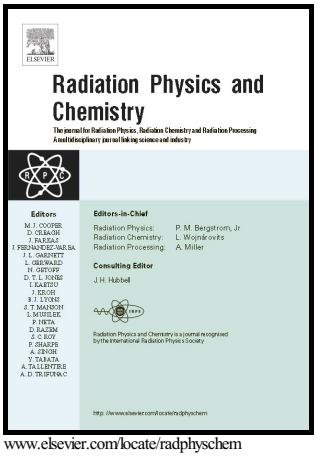

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Development of low level ^{226}Ra analysis for live fish using gamma-ray spectrometry

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Abstract

A low level ^{226}Ra analysis method for live fish was developed using a 4π NaI(Tl) gamma-ray spectrometer. In order to find out the best algorithm for accomplishing the lowest detection limit, the gamma-ray spectrum from a ^{226}Ra point was collected and nine different methods were attempted for spectral analysis. The lowest detection limit of 0.99 Bq for an hour counting occurred when the spectrum was integrated in the energy region of 50 - 2520 keV. To extend ^{226}Ra analysis to live fish, a Monte Carlo simulation model with a cylindrical fish in a water container was built using the MCNP code. From simulation results, the spatial distribution of the efficiency and the efficiency correction factor for the live fish model were determined. The MCNP model will be able to be conveniently modified when a different fish or container geometry is employed as fish grow up in real experiments.

Keywords
^{226}Ra; Low level analysis; 4π NaI(Tl) detector; Gamma-ray Spectrometry; Detection Limit; Monte Carlo.

1. Introduction

Radium exists in minute quantities in the environment, but its high toxicity has drawn attention for many decades in order to enhance the radium detection limit encountered in various materials. [Diab & Abdellah, 2013]. Among the Ra isotopes, ^{226}Ra and ^{228}Ra have been of great significance from a radiological protection aspect due to their relatively long half-lives, presence in nature, and high radiation dose per unit intake. One of the important areas requiring environmental radium monitoring is aquatic organisms, which are exposed to the risk of accumulating a substantial radioactivity from water even at low concentrations. In contrast to the marine environment, the information available on the distribution and the bioaccumulation of radionuclides in freshwater systems is scarce [Hameed *et al*, 1997]. ^{226}Ra is the most common in natural waters among the radium isotopes, because of the abundance and mobility of its parent ^{238}U in ground water. [Vandenhove *et al*, 2010]
Recently, the Radiation Biology research group at McMaster University established a study on the fish (fathead minnows) chronically exposed to low levels of ^{226}Ra in order to investigate the biological effects of the internally deposited alpha emitters in the fish. [Mothersill et al, 2014] Chronic exposure was carried out by steadily feeding fathead minnow fish species with a diet contaminated with ^{226}Ra [Mothersill *et al*, 2014]. A short feeding (~ 70 days) experiment using a 100 Bq/g dietary radium led to a typical fish ^{226}Ra activity of a few Bq/g. Therefore, it is reasonable to set an activity range of interest from 1 to 100 Bq. In order to build the correlation between the exposure and the biological effect, the accurate and precise quantification of the ^{226}Ra activity in fish is vital. A popular method for ^{226}Ra analysis in the fish is liquid scintillation counting (LSC). However, the LSC method requires complicated and tedious sample preparation steps. Moreover, with this method, fish should unavoidably be sacrificed, which requires a significant amount of time and effort in conducting fish radiation biology experiments to build a dose response curve. An obvious solution for these shortcomings is to employ a method that allows for collecting data using live fish. To this end, this study aims to develop a method for ^{226}Ra analysis for live fish using gamma-ray spectrometry.