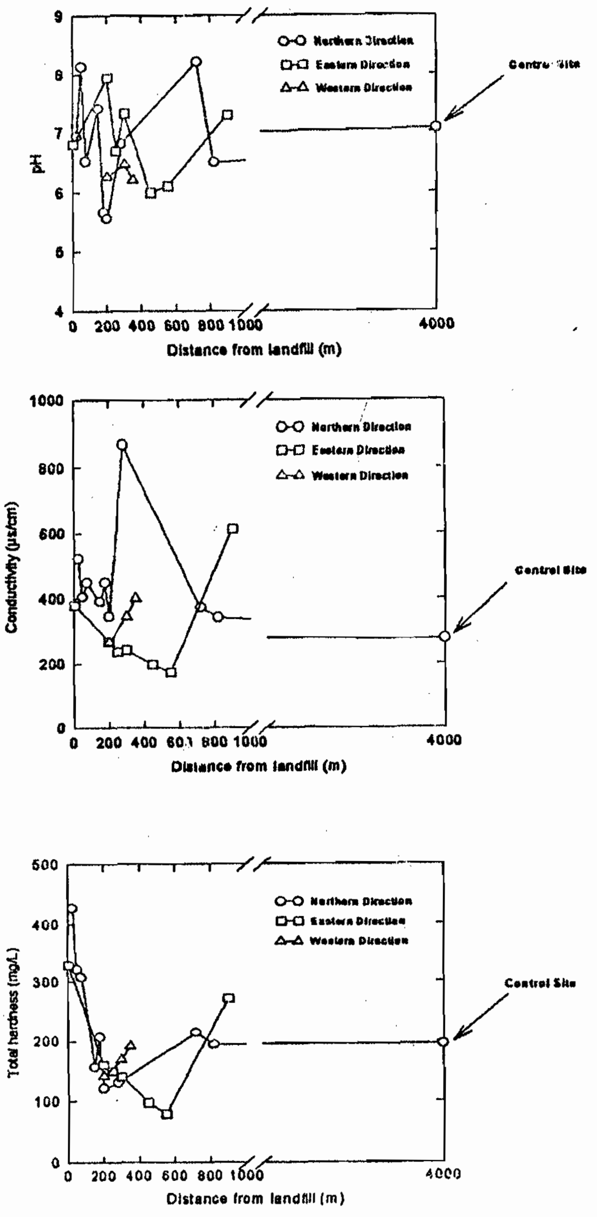

Fig. 2: Variation in pH (A), conductivity (B) and total hardness (C) with distance from landfill.

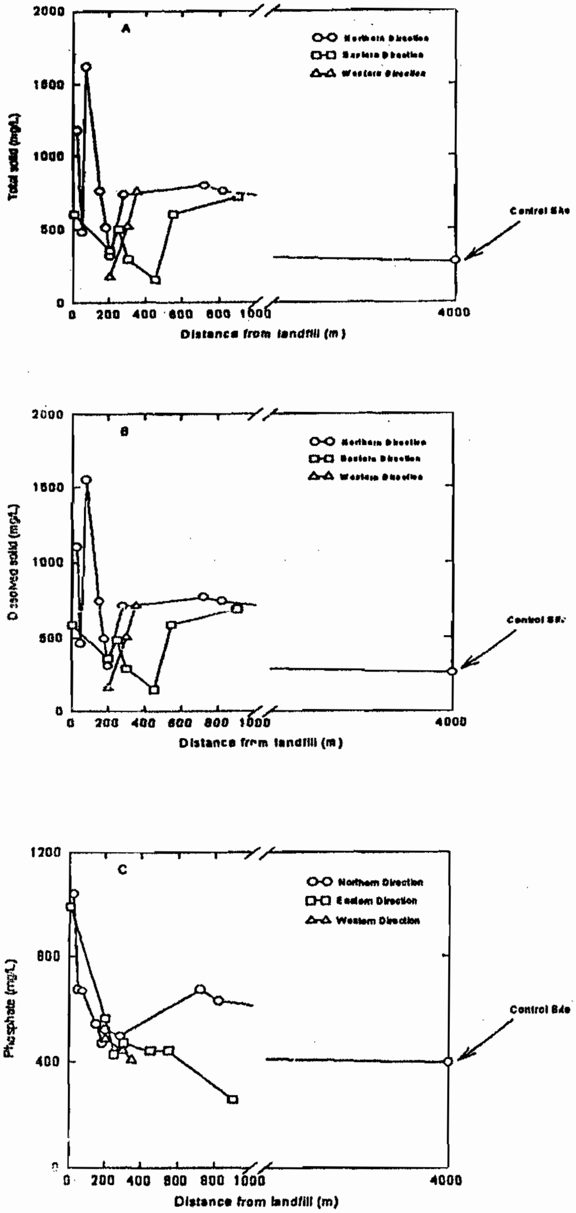

Fig. 3: Variation of total solid (A), dissolved solid (B) and phosphate (C) with distance from landfill.

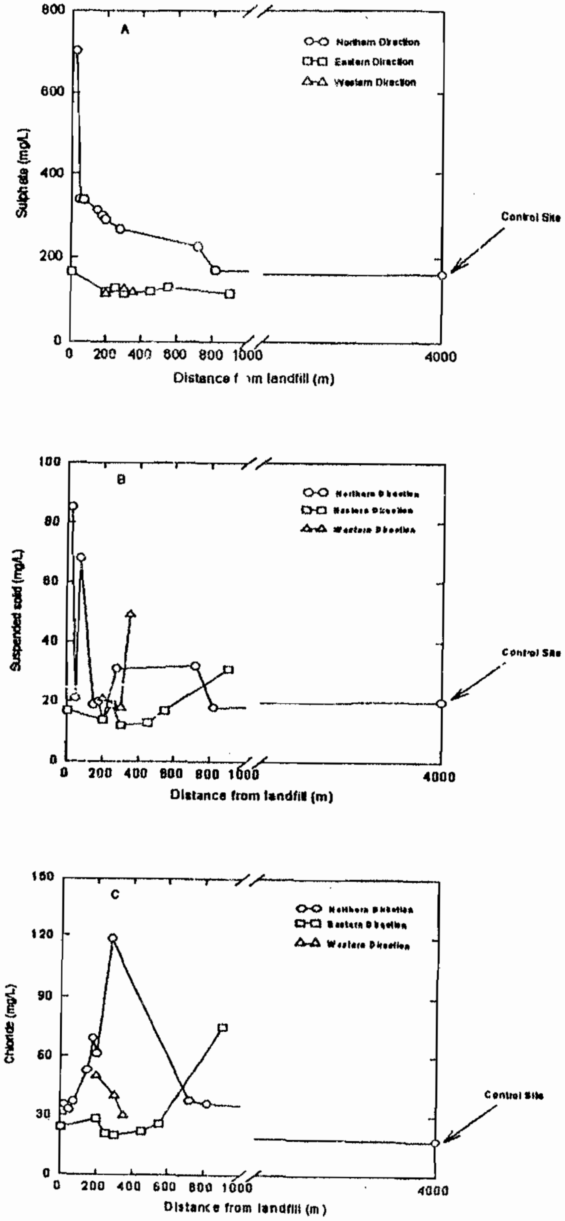

Fig. 4: Variation in sulphate (A), suspended solid (B) and chloride (C) with distance from landfill

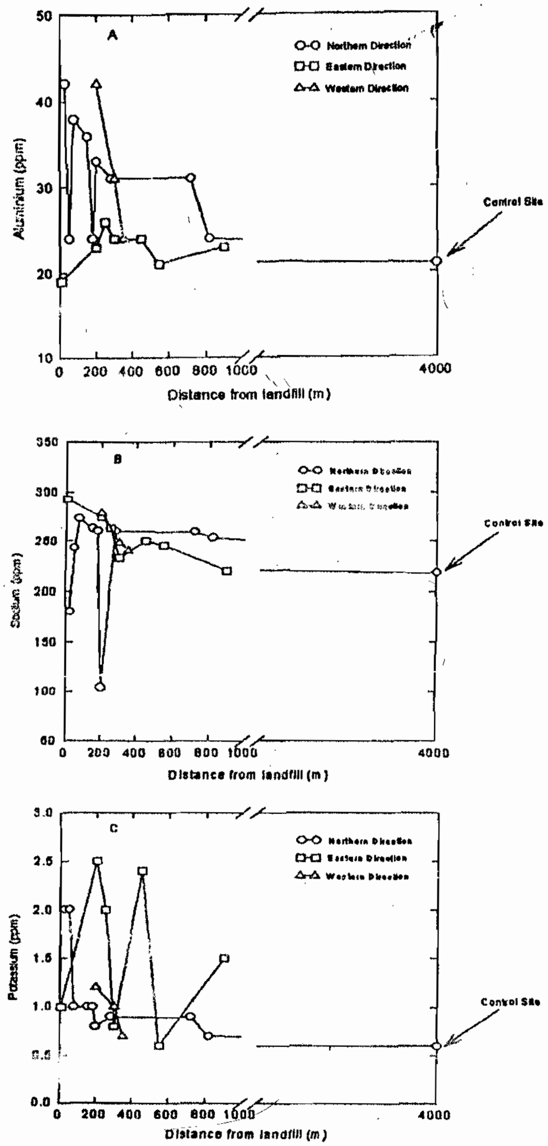

Fig. 5: Variation in aluminium (A), sodium (B) and potassium (C) with distance from landfill.

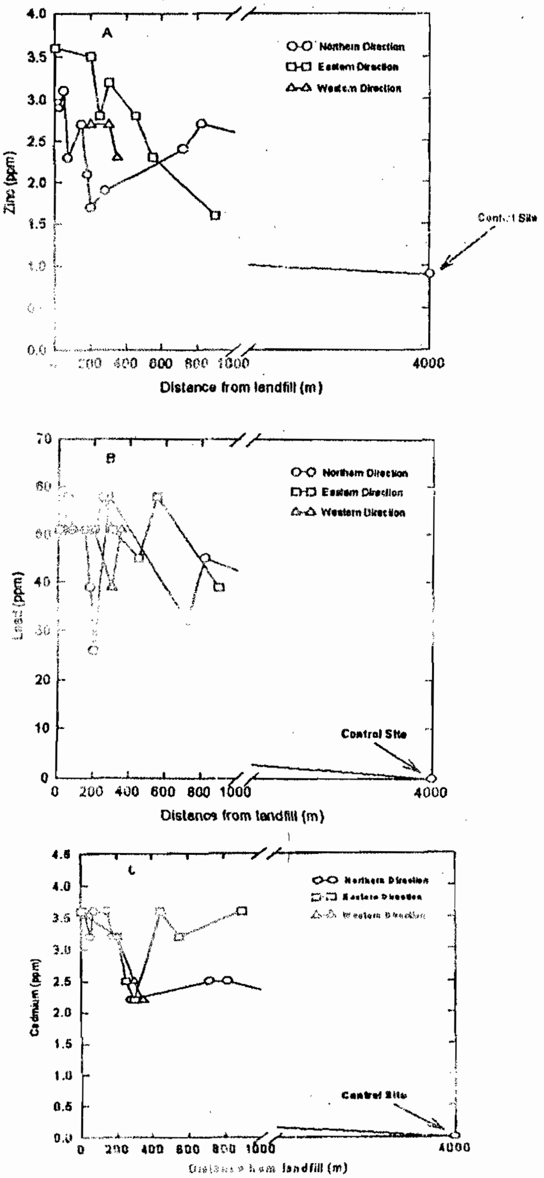

Fig. 6: Variation in zinc (A), lead (B) and cadmium (C) with distance from landfill

method, while phenol was by sulphanilic acid method by comparison with standards (APHA, AWWA, WPCF and Department of the Environment, 1972).

RESULTS AND DISCUSSION

Table 1 shows the result of levels of the non-metallic parameters for the underground

Table 2: Levels of Metals in Groundwater and Surface Water at Ring Road Landfil, Ibadan (mg/L)

	Site	Distance from landfill (m)	Al	Na	K	Zn	Pb	Cd	Cr	Ca	Fe
Northern Direction	GW1	25	42	180	2.0	2.9	51	3.6	6.0	4.0	21
	GW2	50	24	243	2.0	3.1	58	3.2	5.0	4.0	17
	GW3	75	38	273	1.0	2.3	51	3.6	5.0	4.0	21
	GW4	150	36	263	1.0	2.7	51	3.6	5.0	3.0	21
	GW5	180	24	260	1.0	2.1	39	3.2	5.0	6.0	13
	GW6	200	33	104	0.8	1.7	26				5
	GW7	280	31	260	0.9	1.9	58	2.2	4.0	3.0	17
	GW8	720	31	259	0.9	2.4	32	2.5	4.0	4.0	13
	GW9	820	24	253	0.7	2.7	45	2.5	4.0	1.0	17
Eastern Direction	GW10	5	19	292	1.0	3.6	51	3.6	5.0	7.0	21
	GW11	200	23	274	2.5	3.5	51	3.2	3.0	7.0	17
	GW12	250	26	263	2.0	2.8	58	2.5	3.0	6.0	21
	GW13	300	24	233	0.8	3.2	51	2.2	5.0	4.0	17
	GW14	450	24	250	2.4	2.8	45	3.6	5.0	9.0	21
	GW15	550	21	245	0.6	2.3	58	3.2	4.0	6.0	17
	GW16	900	23	220	1.5	1.6	39	3.6	5.0	4.0	17
Western Direction	GW17	200	42	278	1.2	2.7	51	3.2	4.0	4.0	13
	GW18	300	31	248	1.0	2.7	39	2.5	4.0	3.0	13
	GW19	350	24	240	0.7	2.3	51	2.2	3.0	4.0	17
	*GWC	4000	21	219	0.6	0.9	N.D	N.D	1.0	3.0	N.D
Surface Water	+SWC		24	269	1.0	3.7	58	2.50	4.0	3.0	13
	SW1		76	358	8.0	2.5	45	2.5	4.0	4.0	21
	SW2		59	278	4.0	2.5	51	2.2	4.0	3.0	17
	SW3		50	271	5.0	2.4	51	2.2	4.0	4.0	17
	SW4		23	265	2.0	2.3	32	N.D	3.0	N.D	25
	SW5		35	260	4.0	2.1	45	2.5	3.0	3.0	17
	SW6		29	184	3.0	2.3	39	2.5	3.0	2.0	17
	WHO Standard					5.0	0.1	0.01			0.1

- GWC - groundwater Control Site + SWC - Surfacewater control site (source of the stream) N.D. not detectable.

These values are within less than 10% coefficient of variation.

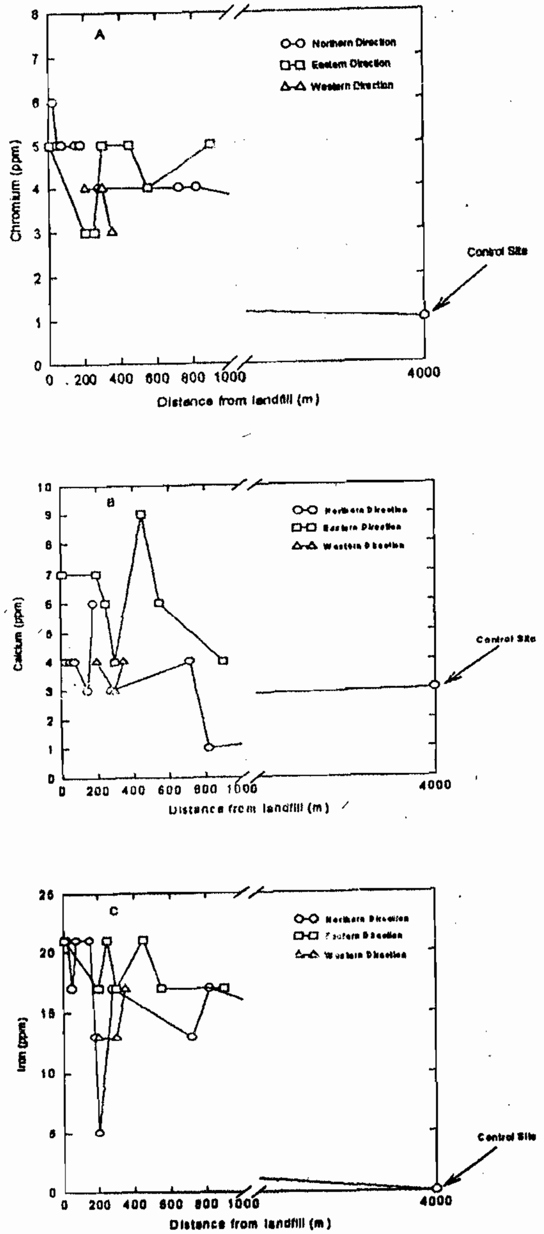

Fig. 7: Variation in chromium (A), calcium (B) and iron (C) with distance from landfill.

water and surface water while Table 2 shows the results for the levels of the metals. Figures 2 to 7 compliment the tables for the same results in the groundwater sites.

The concentrations of some of the non-metallic parameters in the groundwater show a progressive decrease as the distance from the landfill increases, while others do not show a clear trend. However most of the sites have values greater than that of the groundwater control site (Table 1, Figures 2, 3, 4).

Except for lead, zinc and copper, the levels of most of the metals in the groundwater sites decrease progressively as the distance from the landfill increases (Table 2, Figures 5, 6, 7). The absence of a clear trend in these three metals may be due to vehicular exhaust pipe emission which would disrupt the trend. This is because studies have shown that these three metals are present in roadside dusts and vegetations at concentrations which depend on traffic density (Odukoya 1999; Odukoya et. al. 2000). However all the sites have higher values of the metals than the groundwater control site. This suggests that leachate from the landfill is responsible for the high level of these parameters in the samples near the landfill. This trend is in agreement with observations made by workers in similar studies (Mirecki and Parks 1993; Tindall et. al. 1994; Onianwa et. al. 1995; El-Fadel et. al. 1995).

In the two tables, surface-water sites SW_1, SW2 and SW3 around the landfill (Figure 1) have higher values in total hardness, total solid, dissolved solid, suspended solid, phenol; the anions phosphate and sulphate, and the metals aluminium, sodium, potassium and iron that the control site SWC (Tables 1 and 2). This observation suggests that the landfill leaches pollutants (organic and inorganic) into the stream as it flows round it, thus reiterating the observation earlier made in respect of the groundwater that the landfill is a source of water pollution. The decrease in concentration of many of the metals in the sites SW5 and SW6 is due to dilution by the incoming stream (Figure 1).

Comparison of the levels of the parameters in the stream (surface water) with those in the wells (groundwater) shows that parameters like total solids, dissolved solids, suspended solids, phosphate, phenol and the metals aluminium, sodium and potassium are higher in the surface-water than in the groundwater samples. This may be due to the filtering effect of the soil as the leachate percolates through to the underground-water, a process which is absent in the surface-water.

Phenol does not really show much trend with distance of the wells (ground water) from the landfill, but the level in most of the wells and the stream are higher than the ground water control site (GWC) of 0.2 mg/l.

Finally, comparison of the levels of the parameters with WHO guidelines on drinking water standards (1991) shows that the following parameters are higher than the recommended values in all the samples: phosphate, iron, lead, cadmium and phenol. Considering that lead, cadmium and phenol are toxic substances, it can be seen that the water from these sites is not suitable for human consumption. It may however be suitable for other purposes like washing, irrigation, and industrial purposes like cooling but should not come in contact with food.

CONCLUSION

This study has shown that the Ring Road landfill at Ibadan is a source of pollution of the groundwater and the surface water flowing around it. This has adversely changed the physico-chemical parameters of the water and posses danger to the population inhabiting this area. It is recommended that treated potable water be provided for the people in this area to save them from imminent danger from the landfill leachate.

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