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EFFECT OF OPEN DUMPSITE ON UNDERGROUND WATER QUALITY IN GANMO, KWARA STATE

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ABSTRACT

The quest to satisfy human needs and wants and the development have led to the consumption of various commodities and generation of wastes. This study investigated the effect of solid waste dumpsite in Ganmo, south-western Nigeria on the underground water with the view to assess the impact of the waste on the quality of the groundwater in the study area. Electrical Resistivity Profiling and Vertical Electrical Sounding techniques of Werner and Schlumberger configurations using Direct Data Capture (DDC-8) resistivity meter to acquire data in the area were employed. Physico-chemical and Bacteria Analyses of the water sample instudy area were carried out. Three sets of water samples were collected for hydro-physicochemical analysis and Bacterial analysis. The 2-D resistivity imaging showed zones of low resistivity in the range 7.47 to 10.5Ωm with the depth ranging from 2.69 to 3.46 m. The vertical electrical sounding results delineated three subsurface layers comprising topsoil, weathered layer and the fresh basement. The low resistivity value could be an evidence of dissolved particles from the decaying rubbish in the waste, forming the constituent of the leachate. The results of hydro-physicochemical analysis of various parameters tested indicated that the quality of the water in the study area was below the recommended standard for drinking water by WHO and NSDQW. The bacterial analysis of the water sample showed presence of bacterial species load of Escherichia coli and Klebsiella resulting from dissolved particles from the decaying rubbish from the waste. However, based on the results of the hydro-chemical and bacteriological status of the surrounding well water, it is concluded that the groundwater is mostly unsuitable for domestic consumption.
***Keywords:** Leachate Plume, Resistivity, Contaminants, Health hazard, Groundwater pollution.*

INTRODUCTION

Nowadays, the problem of environmental contamination and waste management is one of the main concerns of earth scientists and researchers from other related fields of science around the globe (Pantelis *et al*, 2006). Refuse dumpsites are found both within and on the outskirts of cities in Nigeria and due to poor and ineffective management, the dumpsites turn to source of health hazards to people living in the vicinity of such dumps. Groundwater pollution occurs solely due to the leachate (pollutant) which migrates in the direction of rainwater percolation into the groundwater. The resultant leachate which percolates into the aquifers after much precipitation is associated with high ionic concentrations, coupled with their low resistivity values make electrical delineation of generated contaminant leachate plume plausible (Bernstone and Dahlin, 2000).

The World Health Organisation (WHO, 2004) standards, state that drinking water should not contain any micro-organisms known to be pathogenic or any bacteria indicative of *faecal* pollution. When water is tested for *Faecal* or Total *Coliform*, the results are usually given as the number of colony-forming units per 100 millilitres (CFU/100 ml) of water sampled.

Electrical resistivity imaging or tomography technique is considered to be a suitable tool for site characterization at disposal site since the presence of leachate rich in soluble ions will facilitate the flow of an electrical current hence lowering the resistivity of the medium (Aristodemou and Thomas-Betts, 2000). Basically the technique involves sending the DC current into the earth via a pair of steel electrodes and the resulting potential is measured by another pair of electrodes. The medium-dependent electrical potential will then be translated into resistivity values. Finally, the resistivity distribution is used in the interpretation of the whole survey line by inverse modeling (Loke *et al,* 1996). Landfill related geo-electrical surveys have been carried out by numerous researchers in the study of leachate contamination of soil and groundwater. Bernstone and Dahlin (1999); Powers *et al*. (1999); Sundararajan *et al*. (2007); Sunmonu *et al.* (2012); Ekeocha *et al.* (2012); and Agboola *et al. (*2018, 2019), applied geophysical methods and their results estimated the depth to groundwater, the extent of contaminant leachate plume and migration paths below surface around landfills. Geochemical analysis is normally used to identify the heavy metals concentration regarded as pollutants and sometimes toxics in the water samples either from surface, boreholes or extracted from soils subsurface. The presence of metals exceeding the background values are considered as strong indicator of pollution levels.

The main objective of this research work is to investigate the impact of contaminants generated by Ganmo dumpsite in Ifelodun LGA, Kwara State, South-Western Nigeria, on underground water by applying some geo-physical techniques to detect the presence of contaminants. In addition, to carryout hydro-physicochemical analysis and Microbiological (Bacteria Analysis) analysis of water samples. This becomes necessary as the inhabitants in the study area depend mostly on groundwater for domestic purposes and as such this might have had deleterious effect on human health.

1.2 Study Area

Ganmo is one of the districts in Ifelodun Local government Area in Kwara State, bounded by latitude $8^0$15' and 8^0 20'N and longtitude 4^0 40'E. The Weather condition in the region is of two broad types (i.e. rain season and dry season). The rain season commences around March and ends in October, while dry season begins in November and ends in March. The annual rainfall ranges from 75 to 112 mm. The humidity ranges between 60 to 89% and mean annual temperature is between 27 to 30° (Sule*et al.*, 2013). It falls in the basement complex of south western part of Nigeria, which is of Precambrian to lower Paleozoic in age (Oyawoye, 1972; Rahaman, 1976; Oluyide, 1979). This Precambrian crystalline basement complex consists of Migmatite and Biotite granite (Figure. 1)

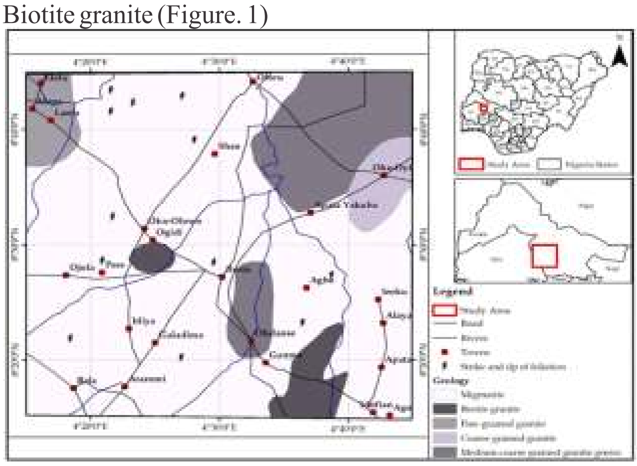


Figure1: Geological Map of Study Area Showing Investigated Site

The hydrological setting of the area is typical of what is obtainable in other basement complex area, where the availability of water is a function of the presence of thick-little clay overburden material and presence of water filled joints, fracture or faults within the fresh basement rocks. The humid tropical climate of Ilorin has particularly encouraged relatively deep weathering of the near surface rocks to produce porous and permeable material that allows groundwater accumulation as shallow aquifer which is recharged principally through infiltration of rainwater (Ige, 2014). The study area is located behind the Ganmo main market along Ajase-Ipo road from Ilorin metropolis. It is the most active dumpsite in the area because of its closeness to the Market (Plate. 1)

Plates 1: Open Dumpsite, Ganmo, Ifelodun

Materials and Method

Geophysical Techniques

The electrical resistivity techniques adopted were Vertical Electrical Sounding (VES) and 2-D Electrical Resistivity Profiling. The resistivity profiling was adopted to map out lateral variations in subsurface resistivity that exist in the survey area along the traverses. The Vertical Electrical sounding was used to characterize the various lithological units and to determine the depth to water table. In Electrical Resistivity Profiling and Vertical Electrical Sounding (VES) measurement, electric current (I) was introduced into the ground through a pair of electrodes A (C1) and B (C2), while electrodes M (P1) and N (P2) measured the potential difference (ΔV) (Figures. 2& 3). Profiles were established on the dumpsites and outside the dumpsites area as control at the extent of 100m away. This operation was repeated when the distance between current electrodes were increased, together with an increase of the study depth. Values of apparent resistivity (ρ_a) were calculated in each distance AB using equation:

$$\rho_a = (\Delta V/I)G \quad \text{(I)}$$

(Where $G = p\left(\frac{AB}{2}\right)^2 / MN$ is geometrical factor which is determined by the electrode configuration of the array.)

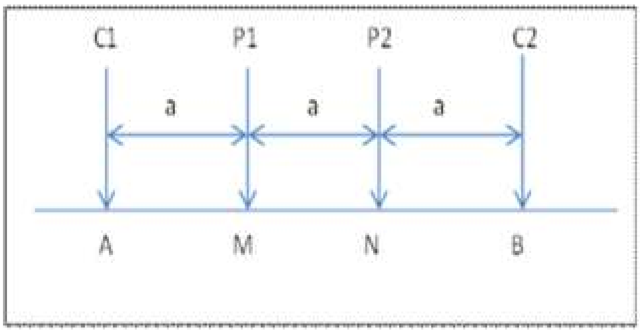


Figure 2: Conventional electrode array for electrical resistivity method (Wenner alpha array)

Wenner alpha array (Figure 2) was employed to acquire the Resistivity , using Direct Data Capture (DDC-8) resistivity meter. The field data were interpreted by applying RES2DINV software. Schlumberger electrode configuration (Figure.3) was also employed to acquire Vertical Electrical Soundings (VES) with maximum half current electrode spacing (AB/2), using Direct Data Capture(DDC-8) resistivity meter. In this method, the centre point of the electrode array remains fixed, but the spacing between the electrodes is increased to obtain more information about the deeper sections of the subsurface. Three vertical electrical soundings (VES) were conducted at preferred points in the study area. Values of apparent resistivity (ρ_a) recorded were interpreted by applying WINRESIST modeling software while 1-D electrical resistivity tomograms were generated.

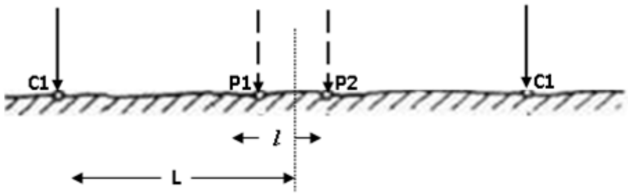


Figure 3: The symmetrical Schlumberger array

2.2 Physico-chemical Analysis

Water samples were taken early in the morning from the three available wells (Plates2:a-c) around the dumpsite in cleaned plastic polyethylene bottles and brought to the laboratory in an icebox jar to avoid unusual change in water quality . Prior to the sampling, all the bottles were washed and rinsed thoroughly with distilled water. Standard methods were followed for sample collection and preservation. Field measurements include physicochemical parameters such as temperature, pH and other physical parameters including: water level, depth to bottom of the well, total dissolved solids, colour, odour, taste, and turbidity. Global Positioning System was used to perform geo-referencing of each sampling point. Cation sampling solutions were acidified (HNO_3) to prevent metallic ions from adhering to the walls of the container and to homogenize the water samples. Samples were refrigerated to prevent any reactivity and laboratory analyses were carried out within 48 hours at the University of Ilorin Central research laboratory, Ilorin. Cations and heavy metals analyses were carried out using Atomic Absorption Spectrophotometer, Sodium and Potassium metal (Na and K) by Flame photometry (Systronics), while anion analysis was performed using Iron Chromatographic method (titrimetric method was used for SO_4^- and HCO_3^-). Four anions were quantified, namely: nitrate ($NO3^-$), bicarbonate (HCO_3^-), chloride (Cl^-), and Sulphate (SO_4^-), while thirteen metal elements including: Calcium, Magnesium, Potassium and Sodium; together with heavy metals: Manganese, Iron, Copper, Zinc, Cobalt, Chromium, Cadmium, Lead and Nickel were also quantified.

Well 1

Well 2

Plate 2: (a &b) Nearby hand dug wells (c) Water Sample Collection

2.3 Microbiological Analysis of Water Samples (Bacteria Analysis)

This study was carried out to determine the bacteriological quality of water. 1ml of water sample was mixed in 9ml of normal saline. The samples were mixed respectively based on the site located. Diluents (1ml) was transferred into the next test tube and diluted serially. From the dilution of 10^{-3} and 10^{-5} of water samples, 0.1ml diluents was aseptically poured on the sterile petri-dishes followed by 20ml of molten *Macconkeyagar*, *Salmonella Shigella agar* and Nutrient agar, these were mixed gently in a clockwise and anticlockwise directions. The plates were incubated at 37°C for about 48 hours. The isolates were identified by morphological methods through colonial morphological Gram staining, Oxidase, Catalase, Indole, Methyl Red (MR) ,Voges-Proskauer (VP) and Motility.

3.0 Results and Discussion

3.1 Results

(i) Electrical Resistivity Profiling

Figures (4 and 5) are the apparent resistivity pseudo-sections from 2-D imaging survey of the study area and the control, showing different colour description in terms of resistivity values upon which the results were interpreted. The blue colour depicts low resistivity zones, the brown colour shows the high resistivity zones, while other colours were within the range.

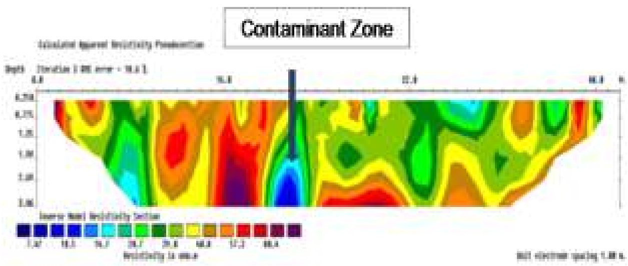


Figure 4: The apparent resistivity pseudo-sections from 2-D imaging survey

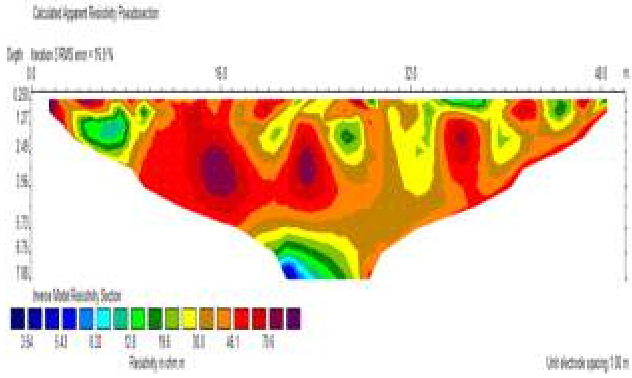
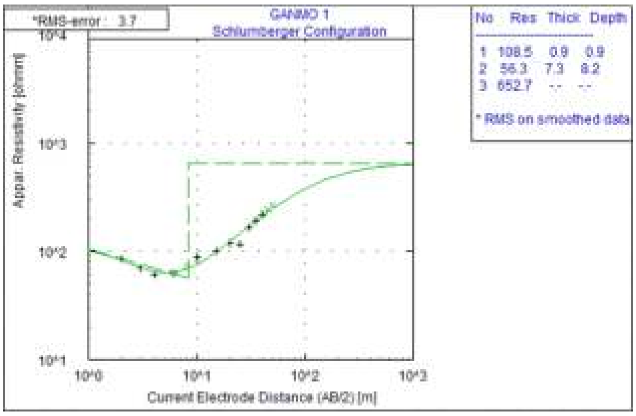


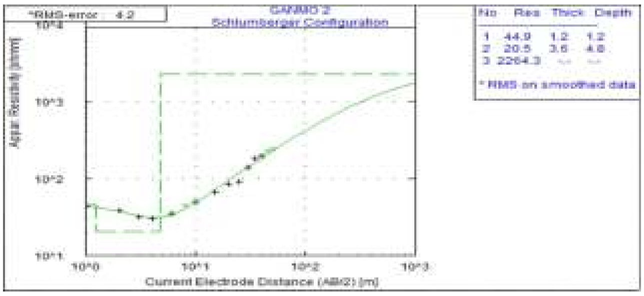
Figure 5. The apparent resistivity pseudo-sections from 2-D imaging survey (Control site)

(ii) Vertical Electrical Sounding (VES) Results

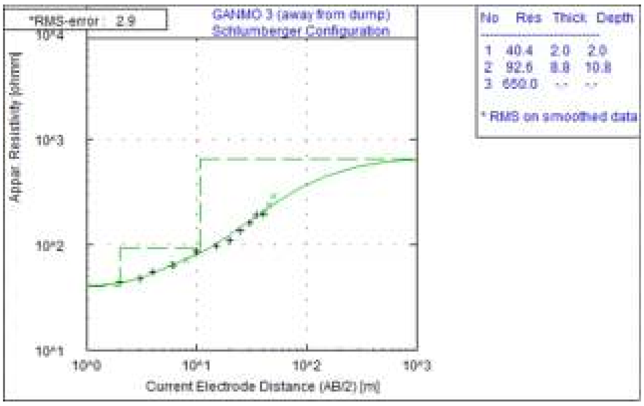
Figures 6 (a) –(c) are VES Type curves obtained in the study area. Various important point along the curve indicate: resistivity, thickness, depth and layers of the area



(a) H- Type Curve for VES-1



(b) H-Type Curve for VES-2



(c) A-Type Curve for VES-3

Figures 6 (a) – (c) VES Type curves obtained in the study area

Table 1 shows the Vertical Electrical Sounding Analysis consisting of number of VES carried out, the layers obtained, the resistivity value of each layer, the thickness and the depth

Table 1: Vertical Electrical Sounding Analysis

VES	LAYERS	RESISTIVITY (Ωm)	THICKNESS (m)	DEPTH (m)
VES 1	1	108.5	0.9	0.9
	2	56.5	7.3	8.2
	3	652.7	-------------	----------
VES 2	1	44.9	1.2	1.2
	2	20.5	3.6	4.8
	3	2264.3	------------	----------
VES 3	1	40.4	2.0	2.0
	2	92.6	8.8	10.8
	3	650.0	-------------	---------

3.3 Physico-chemical Analysis

Table 2 shows the Comparative analysis between water quality standard and physical appearance of the water sample, the concentration of the identified elements in the water sample from the result of Physico-chemical analysis of hand dug well water samples in the study area. Table 2: Comparative analysis between water quality standard and the result of Physico-chemical analysis of hand dug well water samples in the study area.

PARAMETERS	WELL A	WELL B	WELL C	NSDWQ (mg/l	WHO (mg/l)
Depth of wells (m)	9.75	8.15	10.0		
Distance of wells from dumpsite(m)	28.00	13.45	20.00		
Colour	colourless	colourless	colourless	Clear,colouless	Clear,colouless
Taste	tasteless	tasteless	tasteless	Unobjectionable	Unobjectionable
Odour	None	none	none		
pH	8.08	8.43	7.88	6.8 -8.5	6.8 - 8.5
Temperature (^0C)	29.0	29.50	30.0		24.5 -39.7
Fe^{2+}(mg/L)	0.3	0.5	0	0.5	0.5
Pb^{2+}(mg/L)	0	0	0	0.01	0.01
Cu^{2+}(mg/L)	0	0	0	1.0	2.0
Zn^{2+}(mg/L)	0.01	0	0	3.0	3.0
K^+(mg/L)	3.3	9.7	2.1		15
Na+(mg/L)	2.9	6.4	4.4	200	200
Mg^{2+} (mg/L)	5.27	5.40	5.35	0.2	0.2
Ca^{2+} (mg/L)	1.5	5.4	5.8	75	75
Ni	0	0	0	0.02	0.02
Cd	0	0	0	0.003	0.003
Cl^-(mg/L)	5.40	10.97	34.92	250.0	250.0
Cr^{+3}(mg/l)	0.15	0	0.06	0.05	0.05
Mn(mg/l)	0.022	0.016	0.042	0.05	0.4
Co(mg/l)	-0.01	0.04	0.05		
SO_4^{2-}(ppm)	7.33	10.51	12.74	250.0	100.0
NO_3^-(ppm)	14.09	1.8	2.09		50
PO_4 (ppm)	1.14	0	1.13		250
CN-(mg/L)	0	0	0		0.07
TDS(ppm)	230.00	330.00	400.00		1000
DO(mg/L)	5.40	4.60	4.00	3.0	3.0
BOD(mg/dl)	5.30	6.00	6.30	10	10
COD(mg/dl)	3.60	4.60	5.4	10	10
Turbidity(mg/L)	0.20	0.52	0.42		5.0

3.4 Bacteria Analysis

Table 3a and 3b show some substances used in the identification of the existence of some bacterial, their number of occurrence, percentage of occurrence in the Water Sample taken in the study area

Table 3a: Results of Microbiological Analysis of Water Sample

Table 3b: Results of Microbiological Analysis of Water Sample

Methy red	*Vogesprausker*	Citrate	Indole	Starch hydrolysis	Coagulase	Catalase	Oxidase	Gram staining	Motility	Hydrogen suiphide	Citrate	Bacteria Identification
+ve	-ve	-ve	+ve	-ve	-ve	+ve	-ve	+ve	+ve	-ve	-ve	***E. coli*sp**
-ve	+ve	+ve	-ve	-ve	-ve	+ve	-ve	-ve	-ve	-ve	+ve	***Klebsiellasp***

WELLS	ORGANISM				WHO, Guideline	
	E.coli		*Klebsiellasp*		E.coli.	*Klebsiellasp*
	Number of occurrence	Percentage of occurrence	Number of occurrence	Percentage of occurrence	0 in 250ml	0 in 250ml
A	15	55.6	-			
B	-		17	56.7		
C	12	44.4	13	43.3		
TOTAL	27	100	30	100		

Key: (+ve) – Positive, (-ve) –Negative, (%) - percentage

3.2 Discussion

The Results of the study area as presented in figure 4 showed a contaminant leachate plume delineated in 2-D resistivity sections as low resistivity zones. The 2-D resistivity imaging showed bluish zones of low resistivity range of 7.47 to 10.50 Ωm with the depth range of 2.69 to 3.46 m in the entire inverse model sections. The low resistivity value obtained revealed the portion of dumpsite that the contaminant was situated. Comparing the profile within the dumpsite to profile 60m away outside the dumpsite serving as control (Figure.5), it was noted, generally, that rocks outside the dumpsite are more resistive than those within the dumpsite indicating non pollutant. The Structures suggesting local pool of contaminant on the dumpsites as shown on 2-D ERP tomograms. High resistivity signatures on 2-D ERP tomograms suggest the presence of basement rocks that are not permeable to contaminant infiltration.

The VES data interpretation results are presented in Figures 6(a) -(c). The partial curve matching technique carried out on the field data acquired on the dumpsite and control revealed a 3 layered model (Ige, 2014) with H and A type curve ($\rho1>\rho2<\rho3$, $\rho1<\rho2<\rho3$) for all the soundings. The VES interpretation reveals three geo-electric layers across the research area: the topsoil consisting of sand and decomposed organic matters; the weathered layer and the bedrock constituting the fractured or fresh basement. The geo-electric sections show subsurface variation in electrical resistivity along the profiles, as presented in Table 1. However, the low resistivity values observed in the second layer (Figure.6b, VES-2) is due to pollution which resulted from the high porosity and permeability characteristics of the sandy soil encouraging the seepages of the leachate plumes to a maximum depth of 4.8m at the subsurface. The third layer has high resistivity values ranging from 650.0 to 2264.3 Ωm which indicated the fractured or basement zones. However, high resistivity values observed in the layers of the control sites of (figure 6a) showed non pollution of the area. (Table 1).The thickness of this geo-electric layer is to an infinite depth.

Assessment of impact of leachates on surrounding groundwater quality shows that all major ions revealed concentration below the acceptable limit of The World Health Organization (WHO) and Nigeria Standard for Drinking Water Quality (NSDWQ) standard guidelines used as standard for assessing the groundwater quality in the research area, except Chromium concentrations in well C, Magnesium concentrations in all the wells which were slightly above the acceptable standards limit in most of the surface and shallow groundwater downslope of the dumpsite, as presented in Table 2. The levels of pH in majority of ground water samples are in the range of 7.88 – 8.43. This is in conformity with The World Health Organization (WHO) and Nigeria Standard for Drinking Water Quality (NSDWQ) standard. The various parameters tested in the sampled wells show different concentration, the depths of the sampled wells and their various distances from the waste disposal site are presented in Table-2.

Base on biochemical characterization and identification of the bacteria, the assessment of bacteriological quality of water shows the presence of bacterial species load of *E. coli* and *Klebsiellasp*, as presented in Table 3(a)-(b) *which* can cause severe health hazards like stomach cramps, diarrhea, vomiting, fever, urinary tract infection, pneumonia, hepatic infections, *bacteraemia*, meningitis, skin and soft tissue and opportunistic infections on burns, wounds and also blood related infection (NSDQW., 2007)

4.0 Conclusion

The study revealed that part of the dumpsite investigated have been considerably contaminated due to migration of leachate which could pose some health risks to the residents. This is evident from Low Resistivity values obtained from the result of the ERT that established the presence of the contaminants in the study area. The hydro geologic features of the study area showed that contaminants derived from the waste disposal site infiltrate through vulnerable sandy formations and hence to the groundwater flow. The variation in the concentration of some metals and element might have been as a result of the infiltration. It could be concluded from this study that contaminant is present in the area. However, based on the results of the hydro-chemical and bacteriological status of the surrounding well water, it is concluded that the groundwater is mostly unsuitable for human consumption.

However, it is recommended that effective and frequently monitoring of ground water quality will safe guard the health of the public residing in the surroundings of the dumpsite and improved waste disposal management system is also advised.

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