Science World Journal Vol 11 (No 4) 2016
www.scienceworldjournal.org
ISSN 1597-6343

Full Length Research Article

GEOPHYSICAL AND GEOCHEMICAL CHARACTERIZATION OF ZANGO ABATTOIR

N.K. Abdullahi

Department of Physics, Kaduna State University, Kaduna.

Corresponding author email: nkhalid26@yahoo.co.uk

ABSTRACT
A Very-Low Frequency measurement in E-M mode and geo-chemical analysis of soil and water samples were conducted at Zango abattoir in Tudun Wada area, Kaduna South, Kaduna State, Northwest, Nigeria. The aim is to study the potential for contaminants intrusion into and consequent contamination of soil/groundwater and to examine the impact of livestock dung on soil/ground water status in the study area. The VLF data were acquired at 5 m intervals along two (2) profiles with maximum length of 60 m in the North-South direction. Quantitative interpretation achieved through inversion of the VLF-EM data detected fractures/ lithological boundaries that may possibly serves as conduit for the movement of solid waste contaminants into the soil/ground water. Analysis of water samples from existing hand dug wells deviated from WHO standards, thus, complementing the VLF - EM results while analysis of results of soil samples shows that the engineering properties of the soil in the study area has been affected as a result of solid waste accumulation.

Keywords: VLF-EM, Abattoir, Geo-chemical, Zango, Contaminants

INTRODUCTION

Water is one of the nature's most important gift to humanity and all living things. The important of this gift of nature is such that without it man hardly exists as noted by (Maguvu and Mutengu, 2008). Groundwater forms a significant part of the water resources all over the world particularly in the arid areas and favoured for domestic purposes partly because: groundwater is of high quality and requires little treatment before use since, according to(Sampat, 2001) fungi, bacteria and other biological pollutants are naturally filtered and diluted as the water percolates through the soil and partly because the provision of portable water via the water supply scheme is grossly inadequate for the needs of the people. But as a result of careless management and/or disposal of hazardous materials, fresh groundwater supplies would be greatly decreased. Adequate water supply to any community is therefore, crucial and determining factor indicating the health condition of such community (WHO, 1985).Ground water development increased significantly during the second half of the last century in most semiarid and arid areas of the world. This development have mainly been undertaken by a large number of small (private or public) developers and often the scientific /technological knowledge of this development by the responsible water administration has been scarce (Llamas, 2004; Ugya et al., 2015). Residents of Kaduna South Local Government Area rely heavily on ground water for domestic use, where over eighty percent (80%) of the populace in the local government area use tube wells or bore holes as water sources. The use of water is restrained by its quality which makes it unhealthy for a particular use, thus, water quality depends on the physical, chemical and biological composition of water. An understanding of the physico-chemical, as well as biological composition of water will enhance the detection of future deviation in water quality (Eze and Madumere, 2012). In the study area, Zango abattoir in Tudun Wada, Kaduna South, Kaduna State, North West, Nigeria, pollution arises from inappropriate disposal of animal waste (dung), lack of good manufacturing practices (GMP) and lack of good hygiene practices (GHP). As such livestock dung piled up and waste water containing blood and dung are discharged into the nearby wells, rivers, and streams without treatment, which could lead to pollution of ground water in the study area. The various metals produced by oxidation processes in the groundwater flow system may change considerably the conductivity of the polluted zone; hence the Geo-electric and Electromagnetic (EM) geophysical methods could effectively be used to map these zones (Reynolds, 1997) In spite of the effective use of these methods, the cost and the required operational time are considerably very high. To overcome this problem, the VLF-EM method can economically be used. The VLF-EM method uses radio signals in the bandwidths of 15 – 30 KHz and is powerful tool for quick detection of near surface structures. Because of the easy operation of the instrument, speed of field survey and low operation cost, this method is suitable for rapid preliminary surveys and has been widely used in many geophysical investigations (Sharma, et ,al, 2005). The existence of fracture zone in a geological medium can assist in creating ground water conduit medium and aids groundwater accumulation. Therefore, the use of VLF as geophysical tool is very crucial as it is very sensitive to changes in lithology and can detects zones of relatively low conductivity (fractures). The present research is aimed at assessing the effect of livestock dung on the physical and chemical properties of soil and groundwater in the Zango abattoir in Tudun Wada area of Kaduna South, Kaduna State, Northwest, Nigeria, using the Very Low Electromagnetic Method (VLF-EM) and physicochemical analysis of soil and water samples.

MATERIALS AND METHODS

Site Description, Geology and Hydrogeology

The study area is Zango abattoir in Tudun Wada, Kaduna South, Kaduna state It is located with coordinates, latitude 10030'104" N, and longitude 007024'452" E in the national grid. The study area

is both accessible by road and foot, covering 104.5028km2. The Zango area, Tudun Wada, Kaduna South lies within the area of the basement complex of Northern Nigeria (Fig 1) and it is underlain by a regional series of granites, gneisses, migmatite and a sequence of lateritic clay, clayey sand/sand and weathered/fractured bedrock. The top soil varies in composition, colour and texture and at most places are predominantly laterite and quartz grains (deep brown or reddish brown soil) The rocks are aquifer only when they are either weathered or fractured, otherwise they are dry or contain just little amount of water. Over most of the area underlain by the basement complex, there is a thin discontinuous mantle of weathered rock, mostly pronounce where the topography is subdued. The average thickness of the mantle is probable of the order of 15m, but in some areas it may extend to depth of up to 60 m (Russ, 1957). The interface between weathered and un-weathered rock is usually sharp, and weathering tend to be particularly well develop alone fissure system, which allow deep percolation of the weathering agents principally oxygenated water(Olugboye, 1975).

Very-Low Frequency Measurements

VLF-EM data were collected along two (2) profiles and measurements were made with a station separation of 5 m using the Scintrex Envi meter in the VLF-EM mode (i.e. measuring the ratio of the polarized magnetic field).The Scintrex Envi meter utilizes the magnetic component of the electromagnetic field generated by military radio transmitters that use the VLF (Very Low Frequency) band, that is, 15 to 30 KHz commonly used for low distance communication. The Scintrex Envi meter measures this field strength and phase displacement around a fracture zone or any conductive body in the rocks (Telford et al., 1990). It detects the ratio (in percent) between the vertical and the horizontal components. The VLF transmitter HWU located in La Blanc, France, operating at a frequency of 18.3 KHz with co-ordinates 46N37-001E05 was selected as the source for the entire VLF survey because it provided a field which is approximately perpendicular to the direction of the strike of the envisaged geological structure beneath the ground surface. Each of the profiles has a maximum length of 60 m. The in-phase and Imaginary data were presented as single profiles. To locate the anomalies, measured data were processed using Fraser filtering. The linear filtering technique developed by Fraser (1969) converts somewhat noisy, non-contourable in-phase components to less noisy, contourable data, which ensures greatly the utility of the VLF-EM survey. The filtering process simply involves a four point weighted average using the weights of -1, -1, +1, +1. This simple digital filter operator passes over the in phase component and when plotted generally peaks over the top of the conductor. Quantitative interpretation of the single frequency (18.3 kHz) VLF-EM data was achieved using the inversion code of Monteiro et al (2006) to yield subsurface resistivity distributions.

Geo-Chemistry: Soil and Water Characterization

Water from eleven wells in zango area designated as control area, abattoir area and cow dung dump area were collected at a different depths of static water table from 0.2 m to 5.10 m for the determination of the following parameters: Bio-chemical Oxygen Demand (B.O.D), Chemical Oxygen Demand (C.O.D), Ph, Cadmium (Cd), Zinc (Zn), Iron (Fe), Copper (Au), Lead (Pb), Chromium (Cr), and electric conductivity (EC).The soil sample were collected from 0.3 m to a maximum of 0.9 m at the three designated locations and the index properties determined were: water content (moisture content), Specific gravity, Sieve analysis and Atterberg or consistency limit. Both the water and soil samples were analysed at Water and Soil laboratories in the Civil Engineering Department of Kaduna Polytechnic.

RESULTS AND DISCUSSION

Interpretation of VLF-EM DATA

Figure 2 shows the VLF profile data (real and Imaginary) and real Fraser Filtered along traverse A. The figure shows that the Imaginary component is positive with values ranging from +0.9% to +11.3% while the real component contains both positive and negative values. These patterns of the VLF profile are suggestive of shallow conductive structure underlying this traverse (Adepelumi et al, 2005). The real component makes sign crossover above profile coordinates 25 m and 35 m which is interpreted as vertical contact/Fracture. The real data became enhance and more definitive after the filtering process.

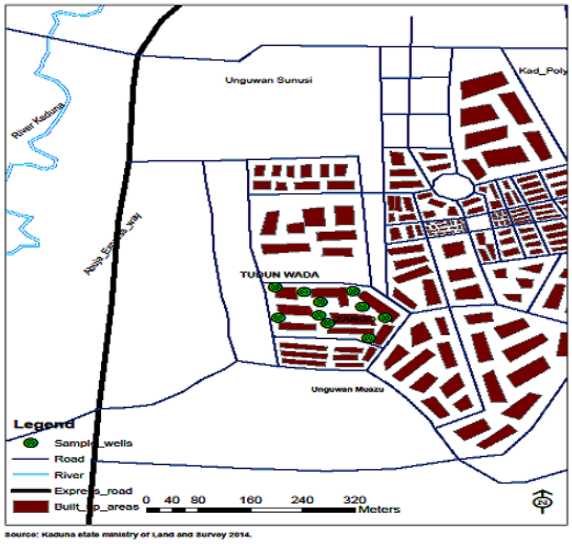

Fig 1: Topographic map of the study area

The Fraser-filtered data (in-phase) has high positive peak (+ 9 %) response at position 35 m and is almost symmetrical; this is an indication of anomalous body of large dimension and steeply dipping source (Abdullahi, et, al, 2011). The anomalous zone (-4%) detected in the Fraser Filtered profile which corresponds with the sign crossover above profile coordinates 25 m observed in the real component VLF data is interpreted as vertical contact between the surface material and the country rocks(Telford et al,1990). The 2D resistivity model generated using the 2DINVLF code (version 1.1) developed by Monteiro Santos (2006) for quantitative interpretation of the VLF data (Fig 3) correlates quite well with the Fraser filtered response of the VLF data. The 2D resistivity model shows resistivity values of 100 ohm-m and >100 ohm-m at the crossover points which is indicative of vertical contact and Fracture in the crystalline basement rock respectively.

Figure 4 is the VLF profile data (real and imaginary) and Fraser-filtered response of the real component along profile B. The real component makes sign crossover above profile coordinates 20 m

and 30 m which is interpreted as vertical contact/Fracture. The imaginary component shows a positive inflection at both sign cross-over and may indicate a relatively weak conductor in non-conductive ground (Jeng et al., 2004). However, a high positive peak response of the Fraser filtered component at the 20 m cross-over point is favorable location for fractures (Sundararajan et al., 2007).

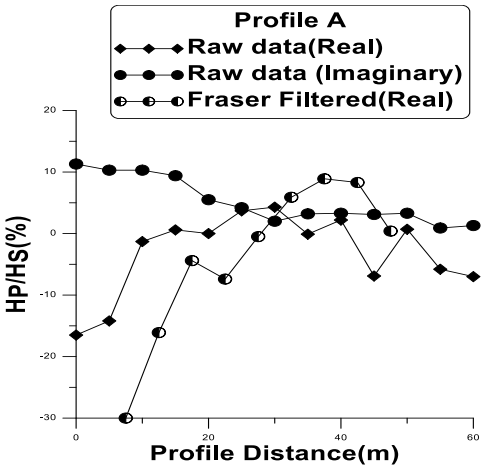

Fig 2: Real, Imaginary and Fraser Filtered (real) along profile A

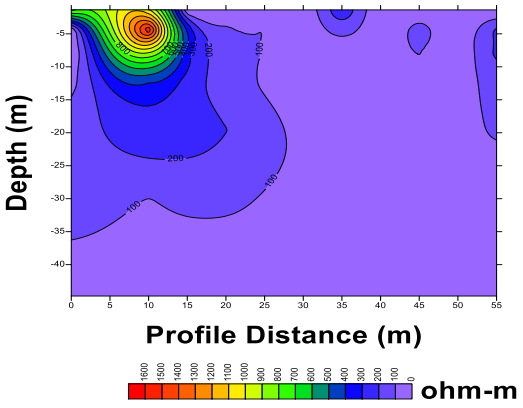

Fig 3: 2D resistivity model obtained from inversion of VLF data along Profile A

The Fraser-filtered data (real) response at position 20 m is almost symmetrical and is an indication of anomalous body of large dimension and steeply dipping source (Abdullahi, et, al, 2010). Fig 5 is the 2D resistivity model generated from the VLF-EM data. The resistivity model shows low resistivity zone (55 ohm-m) at the cross-over points (20 m and 30 m) which corroborated the conclusion drawn from the results of the VLF data. The low resistivity end (10 ohm-m to 30 ohm-m) may indicate contamination of the soil.

Groundwater geochemistry

Table 1 shows the measured parameters of well samples from 11 locations (three from residential area, five from the abattoir and three from cow dung dump area) with different static water depths. From the results of table 1, the cow dung dump and abattoir investigated areas show elevation of the heavy metals higher than the control area apparently due to excessive exposure of the area to livestock waste. The concentration of BOD ranges from 48.00 mg/l to 520 mg/l. The result shows that the Control area has the minimum mean (average) of 268.67mg/l due to lack of constant dumping of dung and non-direct discharge of organic waste directly into the streams and wells from adjourning abattoir. Due to direct discharge of organic waste into the streams and wells, the cow dung dump area has the highest mean of 447.33mg/l and 808.85mg/l of BOD and COD respectively. The acidic nature of the pH(mean of 5.97) in the Cow dung dump area is due to the production of acid by bacteria as a result of permanent exposure to organic waste action (Bhaita, 2011). This signifies that the water is unsafe for drinking.

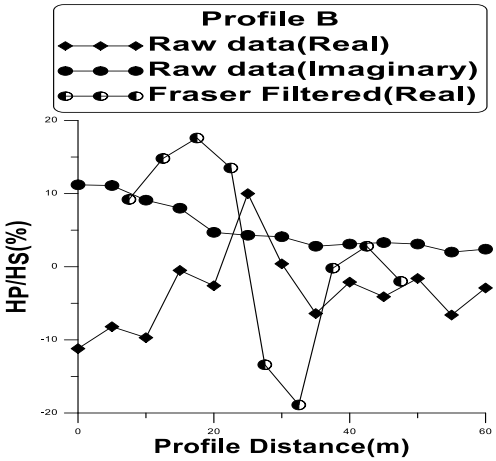

Fig 4. Real, Imaginary and Fraser Filtered (real) along profile B

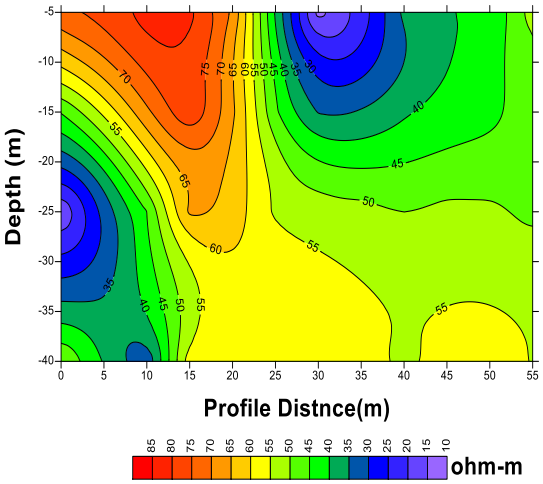

Fig 5: 2D resistivity model obtained from inversion of VLF data along Profile B

Table 1. Geochemical Parameters of well water samples

Investigated area	Measured Parameters										
	Depth of static water level(m)	Conductivity (µs/Sm)	pH	COD (mg/l	BOD (mg/l)	Cadmium (mg/l)	Zinc (mg/l)	Iron (mg/l)	Lead (Mg/l)	Copper (mg/l)	Chromium (mg/l)
Control	0.50	1030.0	6.7	90.24	48.00	NIL	0.01	0.14	0.01	0.08	0.12
	1.00	580.0	6.4	658.00	350.00	0.410	0.02	0.20	0.01	0.12	0.33
	0.50	1280.0	6.4	767.00	408.00	0.010	0.03	0.35	0.10	0.11	0.30
Abattoir	1.20	1510.0	6.3	977.00	520.00	NIL	0.03	0.30	0.10	0.14	0.31
	0.40	1610.0	6.3	838.48	446.00	NIL	0.05	0.25	0.11	0.14	0.41
	0.20	590.0	6.0	733.20	390.00	0.001	0.05	0.32	0.12	0.15	0.32
	0.10	1810.0	6.1	893.00	475.00	0.001	0.06	0.40	0.14	0.16	0.11
	1.20	1310.0	6.4	962.56	512.00	NIL	0.07	0.26	0.11	0.11	0.16
Cow dung dump	0.40	570.0	5.8	909.92	484.00	NIL	0.05	0.31	0.12	0.12	0.17
	1.40	580.0	5.9	748.24	398.00	NIL	0.08	0.32	0.14	0.14	0.12
	5.10	1930.0	6.2	864.80	460.00	NIL	0.11	0.34	0.16	0.16	0.14
WHO(1992)		1000	6.5-8.5	80.0	<40	0.003	3	0.30	nil	1.00	0.05

Soil analysis

From table 2, as a result of animal activities at the cow dung dump area, the moisture content (12.5%) is higher than that of the abattoir and control area. This result suggests that the action of livestock has affected the soil by increasing its water holding capacity. Results of the specific gravity reveals that the cow dung dump area has the least mean value of 2.22. This could be attributed to reduction of the density of the soil in the area as a result of the effect of the organic waste. The results of the percentage content of clay and slit in the control area is low compare to those of the abattoir and cow dung dump areas apparently due to absence of livestock activity. Table 2 also shows the shearing strength against flowing of soil (consistency of the soil) for control area is greater than both the cow dung dump and abattoir areas. Also, livestock dung effects manifest in the shrinkage limit analysis of the soil samples. The results show abattoir and cow dung dump area have an average shrinkage limit of 10.11% and 8.92 % respectively while the control area has an average of 38.81%.

Table 2. Geochemical Parameters of soil samples

Investigated area	Measured Parameters								
	Sample no	Depth(m)	Moisture content (%)	Specific gravity	Sieve analysis (%)	Atterberg determination			
Control						Plastic Index (%)	Plastic limit (%)	Liquid limit (%)	Shrinkage limit (%)
	C_1	0.0-0.3	7.08	2.58	42.84	14.09	18.26	33.00	8.57
	C_2	0.3-0.6	11.53	2.52	52.28	20.36	17.64	38.00	10.71
	C_3	0.6-0.9	10.53	2.23	54.30	19.97	17.03	37.00	11.43
Abattoir	A_1	0.0-0.3	2.67	2.65	35.74	4.04	34.96	39.00	10.00
	A_2	0.3-0.6	7.43	2.42	45.74	12.64	18.36	31.00	9.29
	A_3	0.6-0.9	7.43	2.32	56.28	9.60	25.40	35.00	10.71
	A_{11}	0.0-0.3	1.54	2.49	44.30	14.09	33.91	48.00	6.43
	A_{22}	0.3-0.6	9.92	2.34	44.90	14.97	16.03	31.00	100.00
	A_{33}	0.6-0.9	9.66	2.61	46.96	16.06	20.94	37.00	10.00
Cow dung dump	D_1	0.0-0.3	6.00	1.92	43.60	15.57	16.53	32.00	10.00
	D_2	0.3-0.6	9.01	2.25	61.12	14.33	18.67	33.00	8.57
	D_3	0.6-0.9	12.37	2.28	57.84	9.49	25.51	35.00	10.71
	D_{11}	0.0-0.3	20.20	2.10	42.84	14.25	31.75	46.00	7.14
	D_{22}	0.3-0.6	14.70	2.32	52.28	12.53	20.47	33.00	8.57
	D_{33}	0.6-0.9	13.03	2.42	54.30	6.44	32.56	39.00	8.57

CONCLUSION

The results from the VLF-EM filtered real curves show the presence of vertically dipping conductive features which were interpreted to be fracture zones filled with contaminants. The asymmetry of the conductive anomaly indicates a dipping conductive sheet and these subsurface structures probably act as conduits for conveying contaminated plumes into the surrounding ground water. The results from the physio-chemical parameters of the study area complemented the VLF EM survey. The ion concentrations of the measured parameter differ significantly from

WHO permissible limit. This implies that, the water is not suitable for human consumption. The level of Bio-Chemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) were high indicating enormous load of organic compound released by hydro spherical environment. The source of heavy metals in the study area could be attributed to release of organic materials to the soil which consequently is transported into the ground water. Both geophysics results and soil test analysis indicated that the engineering properties of the soil has been affected, and the study area is not good for engineering work , such as construction of high rise building and waste facilities..

REFERENCES

Abdullahi, N.K, Osazuwa, I.B and Sule, P.O (2011): Application of Integrated Geophysical Techniques in the Investigation Of Groundwater Contamination: Case study of Municipal solid waste leachate. *Ozean Journal of applied sciences, 4(1): 7- 25.*

Adepelumi A. A., Ako, B. D., Afolabi O., Arubayi J. B.(2005). Delineation of contamination plume around oxidation sewage-ponds in Southwestern, Nigeria. Environmental Journal, 48: 1137-1146.

Bhaita, S.C. (2011) Environmental Pollution and Control in Chemical Process Industries. 2nd Edition, Kanna Publishers India pp 1273

Eze S. and Madumere I. (2012). Physicochemical and microbiological analysis of water bodies in Uturu, Abia State_Nigeria, Annual Joint Scientific Conference, 1, 58–65.

Fraser, D.C (1969):.Contouring of VLF-EM data. *Geophysics,* 34: 958–967.

Llamas R (2004). Water and Ethics Use of Ground Water, France UNESCO

Maguvu, E. S. and Mutengu, S. (2008). An Investigation into the Factors Limiting Effective Water Supply in Rural Areas of Zimbabwe. A case study of Zhomba in Gokwe North District, Journal of Sustainable Development in Africa, Vol. 10, No 1, 120-138.

Monteiro, S. F. A., Mateus, A., Figueiras, J. and Gonçalves, M, A Mapping groundwater contamination around a landfill facility using the VLF-EM method— A case study: Journal of Applied Geophysics, 60, 2006, 115–125

Olugboye, N.O (1975): Hydrogeology of Kaduna Town. G.N.S Report No 1539.

Reynolds J.M, An Introduction to applied and environmental geophysics (John Wiley& Sons Ltd, 1997).

Russ, W (1957), The Geology of parts of Nigeria, Zaria and Sokoto Provinces. Published by the Authority of Federal Government of Nigeria.

Sharma, S.P, and Baranwal, V.C, Delineation of Groundwater–bearing Fracture Zones in a Hard Rock Integrating Very Low Frequency Electromagnetic and Resistivity Data. Journal of Applied Geophysics, 57, 2005, 155-166.

Sundararajan, N., Narasimah, C. M., Nandakumar, G. and Srinivas, Y, VES and VLF—an application to groundwater exploration, Khammam, India. The Leading Edge, 25, 2006, 708-716

Ugya, A.Y., S.A. Umar and A.S. Yusuf, 2015. Assessment of well water quality: A case study of Kaduna South local Government area, Kaduna state Nigeria. Merit Res. J. Environ. Sci. Toxicol., 3: 39-43.

Telford, W.M., Geldard, L.P. and Sheriff, R.E. (1990). Applied Geophysics (second edition).Cambridge University Press.

YihJeng, Ming-Juin Lin, Chih-Sung Chen, and Yu-Huai Wang, Noise reduction and data recovery for a VLF-EM survey using a nonlinear decomposition method. Geophysics, 72, 2007, 223–235

World Health Organization. 1992. Guidelines for drinking water quality (WHO Geneva 1992).