International Journal of Scientific & Engineering Research, Volume 6, Issue 10, October-2015 128
ISSN 2229-5518

Measurement of Metals and Radionuclide Concentrations of Water for Domestic and Other Purposes in Ozoro, Delta State, Nigeria

*K. Emumejaye and J.O.Ekibade
Department of Science Laboratory Technology, Delta State Polytechnic, Ozoro,Nigeria
*Corresponding Author's email address: ekugbere@gmail.com

Abstract— A survey of radionuclide concentrations in the various sources of water for domestic `and other purposes (like poultry, fish farming, recreation etc.) of the crude oil producing community of Ozoro, Delta State, Nigeria was carried out using a high purity germanium (HPGe) detector and atomic absorption spectrophotometer (heavy metals). The study area was divided into three sections for the purpose of sample collection namely; Okpaile, Polytechnic environs and NDC. Samples of well-water, rain and bore-hole water were collected from these areas and analyzed for heavy metals and radioactivity concentrations. The results indicated that values for 40K in Bq/l ranged from 12.68 – 769.68, 232Th < 0.12 – 3.38 and 0.62 – 1.48 of 238U. Annual effective doses computed from measured concentrations showed low values: 0.03 – 1.74 for K-40; 0.16 – 0.37 for Th – 232 and 0.01- 0.34 for U – 238 in mSv/y. For lead (Pb) (0.181 – 0.245 mg/l), copper (0.000 to 0.007 mg/l) Zinc (0.001 to 019gm/l), Nickel (0.1-0.13mg/l), iron (0.02 – 1.42mg/l) manganese (0.008 – 0.032 mg/l) and cadmium below detection limit. Some of these concentration levels in samples from Okpaile for both well and rain water are above World Health Organization (WHO) maximum permissible limits for Pd and Fe. The general results showed that water in the study area had acceptable quality for domestic utilization except the ones that contain excess lead and iron which may require treatment.

Index Terms— heavy metals, oil producing, , Okpaile, radionuclides, radioactivity concentration,

1 INTRODUCTION

Sources of water supplies (including public supplies) are of interest since drinking water is one modes of entrance of natural radioactivity into the human body. Radioactive elements are present in the air breathed by humans, in food and water [1,2,3]. Thus, measurements of natural radioactivity in ground water, surface water and domestic water have been carried out in many parts of the globe, mostly for assessment of dose and risk resulting from drinking water. The determination of levels of such radioactivity will help in the development of guidelines for the protection of human lives [4].

A wide range of natural radioactivities exist in various types of water, depending largely on their origin. The levels of natural activity originating from uranium and thorium series are found to be high in

certain natural springs which are found in areas where there are high concentrations of uranium and thorium in the soil. Similarly, drinking water exhibits wide variations of activity depending upon its origin and on the treatment it receives before it becomes available for consumption. High levels of natural potassium 40 activities are found in sea – water [5].

Enhanced radiation levels of thorium, uranium and their progenies might be present in water in area that is rich in natural radioactivity or through human activities such as petroleum activities and dumping of waste materials in sites without adequate soil protection measures result in soil as well as, ground and surface water contamination [6,7]. As groundwater passes through soil and rocks that contain these deposits, radioactive minerals can leach out into ground water system [8]. The motivation of this research is due to the fact that Ozoro community is an oil producing community and these oil activities could contribute to the radionuclides level in the area.

1.1 Study Area

Ozoro is situated in Isoko North one of 25 Local Government Areas of Delta State. Ozoro is an oil producing community with several oil wells, the people are mainly Isokos. They are industrious and hardworking. They indulge in farming, rubber tapping, petting trading etc. they are hospitable and receptive to all people. The study area lies within the Niger Delta sedimentary basin which is characterized by both Marine and mixed continental quaternary sediments that are composed of abandoned beach ridges and mangrove swamps [9]. The area lies on latitude 5^0 33'23''N and longitude 6^0 14'58''E. The area experiences wet and dry season which are typical seasons in Nigeria [10, 11].

Sources of water for these people include rivers, streams, ponds, wells, rain water and borehole. Water from these sources is not subjected to treatment before use and the water may have been radiologically contaminated due to natural and human activities over time.

2 Methodology and Sampling Techniques

ISSN 2229-5518

Data Collection

Samples of water were collected in August, 2014 from three different locations of the study area. Okpaile location is an area very close to oil wells, the second location is the Delta State Polytechnic Ozoro premises and NDC is the third location which is farther away from the oil wells which might have least effect of contamination. Samples of rain water, borehole and well water were collected in clean plastic bottles and taken to the laboratory for analysis. To ensure that no foreign substance was introduced into the sample, the non – radioactive plastic containers were washed with the samples before final collection.

Procedure

The radioactive concentration of uranium, thorium and potassium was measured for each sample according to Chibowksi [12]. About 5ml of each sample was taken to carry out for further procedures.

The sample was set into a beaker Marinelli, suited for high purity germanium (HPGe) detector and is designed to match the detector's hole. In order to get secular equilibrium the containers were hermetically sealed with adhesive tape for over a month [13]. In this study samples were kept for 32 days. Initially samples were laid in the HPGe detector and then gamma spectrum was obtained. Gamma ray spectrometry system was calibrated using a mixture of radioactive sources ^{22}Na, ^{60}Co, and ^{137}Cs.

Concentration of Uranium, Thorium and Potassium

The concentration of ^{238}U, ^{232}Th and ^{40}K for each sample was determined by using the following arithmetic expression:

$$Concentration\ C_S = \frac{N_S}{N_P} C_P \qquad (1)$$

Where C_S is concentration of samples, N_S is net activity of sample, N_P is net activity standard and C_P represents the standard concentration (^{238}U, ^{232}Th and ^{40}K).

The values of eU, eTh in mg/Kg and K in percent were converted to activity concentrations, (Bq/kg), using the conversion factors given by the International Atomic Energy Agency [14]. The activity concentration of a sample containing 1 mg/l by weight of 238U is 12.35 (Bq/l), 1 mg/l of 232Th is 4.06 (Bq/l) and 1 % of 40K is 313 (Bq/l).

The elemental analysis of samples was carried out using the atomic absorption spectrophotometer. The procedure is well reported in other literature [15].

Results and Discussion

The results obtained from the analytical procedure of heavy metals and determination of radioactivity concentration of some water sample for domestic purposes collected from the study area are presented in table1, table 2, table 3 and table 4 respectively.

Table1: Sample site: Okpaile – elemental results of well, rain and borehole samples

	Standard methods	Location			(mg/l) WHO limits*
		Okpaile			
Elements		Well (mg/l)	Rain (mg/l)	Borehole (mg/l)	
Pd	ASTMD3559 – 96	**0.195**	**0.245**	0.04	0.05
Cu	ASTMDI688 – 95	0.007	0.007	ND	1.5
Zn	ASTMDI691 – 95	0.002	0.019	0.001	5
Ni	ASTMDI1886 –94	0.07	0.1	0.13	N/A
Fe	ASTMDI068 – 95	0.08	**1.42**	0.02	1.0
Mn	ASTMD858 – 95	0.029	0.008	0.032	0.5
Cd	ASTMD355795	ND	ND	ND	0.005

*WHO [16]

Table 2: Sample Site: Polytechnic - elemental results of well, rain and borehole samples

	Standard methods	Location			(mg/l) WHO limits*
		Polytechnic			
Elements		Well (mg/l)	Rain (mg/l)	Borehole (mg/l)	
Pd	ASTMD3559 – 96	0.005	0.004	0.001	0.05
Cu	ASTMDI688 – 95	0.006	0.007	ND	1.0
Zn	ASTMDI691 – 95	0.002	0.018	0.001	5
Ni	ASTMDI1886 –94	0.08	0.1	0.14	N/A
Fe	ASTMDI068 – 95	0.08	0.02	0.22	0.3
Mn	ASTMD858 – 95	0.029	0.008	0.032	0.5
Cd	ASTMD355795	ND	ND	ND	0.005

N/A = Not Available, ND = Not Detected

Table 3: Sample site: NDC - elemental results of well, rain and borehole samples

	Standard methods	Location			(mg/l) WHO limits*
		NDC			
Elements		well (mg/l)	Rain (mg/l)	Tap (mg/l)	
Pd	ASTMD3559 – 96	0.005	0.004	0.001	0.05
Cu	ASTMDI688 – 95	0.006	0.007	ND	1.0
Zn	ASTMDI691 – 95	0.002	0.018	0.001	5
Ni	ASTMDI1886 –94	0.08	0.1	0.14	N/A
Fe	ASTMDI068 – 95	0.08	0.02	0.22	0.3
Mn	ASTMD858 – 95	0.029	0.008	0.032	0.5
Cd	ASTMD355795	ND	ND	ND	0.005

N/A = Not Available, ND = Not Detected

Note: The results obtained complied with WHO limit except those highlighted.

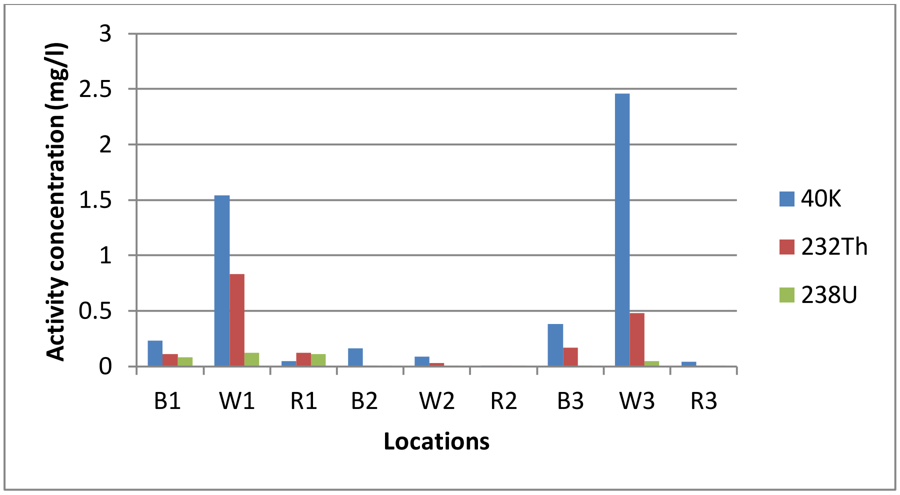

Fig. 1 A plot of radionuclides concentration by location

Table 4: Results of radionuclides concentrations (Bq/l) of various samples

					Annual effective dose (μSv/y) ingestion dose coefficient (Sv/Bq) *		
Sample location	Sample type	^{40}K (Bq/l)	^{232}Th (Bq/l)	^{238}U (Bq/l)	6.2 E-9 for K-40	2.8 E-7 for U-238	6.9 E-7 for Th-232
Okpaile	Borehole	71.99	0.45	0.99	0.16	0.05	0.25
	Well	482.02	3.37	1.48	1.09	0.34	0.37
	Rain	15.65	0.49	1.36	0.04	0.05	0.34
Polytechnic	Borehole	50.08	ND	ND	0.11	ND	ND
	Well	28.17	0.12	ND	0.06	0.01	ND
	Rain	ND	ND	ND	ND	ND	ND
NDC	Borehole	118.94	0.69	ND	0.27	0.07	ND
	Well	769.98	1.95	0.62	1.74	0.20	0.16
	Rain	12.52	ND	ND	0.03	ND	ND

*ICRP 68 [17]

The heavy metal concentration in mg/l ranges from 0.001 to 0.245 for Pb and was highest in rain water samples from Okpaile which is above WHO limit. Fe values ranges from 0.02 to 1.42. Rain water at Okpaile registered the highest Fe concentration above the WHO permissible limit for water. Other metals (i.e cu, Zn, Ni, Mn, and Cd) concentration levels range from 0.001 to 0.032. These are well below the permissible limit in water for domestic purposes.

The radionuclide concentration in Bq/l for K-40 ranges from 0.04 to 2.46 as shown in fig.1. It is highest in well water sample from NDC. This high value may probably be due to use of fertilizers for growing crops in the area. For Th- 232, values were <0.001 to 0.83, the highest concentration of 0.83 was found in well water sample from Okpaile. U -238, ranges from <0.001 to 0.12, with the highest concentration in well water at Okpaile. This high value could be due to contributions from petroleum activities in this area where there are several oil wells.

No correlation was established between the concentration of Th – 232 and U – 238. In this investigation, in most cases, Th – 232 values exceeded that of U -238. In fact, the geological and solubility properties of Th – 232 and U- 238 are different [8]. Their presence in water are due to several factors such as the geology and their geochemistry [18], these allow them to move easily and to contaminate much of the human environment. Uranium is easily mobilized in ground water and surface water, as a result its decay product, radium enter the water supply through ground water, well water, surface water, streams and rivers [8].

Annual Effective Doses from Daily Intakes of ^{238}U, ^{232}Th and ^{40}K from water

In order to calculate the annual effective dose as a result of ingestion of these radionuclides, the daily intake of drinking water for male (adult) was taken to be 1 litre per day [19]. The equation for calculating the annual effective dose per person according to Tchokossa [8] is given by

$$AED = \sum_i I_i \, x 365 x D_i \quad (2)$$

Where AED is annual effective dose, D_i is the ingestion doses coefficient (Sv/Bq) and i is the daily intakes of radionuclides (Bq/d).

Table 4 presents the results of annual effective doses obtained from calculation using equation (1). Estimated AED due to ingestion of K-40 in borehole water ranged from 0.11 – 0.27, well water 0.06 – 1.74 and rain water 0.03 – 0.04 mSv/y. for U – 238, borehole water have the range of 0.05 – 0.07, well water 0.01 – 0.34 and rain water, the radionuclide was not registered except in sample from Okpaile location where petroleum activities takes place. Th-232 was present in only sample from okpaile borehole water but not detected in other two locations. Th – 232 in well water is in the range of 0.16 – 0.37 and in rain water 0.34mSv/y was received by the population. The permissible limit set by [20] for public exposure is be given as 1mSv/y. All the estimated doses from our investigation are below the permissible limit.

Conclusion

This work is aimed at measuring the radionuclide concentration and heavy metal concentration in water and estimated annual effective doses received as a result ingesting water of the oil producing community of Ozoro, Delta State, Nigeria. The results of the study indicated that the average radionuclide concentration of U-238, Th -232 and K- 40 in community water are within the values of those reported in other countries in the world.The annual effective doses were found to be below permissible limits. However, Pb and Fe in some samples from Okpaile are above WHO permissible limits and may require treatment. Regular monitoring of water from these areas should be carried out by relevant agencies to ensure safety.

References

[1] Olomo,J.B.,(1990) “The Natural Radioactivity in Some Nige-rians Foodstuffs,” *Nuclear Instruments and Methods in Physics Research A*, 299(1-3), 1990, pp. 666-669. doi:10.1016/0168-9002(90)90866-5

[2] Ciezkowski,W & Przylibski, T. A. (1997) “Radon Waters from Health Resorts of the Sudety Mountains (SW Po-land),” *Applied Radiation and Isotopes*, 48(6), 1997, pp. 855-856. doi:10.1016/S0969-8043(96)00305-3

[3] Hakonson-Hayes, A. C., Fresquez, P. R. & Whicker, F. W.(2002) “Assessing Potential Risks from Exposure to Natural Uraniumin Well Water,” *Journal of Environ-mental Radioactivity*, Vol. 59, No. 1, 2002, pp. 29-40. doi:10.1016/S0265-931X(01)00034-0

309, IAEA, Vienna.

[4] Ferdous,M.J.,Rahman, M.M & Begum, A (2012). Gross Alpha and Gross Beta Activities of Tap Water Samples from Different Locations of Dhaka City Sri Lanka Journal of physics. Published by Institute of physics Sri Lanka vol 13(1) 01-08

[5] Lucas,H.F.Jr.,(1961) Correlation of the natural radioactivity of the human body to that of its environment: Uptake and retention of Ra-226 from food and water. Argonne National Laboratory report ANL-6297,pp.55-56.

[6] Eikelboom, R. T., Ruwiel, E. & Gounmans, J. J. J. M. (2001) “The Building Materials Decree: An Example of a Dutch Regulation Based on the Potential Impact of Materials on the Environment,” *Waste Management*, Vol. 21, No. 3, 2001, pp. 295-302. doi:10.1016/S0956-053X(00)00103-3

[7] Namasivayam, C., Radhika, R. & Suba, S. (2001) “Uptake of Dyes by a Promising Locally K.S.V., Bapat, V.N., David M. Available Agricultural Solid Waste: Coir Pith,” *Waste Management*, Vol. 21, No. 4, 2001, pp. 381-387. doi:10.1016/S0956-053X(00)00081-7

[8] Tchokossa, P, Olomo, J.B and Balogun, F. A (2011). Assessment of radionuclide concentrations and absorbed dose from consumption of community water supplies in oil and gas producing areas in Delta State, Nigeria.world J of Nuclear science and Technology. Pp.77-86 doi:10.4236/wjnst.2011.13012 published online October 2011.

[9] Anoliefo. G.O (1991), Forcados Blend crude oil effects in Respiratory mechanism, mineral element composition and growth of citrulus vulgaris school unpublished doctoral thesis, university of Benin.

[10] Eteng Inya A., (1997). The Nigerian State, Oil Exploration and Community Interest: Issues and Perspectives. University of Port Harcourt, Nigeria conf paper

[11] Etu – Efeotor J.O (1998). Hydrochemical analysis of surface andground waters of Gwagwalada area of central Nigeria. Globa J Pure Appl. Sci – 4 (2): 153 – 163.

[12] Chibowksi, S.(2000). Study of radioactive contaminations and heavy metal contents in vegetables and fruits from Lublin, Poland, *Polish J. environmental studies.* 9(4): 248-253.

[13] Olomo,J.B., Akinloye,M.K., & Balogun, F.A.(1994) Distribution of gamma-emitting natural radionuclide in soil and wateraround nuclear research establishment, Ile-Ife, Nigeria. *Nuclear Instruments and methods in physics Research Section A*, 353, 553-557.

[14] IAEA (1989) Construction and use of calibration facilities for radiometric field equipment. International Atomic Energy Agency, IAEA Technical Reports Series No.

[15] Emumejaye, K (2012) Effects of gas flaring on surface and ground water in irri and environs,Niger – Delta, Nigeria. *IOSR Journal Of Environmental Science, Toxicology And Food Technology (IOSR-JESTFT) ISSN: 2319-2402, ISBN: 2319-2399. 1(5), 29-33*

[16] World Health Organization, WHO (2007). International Drinking Water Standards. 3rd ed.

[17] International Commission on Radiological Protection, (ICRP) (1994), “Doses Coefficients for Intake of Radionuclides by Workers: Replacement of ICRP Publication 61,” Per-gamon Press, Oxford, ICRP Publication 68.

[18] Molinari, J. & Snodgrass, W. J. (1990) “The Chemistry and Radiochemistry of Radium and the Other Elements of the Uranium and Thorium Natural Decay Series,” *The Envi-ronmental Behavior of Radium*, IAEA 1, 1990, pp. 1-56.

[19] World Health Organisation (WHO) (1997) Guidelines for drinking water quality vol.1

[20] International Commission on Radiological Protection, (ICRP) 1991), “1990 Recommendations of the International Commission on Radiological Protection,” *Annals of ICRP*, ICRP Publication 60, Vol. 21, No. 1-3,