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Determination of Potassium – 40 (^{40}k) Concentration in Some Powdered Milk Samples Consumed In Delta State, Nigeria

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Abstract: *This work is based on the determination of ^{40}K in samples of powdered milk consumed in Delta State and also a brief discussion of radioactivity transference from the environment to mankind. Ten samples of milk were collected and analyzed for radioactivity concentration. The measurements were performed using a Laboratory fluorimeter, Models CBS- 380. The results obtained for the milk sample were compared to world Health organization (WHO) standard to ensure its safety to human consumption and were found to be lower than the permissible limits. Thus, there is full confidence in consumption of these milk brands.*
Keywords: *Potassium – 40, Radionuclides,Radioactivity,Half life,Concentration*

I. Introduction

The radioactivity measurements in environment and foodstuffs are extremely important for controlling radiation levels to which mankind is direct or indirectly exposed. Besides natural radionuclides, due to several nuclear weapon tests and numerous nuclear reactor accidents, various artificial radioactive elements were introduced in the biosphere. Another important fact is that, importation of contaminated food from any region that suffered a nuclear accident, can indirectly affect people's health [8].

A great percentage of natural radiation exposure is due to ingestion of food containing natural radionuclide such as ^{40}k, ^{226}Ra,^{210}Po,^{210}Pb. Among these,^{40}K is the most important natural radionuclide in the environment from the health physics point of view.

The half life of ^{40}K is 1.3 billion years and it decays to ^{40}Ca by emitting a beta particles with no attendant gamma radiation (89% of the times) and the gas ^{40}Ar by electron capture with emission of an energetic gamma ray (11% of the times). So ^{40}K can present both external and internal health hazards. The strong gamma radiation (Ey = 1.46 Mev) makes the external exposure to this radioisotope a concern. While in the body ^{40}K poses a health hazard from the beta particles (E_B Max = 1.35 Mev) and gamma rays which association with cell damage and general potential for subsequent cancer induction [1].

Among different kinds of foodstuffs, milk is a reliable indicator of the general population intake of certain radionuclides, since fresh milk is consumed by a large segment of the population, and contains several biologically significant radionuclides. Also this work is to create the awareness of the activity concentration of ^{40}K in powdered milk samples among the populace in locality of research and the danger it can caused when the level of ^{40}K is high compared with world Health standard values.

II. Contamination Pathways.

Radioactive contamination can enter the body through ingestion, inhalation, absorption or ingestion. Radioactive contamination may also be ingested as the result of eating contaminated plants and animals or drinking contaminated water or milk from exposed animals Also, Dietary pathways become contaminated with radioactive materials from these man-made applications during routine operation, accidents and migration of radionuclides from radioactive waste disposal repositories into the biosphere. This anthropogenic contribution gained prominence after the Chernobyl nuclear power plant accident on 26th April 1986 when large quantities of the radioactive substances were released to the environment, which eventually found their way in the soil and vegetation [10,14].

One of the major anthropogenic means of contamination in the environment is radiocaesium (^{137}Cs, half –life 30.2years), as reported by some authors [14,13,4]

It is a dormination fission product with a high relative mobility in the soil – plant system, long term bioavailability, and high radio toxicity and is long lived. Apart from these man – made sources, the radiation burden of the environment is constantly being enhanced by ionizing environment is constantly being enhance by ionzing radiations from natural sources and their transfer to plant and produce have been noted by some authors [13,7].

Contamination of the food chain occur as a result of direct deposition of these radionuclides on plants leaves, fruits tubers, root up take from contaminated soil or water, and animals ingesting contaminated plants, soil or water. Some works have been carried out in this area by some authors in recent time. The aquatic environment (like Niger Delta environment) received the greatest input of radionuclides from atmospheric

testing of nuclear weapons and low levels of radioactive wastes discharges from nuclear industries where they exist. Sea also contains natural occurring radionuclides of primordial and cosmogenic origin. Both aquatic plants and animals accumulate elements to concentrations greater than those of the ambient water [2]. As a source of food, that aquatic environment provides a large fraction of the diet through aquatic foods of some individual and certain local population. Contamination of fish therefore, constitute a significant pathway for the uptake radiocaesium to man.

The presence of ^{226}Ra in water constitutes a major sources of naturally occurring radionuclide and its content in food contributes significantly to the radiation intake on the general populace [9]. Fruits, vegetables, cereals, and tubers are vital in our diet and presence of natural radionulides ^{40}k, ^{238} U and ^{232} Th in them have certain radiological implication not only in the food, but also on the populace consuming these food sources [6]. These doses received by a person consuming aquatic foodstuffs, fruits, vegetable depends on the radionuclides concentration of the food and the quantity [5, 7].

III. Materials and Methods

Study Area

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 [3]. The area is bounded by latitude 5^0 31' and 6^0 00' North, and longitude 5^0 00' and 7^0 00 East. The area experience wet and dry season which are typical seasons in Nigeria [12].

Ten samples of different types of powdered milk were collected from the local market in Delta State and were analyzed using Laboratory Fluorimeter, Model CBS-380. Numbers were used as codes to hide the identity of brand names.

Extraction procedure

Determinations are useful only in organic solvents into which the radioactive elements are extracted with Dibenzoyl methane.

Determination

This method is used for the determination of very low concentrations of radioactive element in water solid samples. This method is based on the fluorescence of radioactive element in a pad prepared by fusion of the dried solids from the water sample with a flux of 10 percent Naf, 45.5 percent $Na_2 Co_{3,}$ and 45.5 percent K_2Co_3 . This flux permits use of a low fusion temperature and yields pads which are easily removed from the platinum fusion dishes for fluorescence measurements. Uranium concentrations of less than 1 microgram per liter can be determined on a sample of 10 milliliters, or less. The sensitivity and accuracy of the method are dependent primary on the purity of reagents used, the stability and linearity of the fluorimeter, and the concentration of the fluorimeter, and the concentration of quenching elements in the water residue.

A purification step is recommended when the fluorescence is quenched by more than 30 percent.

Fluorescence Theory/Principle

Fluorescence is the molecular absorption of light energy at one wavelength and its nearly instantaneous re-mission at another, usually longer, wavelength. Some molecules fluorescence naturally and others can be modified to make fluorescent compounds.

Fluorescent compound have two characteristic spectrums: an excitation spectrum (the wavelength and amount of light absorbed) and an emission spectrum (the wavelength and amount of light emitted). These spectra are often referred to as a compound's fluorescence signature of fingerprint. No two compounds have the same fluorescence signature. It is the principle that makes flourometry a highly specific analytical technique.

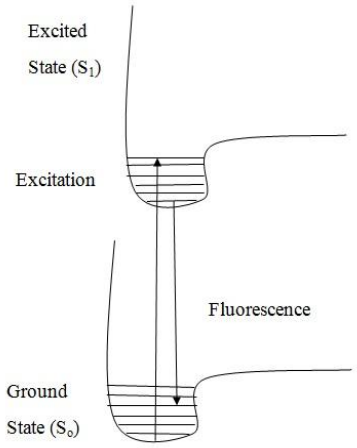
Fluorometry is the measurement of fluorescence. The instrument used to measure fluorescence is called a fluorometer or fluorimeter. A fluorimeter generates the wavelength of light required to excite the analyte of interest; it selectively transmits the wavelength of light emitted, then it measures the intensity of the emitted light. The emitted light is proportional to the concentration of the analyte being measured (up to a maximum concentration).

Fluorimeters employ monochromators (spectro fluorimeter), optical filters (a filter fluorimeter) or narrow band light sources like LED's or laser to select excitation and emission wavelengths.

Fluorometry is chosen for its extraordinary sensitivity, high specificity, simplicity, and low cost as compared to other analytical techniques. Fluorometry is ordinary 1000-fold more sensitive than absorbance measurement. It is a widely accepted and powerful technique that is used for a variety of environmental, industrial, and biotechnology applications. It is valuable analytical tool for both quantitative and qualitative analysis.

Molecular florescence is the optical emission from molecule that have been excited to higher energy levels by absorption of electromagnetic radiation. The main advantage of fluorescence detection compared to absorption

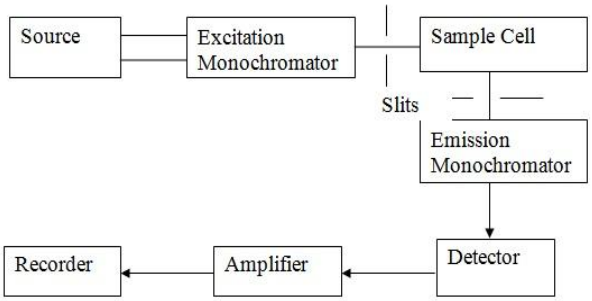
measurements is the greater sensitivity achievable because the fluorescence signal has in principle a zero background. Analytical applications include quantitative measurements of molecules in solution and fluorescence detection in liquid chromatography.



Transition between molecular electronic energy levels: Instrumentation

A Typical Fluorimeter

A typical fluorimeter contains an excitation source, sample cell, fluorescence detector. Molecules in solution are usually excited by Uv light and the excitation source usually a deuterium or xenon lamp. Broad-band excitation light from a lamp passes through a monochromator, which passes only a selected wavelength. The fluorescence is dispersed by another monochromator and detected by a photomultiplier tube. Scanning the excitation monochromator gives the excitation spectrum and scanning the fluorescence monochromator gives the fluorescence spectrum. Simple instruments sometime use only a band pass filter to select the excitation wavelength. Below is the diagram of a typical fluorimeter.



Light emission from atoms or molecules can be used to quantitate the amount of the emitting substance in a sample. The relationship between fluorescence intensity and analyte concentration is:

$$F = k.\ EQ.\ Po.\ (1\text{-}10\ |\text{-}e.b.c\ |)$$

Where F is the measured fluorescence intensity, K is a geometric instrumental factor, QE is the quantum efficiency (photons emitted (proton absorbed).

Po is the radiant power of the excitation source, Ɛ is the wavelength-dependent molar absorptivity coefficient, b is the path length, and c is the analyte concentration (Ɛ,b, and c are the same in the Beer-Lambat law).

Expanding the above equation in a series and dropping the higher terms gives

$$F = k.\ Q\ E\ .\ Po.\ (2.303.Ɛ.b.c)$$

This relationship is valid low concentrations (<10-5M) and shows that fluorescence intensity is linearly proportional to analyte concentration.

Determining unknown concentration from the amount of fluorescence that a sample emits requires calibration of a fluorimeter with a standard (to determine k. and QE) or by using a working curve.

Limitations

Many of the limitations of the Beer-Lambart law also affect quantitative fluorimetry. Fluorescence measurements are also susceptible to inner filter effects. These effects include excessive absorption of the excitation radiation (pre-filter effect) and self- absorption of atomic resonance fluorescence (post-filter effect)

IV. Results and Discussion

Results:

MILK Sample	Uranium 233 (Bq/l)	Pb 212 (Bq/l)	Pb 208 (Bq/l)	Potassium 40 (Bq/l)
1	<0.001	<0.001	<0.001	<0.001
2	<0.001	<0.001	<0.001	$1.3x10^{-6}$
3	<0.001	<0.001	<0.001	$1.1x10^{-6}$
4	<0.001	<0.001	<0.001	<0.001
5	<0.001	<0.001	<0.001	$1.3x10^{-6}$
6	<0.001	<0.001	<0.001	$1.2x10^{-6}$
7	<0.001	<0.001	<0.001	$1.3x10^{-6}$
8	<0.001	<0.001	<0.001	<0.001
9	<0.001	<0.001	<0.001	$1.2x10^{-6}$
10	<0.001	<0.001	<0.001	$1.3x10^{-6}$

Table 1. Summary of results (Bq/l) from the analysis.

V. Discussion

The results above are the values obtained from the powdered in milk samples collected from the local markets in Delta-State.

The measured activity concentration of ^{233}U, ^{212}Pb, ^{208}Pb and ^{40}k detected in the samples of powdered milk are summarized in table 1. It can be noticed that ^{40}K was detected in all the samples and varied between <0.001Bq/L to $1.3x10^{-6}$ Bq/L. The measured concentration for ^{233}U, ^{212}Pb, ^{208}Pb and ^{40}K are <0.001. On the other hand, the least value of ^{40}K is $1.3x10^{-6}$ Bq/L in samples No. (2,5,7 and 10) respectively. The highest concentration of ^{40}K was <0.001 in sample No.(1). While the concentration for of ^{233}U, ^{212}Pb and ^{208}Pb are the same.

The ^{233}U, ^{212}Pb, ^{208}Pb and ^{40}K activities measured in the present work were compared with the values obtained with the World Health Organization (WHO) standard. It is important to remark that the ^{233}U, ^{212}Pb, ^{208}Pb and ^{40}K activities levels determined in the present study were within the accepted limits. Thus this makes it saved for Human consumption.

VI. Conclusion and Recommendations

Natural radioactivity such as ^{233}U, ^{212}Pb, ^{208}Pb and ^{40}K radionuclides were determined for most available powder milk consumed in Delta-state. The measured activities for ^{233}U, ^{212}Pb, ^{208}Pb and ^{40}K were below the detection limits when compared to World Health Organization (WHO) standard.

Moreover, radioactive contamination is as the result of eating contaminated plants and animal or drinking contaminated milk from exposed animals. A long accumulation of high concentration of the natural radionuclides is capable of causing serious health impairment like serious health impairment like serious brain damage, weight lost, Retinal degeneration, Hearing impairment and even death.

It will be advisable that the milk from cow, goat and sheep should be checked periodically over a long period because of their grazing habits. Regular monitoring of these radionuclide's in milk and in other food to prevent excessive build up of radionuclides in the food chain.

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