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Determination of Annual Effective Dose and Concentration Level of Gross Alpha "A" And Beta "B" In Three (3) Different Fish Feed Samples

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ABSTRACT

This study was conducted for natural radioactivity of some fish feed samples in Nigeria, using gross alpha and beta method with protean instrument corporate (PIC) MPC 2000DP detector. The range of the gross alpha concentration for the sample, for the Uranium series was 0.0246 ± 0.0051 Bq/g to 0.0028 ± 0.0055 Bq/g, similarly for gross beta concentration ranges from 0.0651 ± 0.0104 Bq/g to 0.0621 ± 0.0100 Bq/g for the samples. The annual effective doses of the activities for the three sample A, B, and C which were 18.56 µSvy^{-1}, 10.91 µSvy^{-1} and 17.20 µSvy^{-1} respectively. The results appeared to be below the standard annual effective dose of 70 µSvy^{-1} for humans as recommended by (UNSCEAR, 1977 and 1982). This research shows that consumers of fish have no risk of radioactivity ingestion in to the food chain, even though no amount of radiation is assumed to be totally safe because radiation is known to trigger or induce cancer.

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Introduction

One of the measures taken to encourage fish farming is the production of fish feeds for nutrition in a stable and concentrated form. This enable the fish to feed efficiently and grow to their full potential. But consumption of various chemical contaminated fish has become a global concern. Environmental radiation originates from a number of naturally occurring and man-made sources. The largest proportion of human exposure to radiation comes from natural sources of external radiation, including cosmic and terrestrial radiation and from inhalation or ingestion of natural radioactive materials. The United Nations Scientific Committee on the Effects of Atomic Radiation has estimated that exposure to natural sources contributes >70% of the population radiation dose and the global average human exposure from natural sources is 2.4 mSvy^{-1} (cosmic ray 0.4, terrestrial gamma ray 0.5, radon 1.2, and food and drinking water 0.3) (UNSCEAR, 2000). Acute health effects of radiation, appearing with symptoms of nausea vomiting, diarrhea, weakness, headache, anorexia leading to reduced blood cell counts and in very severe cases to death, occur at high doses of exposure of the whole body or large part of the body. Therefore, acute health effects of radiation are practically not a concern for continuously monitored for radioactivity content–central drinking water supplies. However, extreme situations of possible terrorist use of radioactive materials to contaminate drinking water supplies, theoretically, cannot be excluded (WHO, 2004).

The dose arising from the intake of 1 Bq (by ingestion) of radioisotope in particular chemical from can be estimated using a dose conversion factor. Data for age related to dose conversion factors for ingestion of radionuclides has been published by the ICRP (ICRP, 1996). The dose conversion factors– synonyms are dose coefficients or dose per unit intake values (mSvBq^{-1}) for naturally occurring radionuclides (detectable primarily at higher natural background radiation areas) or those arising from human activities that might be found in water supplies at somewhat higher probability (in case of incident)(WHO, 2004).

Naturally abundant radionuclides (^{226}Ra, ^{232}Th and 40K) in the environment, and releases from fertilizers, agrochemicals, research and medical facilities form the bulk of radionuclides in ground and surface water and get in to human body via consumtion (Wisser, 2005). Therefore presence of radioactivity in contaminated environment can be attributed to naturally occurring and artificially induced sources (Wisser, 2005).

Artificial radioactivity is due to human activities, mainly as a result of agriculture (foods), medicine, research as well as other activities like mining and milling of mineral ore which exposes the earth surface. All this contamination may have health effect; that poses great danger to human and other living organism in the biosphere. Study of natural radioactivity is usually done in order to gain information about the present levels of harmful pollutants that are discharged to the environment itself or in the living creatures (Wisser, 2005). Radionuclides lead to production radiations, whereas radiation is known to trigger or induce cancer in living tissue. In nature, alpha particles come from the radioactive transformation of heavy elements (e.g., uranium, radium, thorium and radon) where long transformation chains produce several successive alpha and beta particles until the resulting nuclide has a stable configuration (NRPB, 1992).

Materials and Method

This research study has been designed to estimate the natural Radioactivity levels of some fish feed commonly used for fish farming in some part of Nigeria. Four samples were carefully selected for the purpose of the research.

Sampling Collection

The study on the fish feeds for natural radioactivity was based on the accepted guideline permissible and adopted by the International Commission on Radiological Protection (ICRP), the National Committee on Radiation Protection and Measurements (NCRP). Fish feeds were collected from various place in Kano Metropolis, there are many commercial feeds which are used by the farmers for production of fish. Among the large number of commercial feed some of the feeds used in the present study were collected from different Agro-vet companies. Three most widely used feeds were sampled, namely:

- Sample FFA
- Sample FFB
- Sample FFC

The sampled were carefully packed into polyethylene bags, labeled and transported to the Centre for Energy Research and Training, Zaria for further preparation, Gross alpha and beta count and analysis in accordance with standard methods.

Sample Preparation

The collected samples of fish feed were grounded to fine powder and packed into fill labelled cylindrical plastic containers of height 7cm by 6cm diameter. This satisfies the selection of optimal sample container height (Ibeanu, 1999). Each container accommodated approximately 300g of fine grounded and sieved fish feed powder. They were carefully sealed (using Vaseline, candle wax and masking tape) to prevent radon escape and store for a minimum of 30 days. The samples were then tightly covered and kept in the laboratory. These samples were analyzed for gross alpha and beta activity using an IN-20 model gas-flow proportional counter at the Centre for Energy Research and training, Ahmadu Bello University, Zaria, Nigeria.

Each sample was counted three times and the mean used in computing the activity. The operational modes used for the counting were the α-only mode for the alpha counting and the β (+α) mode for the beta counting. The count rate of each sample was automatically processed by the computer (IN-20 Model Technical Manual, 1991).

Estimation of Ommitted Effective Dose

Radionuclide may reach the gastrointestinal tract directly by ingestion or indirectly by transfer from the respiratory tract. From small intestine (S1) the radionuclide can be absorbed to the body fluids. The annual alpha and beta effective dose due to intake of ground water was determine by averaging the individual annual committed effective doses contributed by the major alpha and beta emitters in the ^{238}U and ^{232}Th series of the naturally occurring radionuclide (Ogundare and Adekoya, 2015). In this work, the effective dose over one year will be calculated using the following relation (IAEA , 2003).

$$E_{avg}(\alpha,\beta) = \sum A_{i(\alpha,\beta)} \times DCF_{i(\alpha,\beta)} \qquad (1)$$

Where E_{avg} (α/β) is the average gross annual alpha or beta committed effective dose in drinkable water, A i(α/β) is the gross alpha or beta activity concentration of individual radionuclides present in water samples and DCF i(α/β) is the dose conversion factor in Sv/Bq for ingestion of the individual radionuclide.

The alpha and beta specific activities were calculated using (Akpa et al., 2004).

$$\text{Specific Activity } (\alpha/\beta)\text{ Bql} - 1 = \frac{\text{counting Rate } (\alpha,\beta) - \text{Backgoundcounting rate } (\alpha,\beta)}{\text{Sample Efficiency} \times \text{channel efficiency} \times \text{weigt of the sample}} \qquad (2)$$

Sample Analysis

After the samples were carefully prepared as explained above according to the IAEA specifications for gross alpha and beta analysis, the samples were analyzed for gross alpha and beta activity using an IN-20 model gas-flow proportional counter at the Centre for energy research and training, Ahmadu Bello University Zaria Nigeria. Each sample was counted three times and the mean used in computing the activity. The operational modes used for the counting where α-only mode for the alpha counting and the B (+α) mode for the Beta counting. The count rate of each sample was automatically processed by the computer using the equation:

$$A(\alpha,B) = B(\alpha,B)\ x\ {}^{60}/_{T} \qquad (3)$$

Where **A (*α*,*B*)**= The count rate (cpm) of the alpha or beta particle
T= count time (2700seconds).

Also the activity of each sample was calculated using the equation:

$$C(\alpha,B) = \frac{(A(\alpha,B) - G(\alpha,B))U(\alpha,B)}{H(\alpha,B) \times S(\alpha,B) \times V(\alpha,B)} \qquad (4)$$

Where $C(\alpha,B)$ = alpha or beta activity (Bq/g).
$G(\alpha,B)$ = Background count of alpha or beta particle.
$U(\alpha,B)$ = unit coefficient of alpha or beta particle ($1.67\text{x}10^{-2}$- conversion factor from cpm to cps, where cps= 1Bq).
$H(\alpha,B)$ = channel efficiency for alpha or beta counting.
$S(\alpha,B)$ = sample efficiency for alpha or beta counting.
$V(\alpha,B)$ = sample volume or mass (litre or g)
The sample efficiency for the soil samples was computed using

$$E_s = \frac{m_r}{m_i} \times 100 \qquad (5)$$

Where m_r = Recovered mass after pellet was formed.
m_i = initial mass of the sample in powdered form.
The error associated with the sample activity was computed using:

$$E_r = \frac{((B + (100000)^2)/T_{bgd})^{\frac{1}{2}}}{((100000 \times U)/(H \times S \times V))} \qquad (6)$$

Where; B = sample raw count,
H = channel efficiency
T_{bgd} = background count time,
S = Sample efficiency
U = unit coefficient ($1.67\text{x}10^{-12}$),
V = sample volume or mass

he average annual alpha or beta effective dose for a particular sample was determined by averaging the individual annual effective doses contributed by the major alpha or beta emitters in the ^{238}U and ^{232}Th series of the naturally occurring radionuclides as shown in the equation below;

$$E_{avr} = I_p \times DCF_{ing} \times A_{sp} \qquad (7)$$

Where:
E_{avr} is the average gross annual alpha or beta effective dose in the medicinal plant sample.
DCF_{ing} is the dose convection factor for ingestion, for each radionuclide (i.e., 4.5×10^{-5} mSv/Bq, 2.3×10^{-4} mSv/Bq and 6.2×10^{-6} mSv/Bq for ^{238}U, ^{232}Th and ^{40}K respectively for an adult) (UNSCEAR, 2000),
I_p is the consumption rate from intake of NORMS in medicinal plants and
A_p is the activity concentration in the plant samples.

Since there is not a well-accepted consumption rate for medicinal plants, a consumption rate of 1.8 kg yr^{-1} was assumed for all the medicinal plants used in this study, assuming that a person needs 100 ml/day (an upper average dosage) of the herbal preparation or product during the treatment period

Results and Discussions

Here is the result of three (3) fish feed samples submitted for total radioactivity analysis. Table below shows the result of gross alpha and beta radioactivity concentration for three (3) samples in the unit of Bq/g.

Table 1: Results of gross alpha, beta and specific activity of plant sample

S/No	Sample ID	Alpha concentration(Bq/g)	Error ±	Beta concentration(Bq/g)	Error ±
1	FFA	0.0028	0.0055	0.0621	0.0100
2	FFB	0.0126	0.0065	0.0651	0.0104
3	FFC	0.0246	0.0051	0.0676	0.0103
	Average	0.0133	0 0057	0.0649	0.0102

Table 2: Committed Effective Dose Due to gross Alpha (^{226}Ra and ^{232}Th) and gross Beta (^{228}Ra) Activity concentrations in three fish feed samples

S/N	Sample ID	Effective Dose rate in µSv/yr ^{226}Ra	Effective Dose rate in µSv/yr ^{232}Th.	Effective Dose rate in µSv/yr ^{228}Ra.	Total Effective Dose rate µSv/yr.
1	FFA	7.84	6.44	4.28	18.56
2	FFB	3.53	2.89	4.49	10.91
3	FFC	6.88	5.66	4.66	17.2
	Average	6.08	4.99	4.47	15.55

Discussion

Alpha particles increases the risk of cancer, in particular alpha radiation is known to cause lung cancer in humans when alpha emitters are inhaled (Globocan, 2002). The greatest exposure to alpha radiation for average citizens comes from the inhalation of radon and its decay products, several of which also emit potent alpha radiation. Lasheen et al., (2008) recognizes ^{238}U, ^{234}U, ^{230}Th, ^{226}Ra, ^{210}Pb and ^{210}Po for the Uranium series and ^{232}Th, ^{228}Ra and ^{228}Th for the Thorium series as the major alpha and beta emitting radionuclides which are of importance to internal irradiation (Lasheen et al., 2008; Agbalagba, 2012 and Tettey-Larbi, 2013). Beta radiation can cause both acute and chronic health effects but acute exposures are uncommon. Chronic effects result from low-level exposure over a long period. They develop relatively slowly (5 to 30 years). When taken internally beta emitters can cause tissue damage and increase the risk of cancer. The risk of cancer increases with increasing dose. Some beta emitters such as carbon-14 distribute widely throughout the body. Others accumulate in specific organs and cause chronic exposures. In this research the feed recorded an average value of the gross alpha activity concentration of 0.0133± 0.0057 Bq/g and gross beta activity concentration of 0.0649 ± 0.0102 Bq/g with an average value of total effective dose rate of 15.5 µSv/yr for all the three fish sample. From this work it revealed that the fish feed used in fish farming have a relatively high alpha and beta activity concentration. This might contribute to the activity concentration in fish, which eventually gets into the food chain.

Conclusion

The research for natural radioactivity by gross alpha and gross beta measurement in three samples obtained from fish feed has been carried out using one channel-gas flow proportional counter (MPC-2000DP). The range of the average gross alpha from; ^{232}Th and ^{226}Ra, for the Uranium series and average gross beta from; ^{228}Th were 0.0133 ± 0.0057 Bq/g and 0.0649 ± 0.0102Bq/g respectively. These activities concentration were converted to mean effective doses is 15.55 µSvy^{-1} which appeared to be below the standard annual effective dose of 70 µSvy^{-1} for humans as recommended by the committee on the effects of atomic radiation report (UNSCEAR, 2000).In general the alpha and beta activity in the three different fish feed samples are far below the WHO limits. Since the alpha and beta activities in the three fish feed samples are far below the WHO contamination limit, the activities in the zones do not contaminate the feed to any significant level. The alpha and beta activity are just background radioactivity. Therefore no radiological hazard to the fish, since the radioactivity in the feed is only background.

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