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DETERMINATION OF GROSS ACTIVITY OF THE ALPHA AND BETA RADIONUCLIDES PRESENT IN DIFFERENT BRANDS OF SACHET WATER WITHIN KADUNA METROPOLIS

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Abstract

In this study, the gross activity of the alpha and beta emmiting radionuclides present in different brands of sachet water within Kaduna metropolis were determined. Ten (10) samples of different brands of sachet water were analyzed and counted for gross alpha and beta activities using MPC – 2000 - DP. The results showed that the range of alpha activity was obtained to be 0.0155 ± 0.0059 for maximum value, 0.0003 ± 0.0001Bq/L for minimum value of alpha activity concentration and 2.2233±0.4484 for maximum value 0.0145±0.0033Bq/L for minimum value of beta activity concentration. The samples show lower concentration than the WHO guideline value of 0.5Bq/L for alpha while some of the values are above 1.0Bq/L for beta. The mean of the activity values was calculated to be 0.0331 for alpha and 9.743 for beta activity.

INTRODUCTION

Radiation is hazardous to human health. Alpha and beta particles deposit their energy at short distances and cause damage in the organs when ingested along with water. It is important that drinking water be characterized with respect to radionuclide content., gross alpha and beta counting becomes a necessary preliminary test as stipulated by the WHO guideline for water quality determination. Radionuclide specific test becomes necessary only if the result of the preliminary test exceeds a recommended value. Therefore, establishing a gross alpha and gross beta counting system, would not only contribute to the health of the populace but also economical in that it offers a more cost effective means of screening drinking water.

An atomic nucleus having a certain neutrons to protons ratio could be unstable, which means it is radioactive. In such a nucleus, a transformation or disintegration occurs spontaneously, usually with emission of a particle. This emission is sometimes accompanied with a gamma ray. In the process, an atom of another nuclide is formed. This is called radioactivity. Therefore, radioactivity is the property possessed by certain nuclides undergoing spontaneous transformation of their nuclei, which is usually accompanied by the emission of particles or radiation (DPM 2010). The particles emitted are mostly alpha particles, beta particles and gamma ray. Radioactivity is classified under natural and artificial.

Radioactive substances emit radiation of the different types such as alpha particles, beta particles, and gamma radiation. The intake of radioactivity into the body results to internal contamination. Inhalation or ingestion of radioactive material brings the radiation from them in contact with the body tissues and organs. Fast replication tissues suffer most from damage. Alpha particles, which are essentially helium nuclei deposit a lot of energy at a short distance and concentrate their damage. Alpha particles are, therefore, the most dangerous specie of radiation in drinking water being most ionizing. Beta particles are simply high-energy electrons. They can travel a longer distance in matter before depositing their energy, thus they deposit their energies thinly over a larger area of the body.

When radioactive heavy elements like barium, calcium or other similar nuclides like strontium and radium are ingested, they concentrate in the bone. For example, the effect of ingested radium on radium-watch-dial painters in the early part of the last century was reported to have caused bone and head carcinomas in the painters. A small number of leukemia was also found in workers that ingested radioactivity substances. Uranium is known to have deleterious or chemotoxic effect to the kidney. In estimating the risk due to uranium in drinking water, the crucial questions are: how much ingested uranium goes to the bone and how much goes to the kidney, what are their relative consequences? (US- EPA 1996)

The International Commission on Radiation Protection (ICRP) estimates that the blood steam from the gastrointestinal tract absorbs an average of 5% of ingested uranium. It also suggests that the value could possibly be as high as 20% as had been shown by 1CRP

(Gonder, 2011). Radioactivity in drinking water was estimated for gastrointestinal absorption to be 1.4%. Other experiments yield better results of uptake value and its determinants (Gonder, 2011). In preliminary results from experiments that used fasting human subjects a value of between Q.5% - 1.0% was suggested (Gonder, 2011). In view of these results, both the 1.4% and the 5% estimates are reasonable, average level to use in risk calculations. Although with large uncertainly, work related to the ingestion of radon suggests that number of fatal cancers from radon ingested from drinking water may be equal to a significant fraction of the fatal lung cancers (US- EPA 1996).

Gross alpha particle activity is a measure of the total amount of radioactivity in a water sample attributable to the radioactive decay of alpha-emitting elements. Alpha particles are highly ionizing, but the particles travel short distances in air being least penetrating before being absorbed. Alpha particles have little ability to penetrate objects thus, they can be stopped by a sheet of paper or the outer layer. The external hazard from alpha particles is minimal, but the internal hazard when they are inhaled or ingested may be significant. Gross alpha particles activity reported in picocuries per litre as natural uranium (pCi/L0 http.//www.chesco.org/water/wrd-radon.html.

Gross beta particle activity is a measure of the total amount of radioactivity in a water sample attributable to the radioactive decay of beta-emitting elements. Beta particles usually travel greater distances in air than alpha particles (about 6 feet) before being absorbed. Beta particles are more penetrating than alpha particles, and some are capable of penetrating the skin and causing radiation damage. Beta particles present an external as well as an internal hazard from inhalation or absorption (pa.water,usgs.gov/../fso12-00.html).

MATERALS AND METHODS

Materials

The following materials were used in this work: -

Gas-flow proportional counting system, Stainless steel counting planchets, Electric hot plate, Drying oven,, Drying lamp, Glass desiccators, Glassware, Analytical balance, Distilled or deionized water having a resistance value between 0,5 and 2,0 megaohms (2,0 to 0.5 microohms)/cm at 25°,Nitric acid, IN; Mix 6.2 *ml* 16N HNO_3 (conc with deionized or distilled water and dilute to 100 mL.

Scope and Application

This analysis covers the measurement of gross alpha and gross beta activities in drinking water. The analyses is a screening technique for monitoring drinking water supplies for alpha and beta particle activities according to the limits set forth under the safe drinking water, act, PL-93-323, 40FR 34324.

Sampling Frame

The sachet water collection was carried out in the month of January and lasted for two weeks. To ensure adequately representative sampling, a preliminary survey was conducted before the selection of water to be analyzed. The sachet water samples were randomly chosen from different locations, retail and wholesale outlets to identify popular brand commonly patronized within the study area. Following this procedure, ten brands of sachet water were identified and a total of 10 samples were purchased from the outdoor hawkers/vendors.

Sampling Collection and Preparation

Ten (10) water samples from various brand in Kaduna metropolis were collected, four sachet water each from different brand was collected into two liters plastic container which was rinsed twice with the water sample and immediately acidified after collection with 20 ml of nitric acid solution to reduce the pH, minimized precipitation and absorption by the walls of the container and to prevent the growth of micro-organisms. The amount of water collected was such that air space of 1% of the container capacity was left for thermal expansion. The samples were air tight; and taken to the laboratory and left for at least 24 hours before analysis. The samples maximum holding time before evaporation was one month and after evaporation was one month. After, evaporation, residues were left in the desicator until they were ready for counting. Evaporation was done using hot plates, without stirring and at moderate heat in an open 600 ml beaker. It took an average of about 16hrs to complete the evaporation of one liter of each sample. In the process of evaporation, when the level of sample in the beaker was about 50 ml, it was then transferred into a petri-dish and placed under infrared light source to completely dry the residue. It was then allowed to cool before weighing was done. The weight of the empty petri-dish plus sample residue was measured.

An empty planchet was weighed after which about 0.077g of the residue was rendered to the planchet (ISO-STANDARD). The planchet plus residue was then weighted. A few drops of vinyl acetate were put on the sample to make them stick to the planchet and prevent scattering of the residue during counting. Sample preparation efficiency was obtained from the relation. (Onoja, R.A 2011)

$$efficiency = \frac{weight\ of\ residue\ transferred\ to\ planchet}{0.077g}\ x\ 100\% \qquad (2.1)$$

Volume of water that gave the total residue was obtained from the relationship.

$$V = \frac{V_W}{TR\ x\ RP} \qquad (2.2)$$

V_N = volume of water = 1litre, TR = total residue and R_P = residue transferred to planchet

Sampling efficiency can also be achieved as

Sampling efficiency = $\frac{(W_{b+S} - W_B)\ (W_{B+S} - W_B)}{(W_{B+S} - W_B)}$ x 100% (2.3)

Counting

The gross alpha and beta counting equipment used in this work was the Gas-flow proportional counting system For the gross alpha and beta counting, the sample was placed in a planchet and the planchet counting the sample was placed in a sample carrier. The carrier was then placed on the sample drawer and closed. Counting was automatically done according to the selected count mode when the appropriate sample information was entered. The activity concentration(c) in Becquerels per litre was calculated using the expression.

$$C = Rn\ x\ \frac{1}{Es}\ x\ \frac{1}{Vp} \quad (2.4)$$

Where C = activity in Becquerel per litre

Rn = sample count rate per second,

Es = fractional efficiency of counting the radioactive standard.

Vp = the volume of sample in litres equivalent to the mass on the planchet.

Rb = the observed sample count rate, in pulses per second.

Ro = the background planchet count rate, in pulses per second.

$$Es = \frac{Rs - Ro}{0.1A\ x\ 14.4}\ x\ 1000 \quad (2.5)$$

Where

Rs = the observed standard rate in pulses per second.

A = the area of planchet, in square millimeters.

The alpha and beta background measurements made for the two different modes – alpha/beta simultaneous mode and alpha or beta only mode respectively. The count rates recorded were reproducible in terms of channels and in terms of mode of measurement. IN20-SYST a proportional counter is not the only detector for low alpha and beta activity measurement in samples. There are other gas filled detectors such as Geiger-Mueller (GM) counters and ionization chambers. Silicon surface barrier, scintillation and semiconductor detectors can also be used for gamma and alpha detection. The choice of gas filled proportional counters was based on availability and the nearly uniform low background level, low plateaux slope and channel efficiency measured in all the channels simultaneously is an added advantage of using this equipment. In addition, the anticoincidence guard circuitry also contributed to low detection level measured in this experiment.

RESULTS AND DISCURSSION

Results

The results obtained so far were based on the characterization of the detector and measurement of radioactivity (gross alpha and gross beta activity) of ten (10) water samples collected from Kaduna metropolises. The alpha and beta defector is obtained to be 87.95% and 42.06% respectively.

Table 3.1: Calculated alpha and beta activities (Bq/L)

Sample ID	Alpha activity(Bq/L)	Beta activity(Bq/L)
Fisl	0.0041±0.0037	0.3554±0.1503
Today	0.0155±0.0059	1.0208±0.2029
Kadpoly	BDL	1.5929±0.3443
Formular	BDL	0.9887±0.2116
Adams	0.0055±0.0023	1.5347±0.1761
Amfat	BDL	1.4917±0.2402
Deez	0.0013±0.0002	0.0305±0.0048
Safa'a	0.0010±0.0000	2.2233±0.4484
Vehesza	0.0003±0.0001	0.0148±0.0033
Aurora	0.0054±0.0003	0.4897±0.1093

The table above shows the result from the Centre for Energy Research and Training (CERT), Ahmadu Bello University, Zaria for the analyses of gross alpha and beta activity concentration of 10 water samples .

Table 3.2 – SAMPLE MEASUREMENT IN THE LABORATORY AND COUNT PER MINUTE

S/N	SAMPLE ID	EVAPORATED VOLUME (ML)	WEIGHT OF RESIDUE (G)	ACTURAL VOL. (ML)	REQUIRED WEIGHT (G)	ALPHA CPM	BETA CPM
1.	FISL	1000	0.15	0.5028	0.0771	0.27	84.04
2.	TODAY	1200	0.25	0.3781	0.0772	0.47	89.27
3.	KADPOLY	1000	0.35	0.2224	0.7770	0.09	88.47
4.	FORMULA	1200	0.26	0.3619	0.770	0.09	88.56
5.	ADAMS	1500	0.26	0.4454	0.0772	0.29	96.78
6.	AMFAT	1000	0.24	0.3217	0.0771	0.13	91.64
7.	DEEZ	1800	0.06	0.1744	0.0638	1.29	92.02
8.	SAFA'A	1200	0.54	0.1711	0.0771	0.16	89.13
9.	VEHEZA	1800	0.06	0.4240	0.0557	0.49	88.22
10.	AURORA	1300	0.14	0.7000	0.0772	0.36	88.12

THE STATISTICAL ANALYSIS OF ALPHA AND BETA CONCENTRATION FROM THE STUDY AREA

	Number	Range	Minimum	Maximum
Alpha	10	0.0016	0.0003±0.0001	0.0155±0.0059
Beta	10	2.2380	0.01475±0.0033	2.2233±0.4484

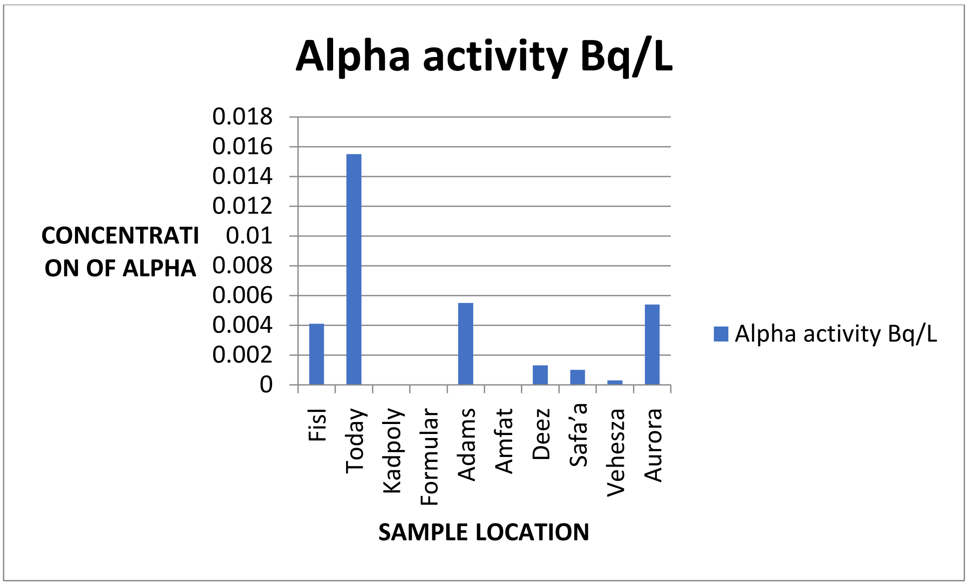

Fig 3.1: Graph of the alpha activities against sample ID in sachet water within Kaduna metropolis. Most area have low alpha activity.

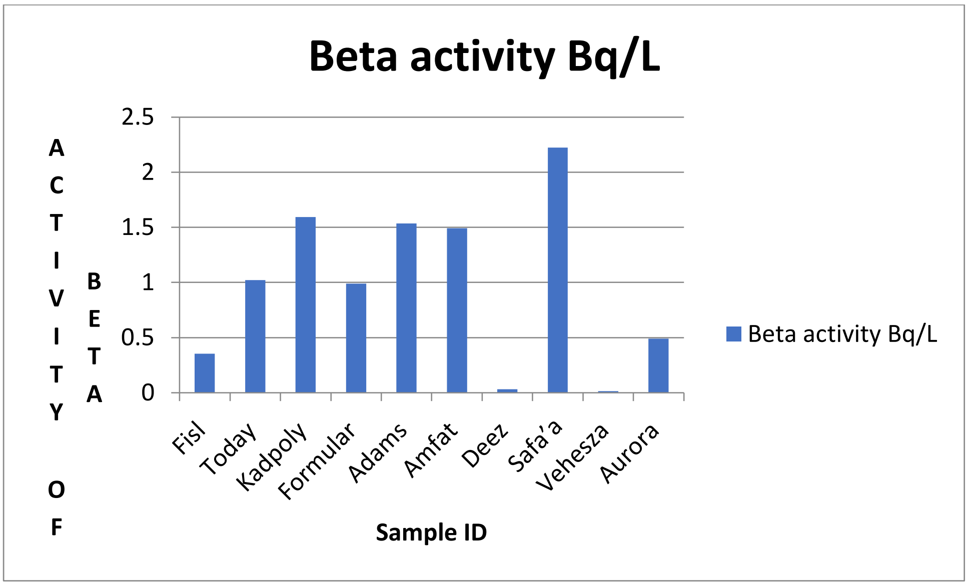

Fig 3.2: Graph of beta activity against sample ID. Some of the brand of sachet have high beta activity. While others have low beta activity.

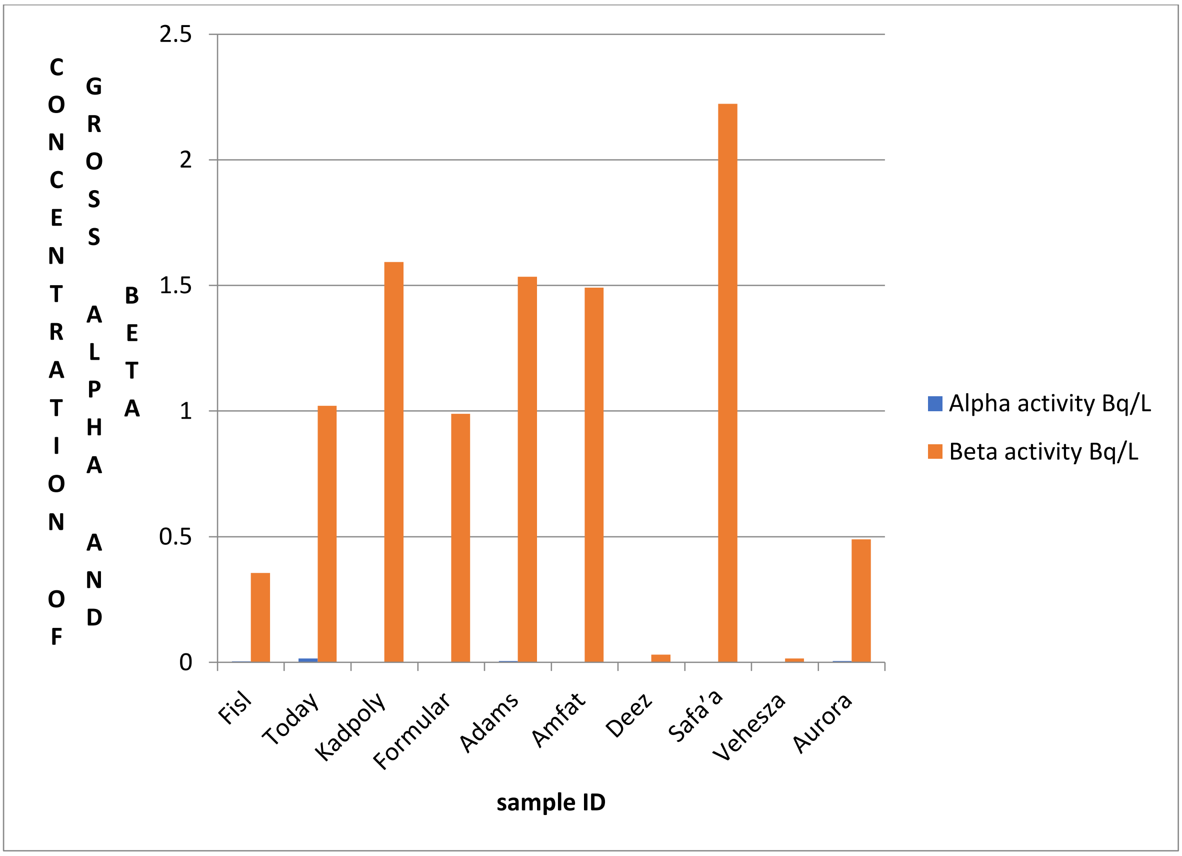

Fig 3.3: Graph of both alpha and beta activity against sample ID. Some of the brand of sachet have high beta activity. While others have low beta activity.

Discussion

600 ml of the preserved drinking water sample was gradually evaporated, the dried residue was scraped, and then 0.77g of residue was achieved using the MPC 2000 machine. The sample preparation efficiency was derived by taking the weight of the empty beaker, W_B and weight of beaker plus sample after evaporation W_{B+S}. at the end the alpha and beta detector efficiency is 87.95% and 42.06% respectively. The counter was used to determine gross alpha and beta activity from sachet water brands collected within Kaduna metropolis. Alpha activity has a range of 0.0155±0.0059 for maximum value and 0.0003±0.0001 for minimum value. Beta activity range to be 2.2233±0.4484 for maximum value and 0.0148±0.0033 for minimum value. Statistical analysis of the results show that measured activity were positively skewed with the highest frequency at high/low activity values.

CONCLUSION

The levels of gross alpha and beta activity concentration in brands of sachet water collected within Kaduna metropolis have been analyzed. The experiment results obtained show that the beta activity concentration in some brand of satchet water (kadpoly with 1.5929±0.3443, Adams with 1.5347±0.1761, Amfat with 1.4917±0.2402, and Safa'a with 2.2233±0.4484) are above the world health organization guide line value of 1.0Bq/L. Today with 1.0208±0.2029 is within the guide line value and the remaining brands of sachet water are below the W.H.O standard. The experiment result obtained show that gross alpha activity for the brands of sachet water are below the world health organization recommendation guide line value of 0.5Bq/L.

In this work, the alpha and beta activities in different brands of sachet water were measured. The alpha activity was analyzed to be 0.0155±0.0059 for the maximum value and 0.0003±0.0001 for the minimum value and for beta activity it was analyzed to be 0.01448±0.0033 for the maximum and 2.2233±0.4484 for the maximum value. The alpha level is lower than that recommended by the world health organization (WHO) which is 0.5Bq/L and some of the beta level is below the W.H.O recommended value and others are above the recommended stand which is 1.0Bq/L.

Various mechanisms are responsible for radiation damage. Exposure to radiation from all sources can result in changes to sensitive biological structures, either directly through the transfer of energy to the atoms within the tissue or directly by the formation of free radicals. Since the most sensitive structure in the cell is the deoxyribonucleic acid (DNA) molecule, exposure to radiation may damage the DNA, causing the cells to die or fail to reproduce. The intake or exposure to radioactivities leads to the various types of cancer most frequently associated with radiation exposure include leukemia and tumors of the lung, breast, thyroid, bone digestive organs and skin.

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