# RADIONUCLIDE IN FOODSTUFFS: THE NIGERIAN SITUATION IN THE ESTIMATION OF INTERNAL EXPOSURE FROM INCORPORATED URANIUM AND THORIUM.

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**Abstract:**
The radiological impact of nuclear radiation in the environment has been a source of concern to many researchers all over the world. This is because of the deleterious effects of radionuclides present in the various environmental samples to human health. The overall sociopolitical implications cannot be over emphasized in view of the fact that a healthy people make a healthy economy of a nation. Until now in Nigeria, little or no quantitative and qualitative data on radionuclide present in the environment are available for the required assessment and reassessment that will help in the mitigation of the above mentioned problem. In spite of the increasing application of radioactive sources in the country, little efforts have been made so far by some researcher in Nigeria in the monitoring of nuclear radiation. These efforts have been bias toward external dosimetry with the neglect of internal dosimetry needed for the comprehensive studies of the radiological risk to the internal organs. In an effort to stimulate increased research in this area, the present work is aimed at the various foodstuffs in the country which is the major pathway of radionuclide into the internal organs of the body. The distribution and retention of some radionuclides following ingestion of local food samples using deterministic models presented by the International Committee on Radiological Protection (ICRP) will be discussed.

***Keywords: foodstuffs, internal dose, model, radionuclide, health***

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**Introduction**

Radiological impacts of nuclear radiation in the environment become a primary source of concern because of the availability of most parent nuclides of primordial origin. In most environments, the main technologically enhanced naturally occurring radioactive materials (TENORM) are the uranium and thorium and their progenies, together with $^{40}K$. These radionuclides, especially $^{238}U$ and $^{232}Th$, may be concentrated in granites and alkaline igneous rocks (UNSCEAR, 2000). These radionuclies ($^{238}U$ and $^{232}Th$) are both radiotoxic and chemically toxic. The health hazards associated with these radionuclides stem from their ability to accumulate in human tissues. During their decay processes, there is the emission of highly penetrating gamma rays and ionized particles, thereby causing intensive damage to the tissues where they are localized.

Natural radionuclides have been found in some foodstuff in Nigeria (Olomo, 1990; Arogunjo, 2003a&b, 2004), only recently, high concentration of natural radionuclides was reported in foodstuffs from some parts of the Jos plateau (Jibiri et al, 2007). In view of the serious hazards posed to man, especially through the ingested pathway, internal contribution to the body burden cannot be neglected in order to properly access the overall radiation body burden.

In monitoring incorporation pattern of radionuclides, reliable knowledge of the daily intake from natural radionuclide sources and their metabolic behaviour are necessary. In Nigeria, the ingestion rate of these radionuclides has not been studied as obtained in other parts of the globe. This paper is aimed at sensitizing the need to evaluate the daily intake of $^{238}U$ and $^{232}Th$ in foodstuffs and water in Nigeria. In addition, the distribution and retention of these radionuclides following ingestion of local food samples using deterministic models presented by the International Committee on Radiological Protection (ICRP, 1995) will be discussed.

## Methods

In order to be able to monitor the incorporation pattern of radionuclide, reliable knowledge of the daily intake from natural radionuclide sources and their metabolic behaviour are necessary. The qualitative and quantitative determination of radionuclide activity in foodstuffs remains the most viable option available if reliable dose calculation is to be made. Various analytical methods such as gamma

spectroscopy, atomic absorption spectroscopy (AAS), atomic emission spectroscopy (AES), X-ray fluorescence, neutron activation analysis (NAA), proton activation analysis (PAA), mass spectroscopy (MS), inductively coupled plasma mass spectroscopy (ICP-MS), etc. Internal dose calculation following the ingestion of food require bioassay measurements involving the determination of biological substances like urine and blood as indicator following radionuclide injected, ingested, or inhaled into the body. Biokinetic models describing the distribution of radionuclide in the various organs of the body are available for the evaluation of doses delivered to the whole body.

**Biokinetic modeling of radionuclide**

In the assessment of the extent of human exposure to radionuclide and the related risk, data on the daily excretion in urine is required; this excretion is related to the intake, the metabolic processes governing the absorption into the systemic circulation from the gastrointestinal (GI) tract and also the distribution and retention in the body organs. Radionuclide transport in the human body can be investigated using deterministic model. This process involves model simulation of the linear transfer processes represented by sets of linear differential equations governed by first order kinetics. In order to be able to compare the measured urinary excretion rates with that predicted by the ICRP biokinetic models for most radionuclide, expected excretion rates through lifetime could be simulated using the age dependent biokinetic transfer coefficients for the six age groups given by the ICRP Publication 69, 1995. For the purpose of simulating the behaviour of the radionuclide between compartments after ingestion, the systemic model must be coupled to the gastrointestinal (GI) tract model. The ICRP age-dependent transfer rates in the GI tract and the transfer rate from the small intestine to blood could also be calculated according to ICRP Publication 69, 1995. In modelling the lifetime excretion rates of a radionuclide like uranium for example, the distribution within the internal organs of the body can be described by a compartmental model illustrated in Fig. 1. The biokinetic transfer coefficients governing the retention R of a particular radionuclide in the various compartments of the systemic and the GI tract models during the integral time course could be performed using age-dependent linear interpolation. The transfer between the various compartments follows a system of first-order kinetics. Hence, the retention of the

radionuclide in the various compartments is governed by linear transfer processes represented by sets of linear differential equations.

Given the compartmental model of the GI section of Fig 1, if q(t) is the radionuclide activity ingested in a compartment at time t, the model is described by the following eqns:

$$\frac{d}{dt}q_{ST}(t) = -\lambda_{ST}q_{ST}(t) - \lambda_R q_{ST}(t) + \dot{I}(t)$$

$$\frac{d}{dt}q_{SI}(t) = -\lambda_{SI}q_{SI}(t) - \lambda_R q_{SI}(t) + \lambda_{ST}q_{ST}(t) - \lambda_B q_{SI}(t)$$

$$\frac{d}{dt}q_{ULI}(t) = -\lambda_{ULI}q_{ULI}(t) - \lambda_R q_{ULI}(t) + \lambda_{SI}q_{SI}(t)$$

$$\frac{d}{dt}q_{LLI}(t) = -\lambda_{LLI}q_{LLI}(t) - \lambda_R q_{LLI}(t) + \lambda_{ULI}q_{ULI}(t)$$

where $\lambda_R$ is the radioactive decay constant of the radionuclide in question

$\lambda_B q_{ST}(t)$ is the rate of transfer of activity to the body fluid (systemic circulation)

$\lambda_i$ is the biological clearance rate from the compartment i to the other

$\lambda_i q_i(t)$ is the rate of transfer of activity from the compartment i to the other

$\lambda_R q_i(t)$ is the decay rate of the radionuclide activity in the compartment i

$\dot{I}_i(t)$ is the rate of intake of the activity from outside into the compartment i at time t.

To model these multi-compartmental systems and to solve the sets of linear differential equations, different software packages are available for solving multi-compartmental systems.

The retentions of uranium in organs and tissues are as follows:

$R_{kidney}(t) = q_{14}(t) + q_{21}(t)$

$R_{skeleton}(t) = q_5(t) + q_6(t) + q_7(t) + q_8(t) + q_9(t) + q_{10}(t)$

$R_{liver}(t) = q_3(t) + q_4(t)$

$R_{othersofttissue}(t) = q_{11}(t) + q_{12}(t) + q_{13}(t)$

$R_{blood} = q_1(t) + q_2(t)$

$R_{wholebody} = q_1(t) + q_2(t) + q_3(t) + q_4(t) + q_5(t) + q_6(t) + q_7(t) + q_8(t) + q_9(t) + q_{10}(t) + q_{11}(t) + q_{12}(t) + q_{13}(t) + q_{14}(t)$

$E_{urine}(t) = q_{21}(t) \times k_{15,21}(t) + q_1(t) \times k_{15,1}(t)$

$E_{faeces}(t) = q_{24}(t) \times k_{18,24}(t)$

where $R_{organ}(t)$ is the activity of uranium in the specified organ at time t; $E_{urine}(t)$ and $E_{faeces}(t)$ are the excretion rates of uranium in urine and faeces at time t; $k_{i,j}(t)$ is the transfer rate from compartment j to compartment i at time t with i, j = 1, 2, ……. 24; $q_i(t)$ is the activity in the compartment, i at time t, shown in Fig 1.

**Daily Intake of Radionuclide**

In the determination of radiation dose from radionuclide within the body, qualitative determination of the amount ingested or inhaled (being the two major pathways into the body) is required. The retention within the body is a function of the concentration of the amount ingested or inhaled and also the kinetics of the metabolism processes discussed above. It is therefore very expedient to have adequate knowledge of the various transfer pathways into the food chain. Fig 2 shows the suggested radionuclide incorporation pattern into the natural ecosystem. The estimated uranium daily intakes (μg) in some selected countries as compared to Nigeria are presented in Table 1. Marked variation observed in the daily intakes presented in this table is attributed to the differences in the composition of diet among the different countries and the contribution of different food categories. The report presented for Vietnam (Giang et al, 2001), variability within a particular country can be observed. In Nigeria, no effort has been made to identify various diet compositions and the contribution of food categories to the daily intakes of radionuclide.

## Conclusion

In view of the complex structural flow chat of the potential sources and transfer pathways presented in Fig 2, quantitative and qualitative determination of radionuclide present in Nigerian foodstuffs require concerted effort by all

stakeholders in the field of radiation and health physics. Little efforts have been made by some authors in Nigeria in the determination of radionuclide present in foodstuffs. The essential data needed to obtain the needed daily intake of radionuclide in Nigerian foodstuffs are very sparse and in most cases not available. Adequate knowledge of the rate of consumption of the various foodstuffs in the country is required in order to effectively estimate their daily intake.

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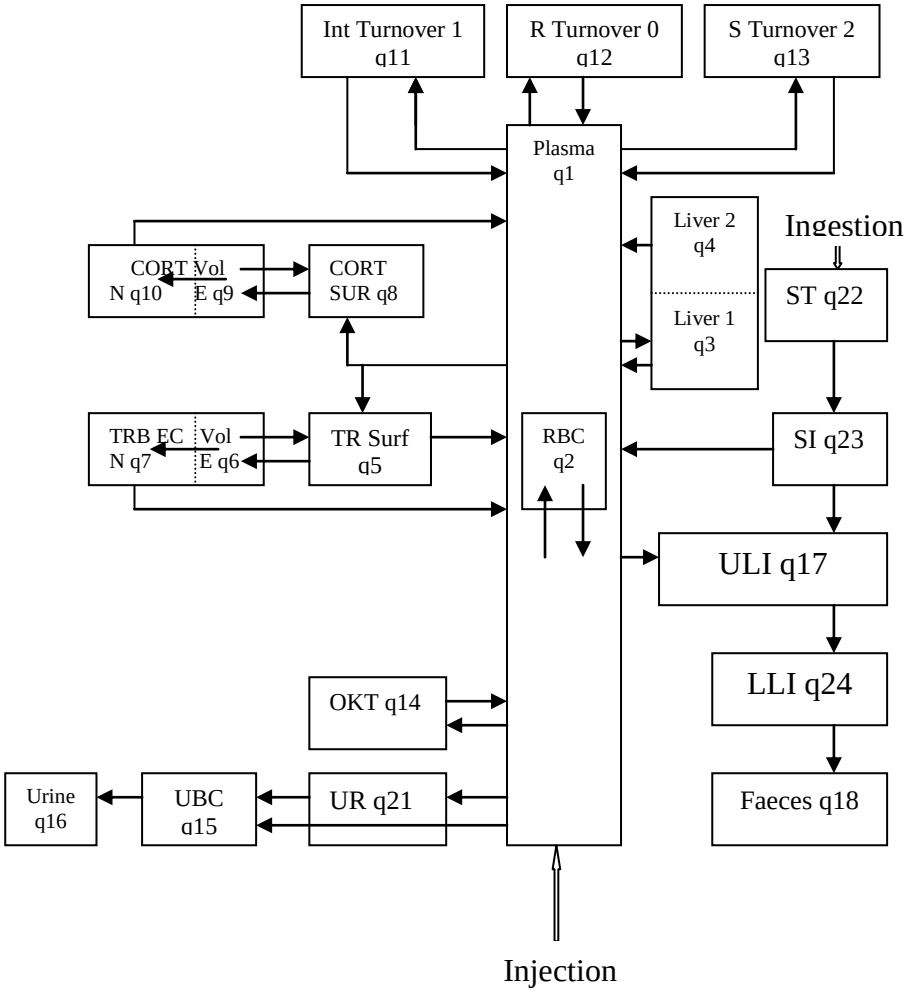
Table 1. Uranium daily intake in other part of the world as compared to Nigeria.

| Country | Total intake (μg) | References |
|---|---|---|
| Italy | 3.9 | Galletti et al. (2003) |
| Central Poland | 1.8 | Pietrzak-flis et al. (2001) |
| Ukraine | 0.6 | Shiraishi et al. (1997) |
| Yokohama Japan | 0.1 | Kuwahara et al. (1997) |
| Vietnam | 0.7 (0.09 – 2.33) | Giang et al. (2001) |
| France | 1.0 | UNSCEAR (2000) |
| Russian Federation | 3.5 | UNSCEAR (2000) |
| Nigeria | - | Present work |
| Worldwide | 1.3 | UNSCEAR (2000) |


Int Turnover 1
q11
R Turnover 0
q12
S Turnover 2
q13
Plasma
q1
Liver 2
q4
Liver 1
q3
Ingestion
ST q22
CORT Vol
N q10 E q9
CORT
SUR q8
TRB EC Vol
N q7 E q6
TR Surf
q5
RBC
q2
SI q23
ULI q17
LLI q24
OKT q14
Urine
q16
UBC
q15
UR q21
Faeces q18
Injection

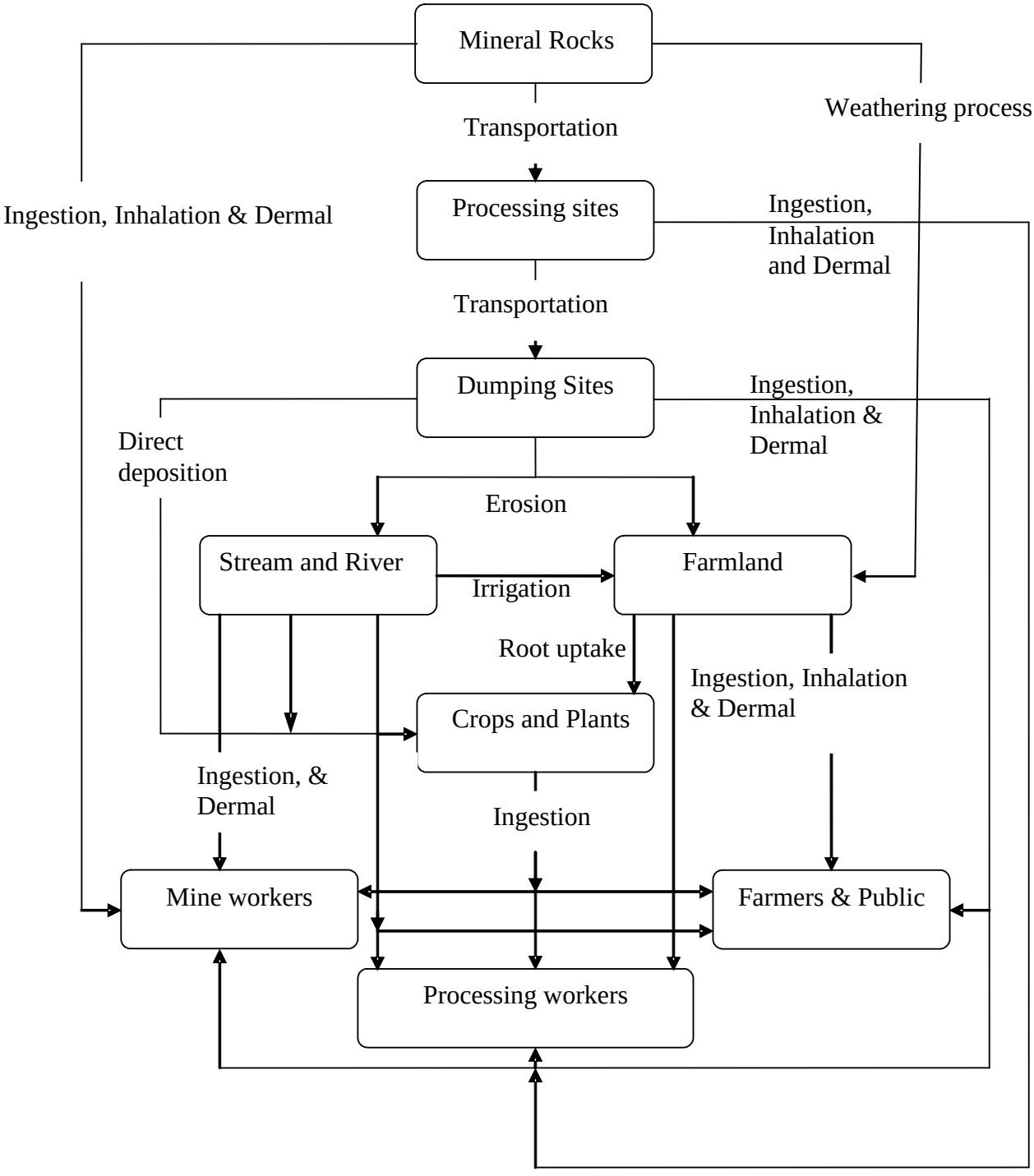



Fig 2: Radionuclide incorporation pattern into the natural ecosystem and man