J. Chem. Soc. Nigeria, Vol. 50, No. 4, pp 909 – 917 [2025] https://dx.doi.org/10.4314/jcsn.v50i4.16

HEAVY METALS POLLUTION LEVELS OF HAND-DUG WELLS IN TARKA LOCAL GOVERNMENT AREA, BENUE STATE-NIGERIA

[1]N. L, Magashi*., [2]M. Abah., [3]T. Magashi., [4]C. H, Dabwan., and [5]D. D, Tsua

[1]Centre for Food Technology and Research (CEFTER), Benue State University Makurdi. Benue State.
[2]Department of Science Laboratory Technology, Federal Polytechnic Wannune, Benue State-Nigeria
[3]Department of Petroleum Engineering, University of Ibadan, Ibadan, Nigeria
[4]National Institute for Hospitality and Tourism (NIHOTOUR), No. 5, Yakubu Gawon Way Kaduna State
[5]Department of Environmental Sustainability, Joseph Sarwuan Tarka University Makurdi. Benue State
Corresponding Author: Magashi Nicholas Luper
Email: magashism@gmail.com Phone: (+234)8062912563

ABSTRACT

This presents study assessed some physicochemical parameters (temperature, pH, conductivity, turbidity and dissolved oxygen) in hand dug well water from ten (10) locations within Wannune in Tarka LGA of Benue State, Nigeria. Ten (10) heavy metals concentration zinc (Zn), mercury (Hg), Arsenic (As), chromium (Cr), copper (Cu), nickel (Ni), iron (Fe), cadmium (Cd) and lead (Pb) were also determined using atomic absorption spectrophotometry (AAS). The results revealed the mean values for temperature, pH, conductivity, turbidity and dissolved oxygen to be 2.79±0.876 ºC, 6.35±0.313, 153.4±99.633 µs/cm, 3.85±1.556 NTU, and 5.70±0.666 mg/L respectively. The results also revealed very low concentrations of heavy metals (within WHO and NSDWQ standard for portable water) except for Fe (0.51 mg/L) from W_4 which is slightly above the prescribed limit (0.3 mg/L) prescribed by WHO and NSDWQ and is attributed to mechanical repairs of vehicles, use of engine oils on daily basis and rusting from iron buckets used for abstracting water from the well. Hg, As, Cu and Mn were not detected in any of the well water samples. The authors therefore recommend that the water is safe for drinking and domestic use but members of the community should construct wells away from dumpsites or sites where mechanical activities occur also adopt a better practice of abstracting well water than the use of iron buckets.

Key Words: Hand-dug, heavy metals, microbial, Wannune, well water

INTRODUCTION

Water is the most crucial and precious natural resources, it is very important in the life of all living organism, plant and microorganism and to humans [1].

According to World Health Organization [2], 75% of all diseases in the developing and underdeveloped countries such as Nigeria arise from polluted drinking water. Therefore, water quality concerns are often the most important component for measuring access to improved water sources.

Wells are dug between one to few meters below the ground surface to explore the ground water. The major source of portable water for drinking and other domestic activities in Wannune is the dug well water. The wells are often more vulnerable to contamination than deeper boreholes and they have been abstracted by hand pump, windlass or rope and bucket system. Contaminants such as heavy metals, nitrates and

ISSN 0795 - 22066

salts have polluted water supplies because of inadequate treatment and disposal of waste from humans and livestock, industrial discharges, and over utilization of limited water resources [3].

This study therefore seeks to investigate heavy metal concentration in hand dug wells in Wannune, Tarka Local Government Area of Benue State with a view to ascertain whether the is safe for human consumption

Heavy Metals occur naturally with high atomic weight and high density that is at least five times that of water [4]. They include lead (Pb), cadmium (Cd), zinc (Zn), mercury (Hg), arsenic (As), silver (Ag) chromium (Cr), copper (Cu) iron (Fe), and the platinum group elements. Their concentrations in water are increasing daily due to increased human activities as a result of urbanization, industrialization, transportation, electricity generation, and agricultural activities as a result of increasing population.

World Health Organization report showed that Cd and Zn are among ten (10) harmful heavy metals of major concern [5]. [6], reported that Cr and Cd are heavy metals of concern in stream waters. According to [7], increase in the occurrence of heavy metals levels in water is becoming a serious hazard to human health. Increase of heavy metals in the body system can lead to a decrease in the mental, psychological and physical health of the individua [8]. For instance, excess amount of iron >10 ppm will result to coagulation of blood in blood vessels and an increase in pulse rate, drowsiness and hypertension [9].

Though, some heavy metals such as Cu and Zn are essential to maintain the metabolism of the human body, but their concentration above acceptable limits can be poisonous [10].

MATERIALS AND METHODS

Description of the Study Area

The study was carried out in Wannune, the administrative headquarters of Tarka Local Government Area of Benue State. Wannune is small town with an area of 371 km^2 and a population of 79,479 (2006 census) sharing boundary with Guma, Gboko, and Buruku local government areas, all in Benue State.

ISSN 0795 - 22066

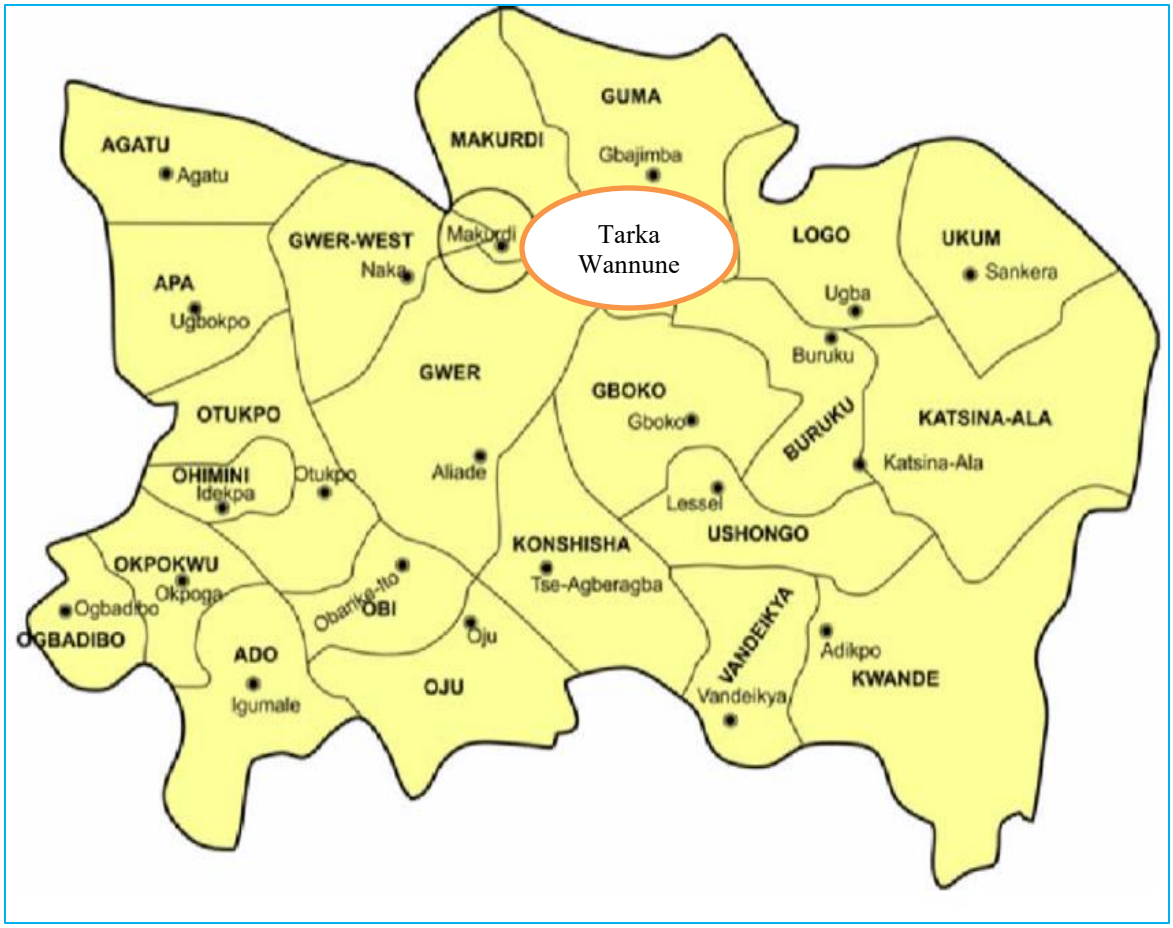

Figure 1: Map of Benue State showing the study area

Sample collection

Water samples from hand-dug wells in Wannune were collected in January, 2025 from ten (10) different areas within Wannune. The water samples were collected using rope tied to plastic bucket, dipped into the wells and drawn out into well-labeled 2 liters plastic containers. The containers were labeled W_1-W_{10}. The plastic bottles were washed in non-ionic detergent and rinsed with tap water after which it was soaked in 10 % JHD nitric acid HNO (Analar Grade) for 24 hours and then rinsed in deionized water ready for use [11]. The containers were rinsed with well water several times before taking samples.

Laboratory Analysis

Temperature, pH, conductivity, turbidity and dissolved oxygen (DO) were all determined at sampling point using mercury in glass thermometer, Jenway pH meter model 3510, Wagtech conductivity meter, direct reading spectrophotometer (DR/2000) made by HACH Company and dissolved oxygen analyzer (JPB-607) portable respectively.

Digestion Procedure

100 mL of the well water sample was placed in a 125 mL conical flask and digested with 5 mL

ISSN 0795 - 22066

Conc. HNO_3 on a hot plate at 95 °C until a clear solution was obtained. The wall of the conical flask was washed with deionized water and then filtered. The filtrate was transferred into a 100 mL volumetric flask, diluted to mark with deionized water and mixed thoroughly. The concentration level of ten (10) heavy metals zinc (Zn), Arsenic (As), lead (Pb), Magnesium (Mg), chromium (Cr), copper (Cu), nickel (Ni), manganese (Mn), iron (Fe) and cadmium (Cd) were determined using an atomic absorption spectrophotometer (AAS, Model PG 990) by procedure reported by Oyelola et al., 2008 [21].

RESULTS AND DISCUSSION

The results for physicochemical properties are presented in table 1 while those of heavy metal concentrations are presented in figure 1-10. The results are compared with World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ) guidelines for portable water.

Table 1: Physicochemical properties of well water

	Parameters				
Sample Code	**Temp (°C)**	**pH**	**Cond. (µs/cm)**	**Turb. (NTU)**	**DO (mg/L)**
W_1	28	6.0	52	1.9	5.20
W_2	27	6.0	71	0.9	6.87
W_3	27	6.8	210	5.0	5.31
W_4	28	6.2	118	2.9	5.80
W_5	27	6.8	89	4.7	5.30
W_6	29	6.5	213	3.8	4.90
W_7	29	6.6	114	4.0	5.30
W_8	28	6.4	192	6.0	5.70
W_9	27	6.0	384	4.2	6.82
W_{10}	29	6.2	91	5.1	5.77
Mean value	27.9	6.35	153.4	3.85	5.70
Stand. Dev.	±0.876	±0.314	±99.633	±1.556	±0.666
WHO(2017)	20-30	6.5-8.5	1000	0-5	5-7
NSDWQ	Ambient	6.5-8.5	1000	5	6

W_{1-10}= well one to the tenth well, WHO=World Health Organization, NSDWQ= Nigerian Standard for Drinking Water Quality, ND= Not Detected

Physicochemical properties

Temperature

ISSN 0795 - 22066

From table 1 above, the results show temperature values in all the samples to range from 27-29 °C with a mean value of 27.9±0.876. The variation in temperature values could be due to the ambient weather conditions of the areas where the well water samples are taken. The values of temperature in all the samples lies within the permissible level of 20-32 °C set by WHO.

pH Concentration

The result of pH concentration in water samples of hand-dug wells is presented in table 1 with values ranging from 6.0- 6.8 across all the sampled wells. The highest value (6.8) was found in W_3 and W_5 with a mean value of 6.35±0.313 across all the sampling sites. These results suggests that all the pH values in the study area were within the WHO and NSDWQ standard of 6.5- 8.5 pH for portable water.

Conductivity

Electrical conductivity is a measure of the salt content of water in the form of ions. It is also regarded as the capability of water to transmit electric current [12]. The values of conductivity in the present study revealed values to range from 52-384 (µs/cm), all of which are within the permissible limit (1000 µs/cm) prescribed by WHO and NSDWQ. The mean value was found to be 153.4 µs/cm which is in agreement with those of [13, 12].

Turbidity

Turbidity values were found to range between 0.9-6.0 (NTU) with an average of 3.85±1.556 across all the sampled well water. High turbidity 6.0 NTU (table 1) value was observed in W_6 and is attributed to the presence of suspended particles in water. Turbidity may have no adverse effect on health, but high levels of turbidity reduces the effectiveness of disinfection procedure as microorganism can be protected from disinfection by suspended materials.

Dissolved Oxygen (DO)

The values for DO in the present study falls within the set standard (5-7 mg/L) recommended by WHO and NSDWQ. The mean value for DO was observed to 5.70±0.666 with values ranging from 4.90-6-87 mg/L. DO is referred to as the amount of oxygen present in water and available for aquatic organisms to respire.

Table 2: Heavy metal pollution levels in hand dug well water

Sample Code	Heavy metals concentration (mg/L)									
	Zn	**Hg**	**As**	**Cr**	**Cu**	**Ni**	**Mn**	**Fe**	**Cd**	**Pb**
W_1	0.28	ND	ND	ND	ND	ND	ND	0.03	ND	0.01
W_2	0.71	ND	ND	0.02	ND	ND	ND	0.01	ND	0.01
W_3	0.08	ND	ND	0.01	ND	0.01	ND	0.01	ND	0.01
W_4	0.13	ND	ND	0.03	ND	ND	ND	0.51	0.001	ND

ISSN 0795 - 22066

W_5	0.21	ND	ND	ND	ND	0.01	ND	ND	ND	0.01
W_6	0.13	ND	ND	ND	ND	0.01	ND	ND	ND	0.01
W_7	0.06	ND	ND	0.01	ND	ND	ND	0.02	0.001	0.01
W_8	0.02	ND	ND	0.03	ND	0.01	ND	0.21	0.001	ND
W_9	0.31	ND	ND	0.01	ND	0.01	ND	0.05	ND	ND
W_{10}	0.05	ND	ND	0.01	ND	ND	ND	0.03	ND	ND
Mean	0.14	0.00	0.00	0.01	0.00	0.01	0.00	0.09	0.000	0.01
S.D	±0.21	±0.00	±0.00	±0.08	±0.00	±0.00	±0.00	±0.33	±0.00	±0.00
WHO (2017)	3	0.01	0.1	0.05	0.01	0.02	0.4	0.3	0.003	0.05
NSDWQ	3	0.01	0.1	0.05	0.01	0.02	0.4	0.3	0.003	0.05

W_{1-10}= well one to the tenth well, WHO=World Health Organization, NSDWQ= Nigerian Standard for Drinking Water Quality, ND= Not Detected, S.D= standard deviation

Heavy Metals

Mercury, Arsenic, Copper and Manganese

Hg, As, Cu and Mn were not detected in all the well water samples. Hg can cause central nervous system disorders such as mental retardation, deafness, blindness etc and also kidney damage [14]. Intake of water with high levels of Arsenic above acceptable limit may increase the risk of health problems of the skin, circulatory system, or the nervous system, including some cancers [15], while the non-detection of copper could be due to few or non-discharge or dumping of wastes such electrical materials, utensils and household items made of copper around the study areas. Mn is one of the most abundant metals in the earth crust, it is an essential element for humans and other animals and occurs naturally in food and water sources.

Zinc (Zn)

The concentration of Zn was found to range between 0.02 mg/L (W_8) to 0.71 mg/L (W_2) with mean value of 0.14±0.21 mg/L (table 2). All the values of Zn concentration recorded are within the set standard by WHO and NSDWQ of 3 mg/L (table 2). Zinc containing batteries, nuts and bolts containing zinc plate, organ pipes, toys, automobile waste materials, paints and rubbers made of zinc, dye containing zinc materials and unused calamine lotions could also be the sources of Zn in well water[16].

Chromium (Cr)

The results revealed the concentrations of Cr in all the samples to range between 0.01-0.03 mg/L with a mean value of 0.01±0.08 mg/L (table 2). Cr was not detected in W_1, W_5 and W_6. The values recorded in all the well samples are within the prescribed limit of 0.05 mg/L set by WHO and

ISSN 0795 - 22066

NSDWQ. Similar results were also reported by [8], in a study of the presence of Cr in well water samples located in close proximity to septic tanks. Long term exposure to Cr can lead to skin irritation and also cause damage to liver, kidney and nerve tissues.

Nickel (Ni)

The result of nickel revealed that the sampling wells are located in areas free from dumping of batteries containing nickel and electronic. Low concentrations of Ni 0.01 mg/L (table 2) were recorded in W_3, W_5, W_6, W_8 and W_9 while Ni was not detected W_1, W_2, W_4, W_7 and W_{10}. The values obtain are within the set limit by WHO and NSDWQ (table 2).

Iron (Fe) concentration

High concentration levels (0.51 mg/L) of Fe were observed in W_4 with values ranging from 0.01 mg/L to 0.51 mg/L (table 2). The mean value was found to be 0.09±0.33 mg/L. The importance of iron include; chlorophyll synthesis, oxidation-reduction in respiration, constituent of certain enzymes and proteins while excess levels of iron can lead to gastrointestinal irritation and enhance the growth of iron bacteria that affects the water taste, staining laundry, metal pipes for reticulation and scaling in pipes. It can also result in gene mutation leading to haemochromatosis [10]. The high concentration of Fe in W_4 (0.51 mg/L) is attributed to mechanical repairs of vehicles, use of engine oils on daily basis and rusting from iron buckets used for collecting the water from the well.

Cadmium (Cd) Levels

The concentration of Cd was found to be 0.001 mg/L in W_4, W_7 and W_8, all of which falls within the permissible limit of 0.003 mg/L set by WHO and NSDWQ. Cd was not detected in W_1, W_2, W_3, W_5, W_6, W_9 and W_{10} (table 2).

Cd occur naturally in nature. It can also be introduced into the environment from natural sources such as combustion of fossil fuel, incineration of municipal or industrial wastes, or land application of sewage sludge or fertilizer. It causes severe damages to the lungs and respiratory irritation, while its ingestion in higher dose can cause stomach irritation resulting to vomiting and diarrhea. Prolonged exposure to Cd can also cause hypertension and kidney damage [17].

Lead (Pb) concentration

Lead concentration was found to be 0.01 mg/L across W_1, W_2, W_3, W_5, W_6 and W_7 (table 2) while it wasn't detected in W_4, W_8, W_9 and W_{10}. The values of Pb obtained in the studied well are within the permissible limit set by WHO and NSDWQ (0.05 mg/L). Lead can end up in water and soils via corrosion of leaded pipeline in a water transporting sustain and through corrosion of leaded paints. High levels of lead in water is harmful to human health just as it is the case with other chemical elements [18].

ISSN 0795 - 22066

CONCLUSION

The results of this study showed that water from all the ten (10) sampled wells meets the prescribed standard set by WHO and NSDWQ except for Fe (0.51 mg/L) in W_4 which is slightly above the permissible limit of 0.3 mg/L. Hg, As, Cu and Mn were not detected in well water in all sapling sites. The high concentration of Fe in water W_4 is attributed to mechanical repairs of vehicles, use of engine oils on daily basis and rusting from iron buckets used for collecting the water from the well.

ACKNOWLEDGEMENT

The authors hereby acknowledge Prof. B. A. Anhwange of the Department of Chemistry, Benue State University Makurdi, the Laboratory Technologist, and Mr. Pius Utange for the laboratory analysis. Also, to the Head of Department, Science Laboratory Technology Federal Polytechnic Wannune, Chief G.B Asaar, colleagues and management of Benue state rural water supply and sanitation agency (BERWASA) and Benue State University Makurdi, where all the laboratory analysis were performed.

REFERENCES

[1] L.M, Mustapha., M.M, Lawan and A. Usman. (2020). Assessment of physicochemical parameters of some heavy metals; Lead Chromium, Copper, Zinc, and Iron in Borehole and hand dug-well water: A case study of Fika Local Government Area, Yobe State, Nigeria. *International Journal of Research and Innovation in Applied Science.* 5(10):56-59

[2] WHO, (2006). Guide line for drinking water quality 3rded, Vol 1. Recommendations. World Health Organization Geneva

[3] C.O. Nwinyi., U.O.A. Emmanuel., T.I. Oyeyemi., M.A. Ugbenyen., O.A. Aliyu., I.A.C, Obinna and M.I. Omoruyi. (2020) Review of Drinking Water Quality in Nigeria: Towards Attaining the Sustainable Development Goals Six. *Annals of Science and Technology.* 5(2):58-77

[4] J.O. Tsor., J.T. Biam., T. Daniel., P.S. Amon and G.T.A Jombo. (2022). Assessment of Physico-chemical Parameters and Heavy Metal Concentrations in Well Water of Logo 2 Area of Makurdi, Nigeria. Nigeria. *Nigerian Annals of Pure and Applied Sciences*. 5(1):137-148.

[5] WHO (2017). *Guidelines for Drinking Water Quality.* Fourth Edition Incorporating the First Addendum. ISBN: 978-92-4-154995-0

[6] O.M. Ojo. (2022). Heavy Metal Pollution Levels of Hand-dug Wells in Close Proximity to Septic Tanks. *FUOYE Journal of Engineering and Technology.* 7 (1): 86 – 89

[7] H.M, Naveedullah., H. Shen., D. Duan., C. Shen., L. Lou and Y. Chen (2014) Concentrations and human health risk assessment of selected heavy metals in surface water of the siling reservoir watershed in Zhejiang province. *China. Pol. Journal of Environmental Studies.* 23(3):801- 811

[8] O.M. Ojo (2023). Assessment of Heavy Metals Content of Hand Dug Wells in Shasha Market, South Western, Nigeria. *Journal of Applied Science and Environmental Management.* 27(10):2165-2170

ISSN 0795 - 22066

[9] WHO (World Health Organisation). (2008). Guidelines for drinking water quality, 3rd edition.
Recommendations. World Health Organisation Press, World Health Organisation, Geneva, Switzerland, 1:1-459.

[10] T.O. Kehinde., A.S, Godwin., A.A. Greatest and N. Christopher. (2015). Assessment of Heavy Metal Concentration in Hand Dug Well Water from Selected Land Uses in Wukari Town, Wukari, Taraba State, Nigeria. *Journal of Geoscience and Environment Protection.* 5(3): 1-10

[11] S.T. Ubwa., G. H. Atoo., J.O. Offem and K. Asemave (2013). An assessment of surface water pollution status around Gboko abattoir. *Academic Journals.*7(3):131-138 March, 2013. DOI: 0.5897/AJPAC2013.0486

[12] S.M.O. Akhionbare., M. Peretomode and G.C.C. Ndinwa (2019). Assessment of Water Quality of Hand Dug Wells in a Riverine Community, Southern Nigeria. *World Journal of Innovative Research.* 7(2):103-116

[13] S.M. Tongo, T.A. Nyijime, R.C, Nwankwo, and J.O. Odiba, (2024). Assessment of Physicochemical Parameters of Hand Dug Well Water in Makurdi, Benue State, Nigeria. *Journal of Chemical Society of Nigeria.* 49(2):153-162

[14] T. Ashar., D.N. Santi E. Naria (2013). "Kromium, Timbal, Dan Merkuri Dalam Air Sumur Masyarakat Di Sekitar Tempat Pembuangan Akhir Sampah." *Jurnal Kesehatan*

[15] S. Sobhanardakani. (2016). Evaluation of the water quality pollution indices for groundwater resources of Ghahavand Plain, Hamadan Province, Western Iran. *Iran Journal of Toxicology*. 10 (2):35-40

[16] A.O. Fatoye and K.A.J. Gbadegesin. (2014). Assessment of Heavy Metals in Drinking Water (Hand Dug Well) in Oye Ekiti, Nigeria*. International Journal of Science and Research (IJSR).* 4(11):1067-1069

[17] M.M. Orusun., P. Tchokossa., L.I. Nwankwo., T.O. Lawal., S.A. Bello and S.O. Ige. (2016). Assessment of Heavy Metal Pollution in Drinking Water Due to Mining and Smelting Activities in Ajaokuta, Nigeria. *Nigerian Journal of Technical Development.* 13(1):31-39

[18] T.O. Falola., I.O. Adetoro and O.A. Idowu (2021). Water Quality Assessment of Groundwater (Hand-Dug Wells) in Abeokuta North Local Government, Nigeria. *International Journal of Waste Resources.* 11(5):1-7

[19] NSDWQ, (2007). Nigerian Standard for Drinking Water Quality. Nigerian Industrial Standard NIS 554 Standard Organization of Nigeria.

[20] NPC, Official Records of the 2006 Census. National Population Commission, Nigeria, Abuja, 2007

[21] O.T. Oyelola and A.I. Babatunde (2008): Effect of municipal solid waste on the levels of heavy metals in Olusosun dumpsite soil, Lagos state, Nigeria. *International Journal of Pure and Applied Sciences.* 2(1):17 - 21.

ISSN 0795 - 22066