Investigation of the Gross Alpha and Beta Activity Concentrations of Hand Dug Well Water from Dutsin-Ma Local Government, Katsina State – Nigeria

Baba-Kutigi, A. N. Joseph, E. Tikyaa, E. V. Sanni, D. M.
Department of Physics, Federal University Dutsin-Ma, Katsina State, Nigeria

Abstract
Water samples from available hand dug wells within Dutsin-Ma Local Government Area of Katsina State, Nigeria have been analyzed for gross Alpha and Beta using an automated gas-flow-proportional counter (Eurisys Measure- IN20) which is an eight channel counter. The activity concentrations of both alpha and beta were determined from the twenty two samples collected from the different locations except for the alpha activity concentration of Wakaji which was below detection limit of the equipment. We found that only wells of seven locations namely Kuki A (Doro 2), Karofi B2, Karofi A2, Garangamawa, Kagara, Bagagadi 1 and Darawa are safe for consumption since their activity concentrations are within the limit set by World Health Organization (WHO, 2006), however, that of Yan Ruma ($\alpha = 0.4447 \pm 0.0387$ Bq/L, $\beta = 28.8406 \pm 1.9578$ Bq/L) in particular is highly enrich in both gross alpha and beta with the value of the beta emitter far above the recommended value. It is highly recommended that this well be discarded as this area is highly expose to elevated external radioactivity. The statistical analysis carried out showed that there is a strong positive correlation (0.74) between the gross alpha and beta activity concentration. Also the t-test of 20.9% clearly shows that there is no difference between the gross alpha and beta activity concentrations.
Keywords: Radionuclides, Gross Alpha and Beta, gas-flow-proportional counter, groundwater

1. Introduction

Water irrespective of it source either surface or underground, must be consumed daily in various volumes because it is essential for human life. Surface and underground water may contain some natural pollutants such as radionuclides which can be transported by them. Radionuclides in water originate from a number of naturally occurring and cosmic radiation (UNSCEAR, 1988, 2000) as well as by man-made sources, but in general, it is known that natural origin is more of a concern than those of artificial, which have been incorporated due to fallout from nuclear accidents and nuclear weapons testing (EPA, 2000).

The activity concentrations of natural radionuclides in groundwater are connected to the activity concentrations of ^{238}U and ^{232}Th and their decay products in the ground and bedrock (Vesterbacka, 2007) because ground water thus reacts with the ground and bedrock, with the release of quantities of dissolved components that depend on the mineralogical and geochemical composition of the soil and rock, chemical composition of the water, the degree of weathering of the rock, among other factors. The high geochemical mobility of these radionuclides in the environment allows them to move easily and to contaminate the environment which human come into contact with (Egunyinka et al., 2009). Also the presence of natural radionuclides in water depends on geological and geographical nature of the water's origin (Isam Salih et al., 2002; El-Mageed et al., 2011; Shashikumar et al., 2011). For groundwater (boreholes and wells), it depends on their presence and contents in lithologic of solids aquifer where water is stored (Nour, 2004; El-Mageed et al., 2011).

The WHO (2006) and the EU Council (1998 & 2010) have determined the reference level of the effective dose received from drinking water consumption at 100 μSv year^{-1}, as this value excludes the dose received from ^{3}H, ^{40}K, ^{222}Rn, and radon decay products, but it includes the other alpha- and beta-emitting radionuclides. Beside the radiation dose from the ingested ^{222}Rn, the water-born ^{222}Ra is released into indoor air during water usage and inhaled ^{222}Ra daughters affect lungs (Vesterbacka, 2007), and other chemical toxicity that predominately affects the kidneys (Auvinen et al., 2002, Kurttio et al., 2005). Therefore, measuring the radioactivity in drinking water is of great interest in environmental studies (Ajayi and Owolabi, 2008).

In the third edition of WHO guidelines for drinking water quality, the recommended levels are 0.5 Bq L^{-1} for gross alpha and 1.0 Bq L^{-1} for gross beta activities (WHO, 2006). If the measured values are below the reference levels of gross activity, the drinking water examined is acceptable for human consumption without any further action with respect to its radioactivity. Otherwise, nuclide specific analysis is required (WHO, 1993) to determine the radionuclide content using more sophisticated, more expensive and time-consuming procedures. This work is intended to help in understanding a quantitative detection of gross alpha and beta radioactivity which is important for a quick surveying of both natural and anthropogenic radioactivity in dug well water at Dutsin-Ma Local Government Area, Katsina State, North – Western Nigeria, which will also serve as a baseline study.

2. Research Methodology

2.1 Sampling location

The samples were collected from Dutsin-Ma Local Government, Katsina State which lies on latitude 12°26'N and longitude 07°29'E. It is bounded by Kurfi and Charanchi LGAs to the north, Kankia LGA to the east, Safana and Dan-Musa LGAs to the west, and Matazu LGA to the southeast. Dutsin-Ma LGA has a land size of about 552.323 km^2 with a population of 169 829 as at 2006 national census (Federal Republic of Nigeria, 2012). The people are mostly farmers, cattle rearers and traders. The vegetation of Dutsin-Ma LGA is the Sudan Savanna type which combines the characteristics and species of both the Guinea and Sahel Savanna (Abaje, 2007; Tukur et al., 2013).

2.2 Sample Collection and Preparation

A total of twenty two (22) water samples were collected from the hand dug wells manually using a water carrier called *'buga'* (in Hausa) in the early hours of the day from the wells with varying depths (6-15 *m*) within Dutsin-Ma LGA, Katsina State North-West Nigeria (Table 2). The samples were collected in a 2-litre plastic containers with about 1% air space deliberately left to accommodate any expansion. In other to reduce contamination, the containers were first rinsed thoroughly at least two times with sample water before use. The water samples were immediately acidified with 20 *ml* ± 1 *ml* of nitric acid per liter of sample collected to reduce the absorption of radioactivity into the walls of the containers (ISO, 9697 & 9698: 1992) and then tightly covered and kept in the laboratory. For purposes of analysis, the samples were gradually evaporated without boiling, down to a volume of about 50 *ml* at a furnace temperature of 60 ^{0}C. The residue was then transferred to a stainless-steel planchet, dried and allowed to equilibrate with ambient temperature and weighed. The counting time was 30000 *s* while the screening technique follows that prescribed by ISO, 9697 and 9698: 1992b guidelines, a procedure which was adopted by Fasae (2013).

3. Counting Equipment and Detector Calibration

The counting equipment which is automated is the gas-flow-proportional counter (Eurisys Measure- IN20) which is an eight channel counter at the Material Laboratory, Centre for Energy Research and Training (CERT), Ahmadu Bello University (ABU), Zaria was used for the counting. Each counter channel has a window thickness of 450 μgcm^{-3} and a diameter of 60 mm. The chambers are covered with lead of varied thickness. The detectors are operated within the radiation environment of < 101μradh^{-1}. The system is connected to a microprocessor loaded with a spread sheet programme (Quarttro-Pro) and graphic programme (Multiplan). The system can be operated at a bias voltage (~1100V with P10 gas: argonmethane of 10%) where only alpha particles are detected, referred to as 'alphaonly' mode.

The alpha standard was ^{239}Pu with a half-life of 24110 years, while the beta standard was ^{90}Sr with a half-life of 28 years. Their respective activities were calculated at the time of the calibration (Akpa *et al.*, 2004). These standards were certified by CERCA LEA Laboratories in France with certification numbers CT 001/1285/001920-1927 and CT 1271/00/1778-1783, respectively. Plateau test was earlier (Akpa *et al.,* 2004) run with the manufacturer's calibration standards (^{239}Pu and ^{90}Sr) whose activities ranges from 133.29 to 185.51 Bq and 92.31 to 103.68 Bq, respectively in all the three operating modes. This test was run for 1800 s for five cycles. The detector parameters used in the present study in the determination of the activities are presented on Table 1.

Table 1.0**:** Detector parameters in the determination of the activities

Physical Parameters	**Values for the present study**	
	A	**B**
Background Activity (Bq)	0.13	120.42
Efficiency (%)	87.95	42.06
Detection Limit (Bq)	0.10	21.52

4. Results and Discussion

The results of the gross alpha and beta activity of the surveyed areas are presented on Table 2.0 as well as on Figures 1 and 2. These results were discussed and compared with other available result from other areas as no similar work has been done in this present location.

Table 2.0: Alpha and Beta Activity Concentrations of the Water Samples Analyzed

S/No.	Location		pH Value	Activity Concentration (Bq/L)	
	Geographic Coordinate	Name		Alpha (α)	Beta (β)
1	N12°24.363' E007°36.972'	Kuki A (Doro 2)	6.94	0.0113±0.001	0.8043±0.005
2	N12°24.313' E007°36.752'	Kuki A (Doro 14)	7.28	0.0300±0.001	3.1546±0.072
3	N12°23.784' E007°35.134'	Kuki Garchi	7.30	0.0084±0.001	1.7202±0.079
4	N12°29.192' E007°35.351'	Karofi A1	6.47	0.0132±0.003	2.8123±0.186
5	N12°29.058' E007°35.469'	Karofi B	6.84	0.1099±0.013	10.2405±0.651
6	N12°28.842' E007°35.334'	Karofi B2	7.14	0.0059±0.001	0.3304±0.005
7	N12°29.279' E007°35.339'	Karofi A2	6.73	0.0015±0.003	0.0950±0.150
8	N12°15.705' E007°27.900'	Garangamawa	6.93	0.0009±0.0008	0.7332±0.046
9	N12°20.958' E007°29.804'	Makera	7.14	0.0008±0.0013	12.3995±0.086
10	N12°26.451' E007°29.794'	Dutsin-Ma L/Cost	7.32	0.0056±0.0013	2.8676±0.073
11	N12°27.134' E007°29.976'	Angwan Yardaka	7.31	0.0847±0.0024	2.2665±0.138
12	N12°25.502' E007°27.566'	Kagara	7.43	0.0531±0.0016	1.4203±0.096
13	N12°27.972' E007°37.342'	Bagagadi 2	7.55	0.0052±0.0030	11.3489±0.181
14	N12°28.144' E007°37.135'	Bagagadi 1	6.90	0.0159±0.0179	1.3930±0.095
15	N12°26.872' E007°28.859'	Shema Qtrs	8.15	0.0025±0.0015	9.0134±0.090
16	N12°26.119' E007°30.766'	Wakaji	7.23	BDL	0.6447±0.0456

Table 2.0: Alpha and Beta Activity Concentrations of the Water Samples Analyzed (Cont’d)

S/No.	Location		pH Value	Activity Concentration (Bq/L)	
	Geographic Coordinate	Name		Alpha (α)	Beta (β)
17	N12°27.193’ E007°31.729’	Yan Ruma	7.27	0.4447±0.0387	28.8406±1.9578
18	N12°12.324’ E007°27.675’	Kutawa Garhi	6.55	0.0412±0.0012	12.3195±0.0813
19	N12°31.954’ E007°29.066’	Dabawa	7.15	0.0019±0.0009	11.9660±0.0561
20	N12°31.316’ E007°32.165’	Shema	7.22	0.0252±0.0030	2.3494±0.1465
21	N12°32.359’ E007°32.113’	Yarwashe Shema	7.19	0.0434±0.0012	2.6852±0.0810
22	N12°28.578’ E007°29.455’	Darawa	7.32	0.0493±0.0012	1.3195±0.0796

The results on Table 2 show that apart from Wakaji whose alpha activity concentration is below detection limit, that of all other locations were measured. In all the twenty one locations successfully measured only that of seven locations namely Kuki A (Doro 2), Karofi B2, Karofi A2, Garangamawa, Kagara, Bagagadi 1 and Darawa are safe for consumption since their activity concentrations are within the limit set by World Health Organization (WHO, 2006) as can be seen also on Figures 1 and 2. The well at Yan Ruma (α = 0.4447±0.0387 Bq/L, β = 28.8406±1.9578 Bq/L) in particular is highly enrich in both gross alpha and beta with the value of the beta emitter far above the recommended value. It is highly recommended that this well be discarded as this area is highly expose to elevated external radioactivity.

More so, the high concentration of the gross beta activity concentration may largely be due to the fact that the water source is drawn from underground water body as majority of these wells are quite deep. The elevated values of the gross beta could also be attributed to the presence of rocks and the geological formations of the area. The statistical analysis of the surveyed sample also indicate that there is a strong positive correlation (0.74) between the gross alpha and beta activity concentration. Also the t-test of 20.9% clearly shows that there is no difference between the gross alpha and beta activity concentrations.

The results of our work show that the low alpha activity concentrations and high beta activity concentrations agrees with the reports by Nwoke (2006) carried out in Kaduna State, and Tajudeen (2006) on Wells and Boreholes in Kano State, both in North-Western Nigeria. The result however deviates slightly from that of Onoja (2004) carried out in Zaria on well water. All these reports suggests high contaminations in hand dug wells in this part of the country.

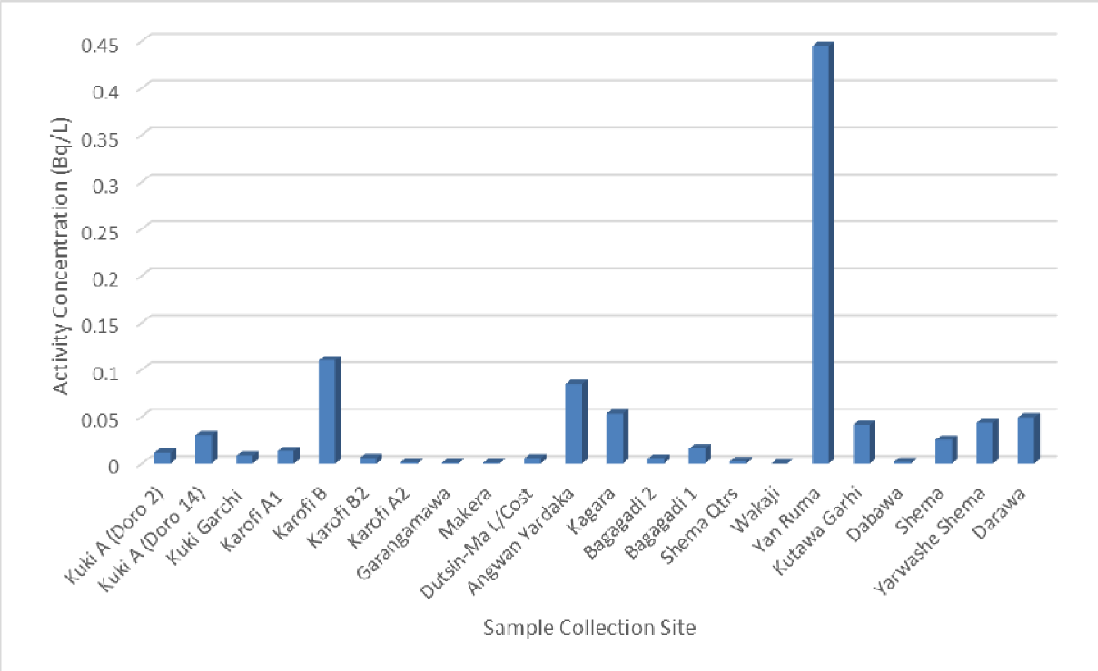

Figure 1: Alpha Activity Concentration for Water Samples

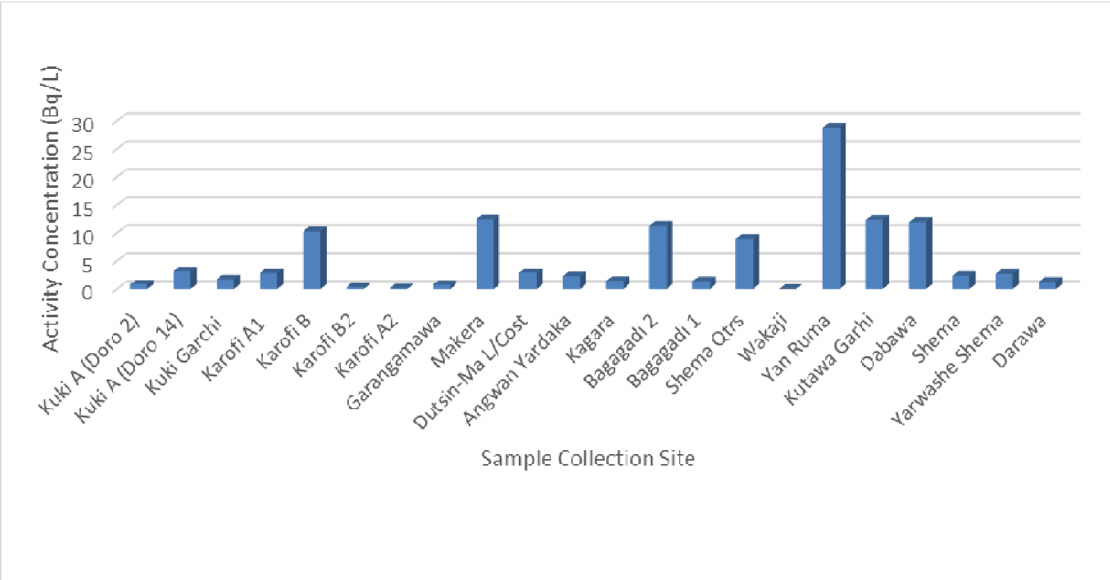

Figure 2: Beta Activity Concentration for Water Samples

5. Conclusion

The gross alpha and beta radionuclide activity concentrations in almost all the available hand dug wells water within Dutsin-Ma Local Government, Katsina State, North-Western, Nigeria have been evaluated. The results showed an elevation over the activity of the control samples and the WHO (2006) limit for gross alpha and beta activity. This elevation could be attributed to the presence of rocks and the geological formations of the area. Our result shows that the water from these wells pose radiological hazards to the inhabitants of Dutsin-Ma Local Government, Katsina State since the radioactivity is above that of the background level.

Acknowledgement

The authors are grateful to the Tertiary Education Trust Fund (TETFund) for providing the grant to carry out this research through the Research Grant approval TFUND/DESS/RP.DIS/FUNI/DUTSINMA/VOL.V/SN14 Batch 1 2013 Research Projects Intervention, and to the Centre for Energy Research and Training, Ahmadu Bello University, Zaria for allowing access to use their facility for this study.

References

Abaje, I. B. (2007). *Introduction to soils and vegetation*. Kafanchan: Personal Touch Productions.

Ajayi O. S., Owolabi T. P. (2008). Determination of Natural Radioactivity in drinking water in private dug wells in Akure, Southwestern Nigeria. Radiat Prot Dosim 128, 477 – 484.

Akpa, T. C., Mallam, S. P., Ibeanu, I. G. E. and Onoja, R. A. (2004). Characterization of Gross Alpha and Beta Proportional Counter in the Centre for Energy Research and Training, Ahmadu Bello University, Zaria. Nig. Journal of Phys. 16(1) 13 – 18

Auvinen A., Kurttio P., Pekkanen J., Pukkala E., Ilus T., Salonen L. (2002). Uranium and other natural radionuclides in drinking water and risk of leukemia: a case-cohort study in Finland. Cancer Causes Control 13, 825 – 829.

Egunyinka, O.A., C.J. Olowookere, I.A. Babalo and R.I. Obed, (2009). Evaluation of U-238, Th-232, K-40 concentrations in the top soil of the University of Ibadam South-Western Nigeria. Pacif. J. Sci. Technol., 10(2): 742-750.

El-Mageed, A.I.A., A. El-Hadi El-Kamel, A. El-Bast Abbady, S. Harb and I. Issa Saleh, (2011). Natural radioactivity of ground and hot spring water in some areas in Yemen. Desalination, Doi: 10.1016/j.desal.2011.11.022.

Environmental Protection Agency (EPA), "National Primary Drinking Water Regulations," Final Rules, 40 CFR, Part 9, 2000, pp. 141-142.

European Communities (1998) Council Directive of 3 November 1998 on the quality of water intended for human consumption (98/83/EC) 32–54

European Communities (2010) Council Directive, in preparation 4. UNSCEAR, United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (2000) Sources and effects of ionising radiation, United Nations, New York

Fasae, K. P. (2013). Gross alpha and Beta activity Concentrations and Committed Effective Dose due to intake of Groundwater in Ado-Ekiti Metropolis; the Capital City of Ekiti State, Southwestern, Nigeria. *Journal of Natural Science Research, Vol. 3 No. 12*

Federal Republic of Nigeria. (2012, April). *Federal Republic of Nigeria 2006 population and housing census*. Priority Table Vol. III. Abuja: National Population Commission.

IN:20 Model Technical Manual (1991). Low Background Multiple Detector for low Alpha and Beta Activities

Isam Salih, M.M., H.B.L. Pettersson and E. Lund, (2002). Uranium and thorium series radionuclides in drinking water from drilled bedrock wells: Correlation to geology and bedrock radioactivity and dose estimation. Radiat. Protect. Dosimet., 102(3): 249-258.

ISO, (1992a). Water Quality-Measurement of Gross alpha & beta; Activity in Non-Saline Water, Thick Source Method. ISO 9696, Geneva, Switzerland, 13pp.

ISO, (1992b). Water Quality-Measurement of Gross alpha & beta; Activity in Non-Saline Water, Thick Source Method. ISO 9697, Geneva, Switzerland, 13pp.

Kurttio P., Komulainen H., Leino A., Salonen L., Auvinen A., Saha H. (2005). Bone as a possible target of chemical toxicity of natural uranium in drinking water. Environ. Health Perspect. 113, 68 – 72.

Nour, K.A., (2004). Natural radioactivity of ground and drinking water in some Areas of Upper Egypt. Turkish J. Eng. Env. Sci., 28(6): 345-354.

Nwoke, J. E. (2006). Measurement of gross Alpha and Beta radioactivity in river Kaduna. Unpublished Master of Science Thesis, Ahmadu Bello University, Zaria

Onoja, R. A. (2004). Survey of gross Alpha and Beta radioactivity in Well Water from Zaria. Master of Science Thesis, Ahmadu Bello University, Zaria

Sa'idu A., Baba-Kutigi A.N., and Badu S. (2012) "Determination of Gross Alpha Radioactivity in Underground Water in Usmanu Danfodiyo University Permanent Site, Sokoto" *International Journal of Science and Technology (IJSAT) 2(1): 151 – 154.*

Shashikumar, T.S., M.S. Chandrashekara and L. Paramesh, (2011). Studies on radon in soil gas and Natural radionuclides in soil: Rock and groundwater samples around Mysore city. Int. J. Env. Sci., 1(5): 786-797.

Tajudeen, H. Y. (2006). Survey of gross Radioactivity in Boreholes and Hand Dug Well-water from Gwamaja Area of Kano Metropolitan City. Unpublished Master of Science Thesis, Ahmadu Bello University, Zaria

Tukur, R., Adamu, G. K., Abdulrahid, I., & Rabi'u, M. (2013). Indigenous trees inventory and their multipurpose uses in Dutsin-Ma area, Katsina State. *European Scientific Journal, 9*(11), 288-300.

UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) (1988). Report to the General Assembly. The Sources and Effects of Ionization Radiation. United National, New York.

UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation). (2000). Report to the General Assembly. Annex B: Exposure from Natural Radiation Sources. United National, New York.

Vesterbacka, P. (2007). Natural radioactivity in drinking water in Finland. Boreal Environmental Reasearch 12, 11-16.

WHO (2006) Guidelines for drinking-water quality, 3rd ed. including the first addendum. World Health Organization, Geneva, Switzerland

World Health Organisation (WHO), (1993), Guidelines for drinking water quality, Recommendations, Vol. 1, Geneva.