DETERMINATION OF ^{134}Cs AND ^{109}Cd TRANSFER FACTOR AND DOSE ASSESSMENT FOR MALAYSIAN COCKLE (*Anadara granosa*)

Bioaccumulation and depuration study of Cs and Cd in the blood cockle (*Anadara granosa)*

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Introduction

Malaysians are a heavy consumer of seafood, which is a major source of protein and nutrition and therefore, become a potential carrier of contaminants from aquatic environment to man (Malek et al., 2004). These marine organisms can accumulate certain amount of toxic elements through continuous exposure to pollutants present in seawater and food (Malek et al., 2004). Coral reefs, fisheries and mangroves are all the marine resources contribute to the continuity of the food chain and the stability of the marine ecosystem. Any sources of pollution either radionuclides or heavy metal derived from land as well as sea would threat and drive these priceless resources to depletion. Human can be affected directly by these pollutants through the consumption of the contaminated seafood.

Potential risks from planned and unplanned releases of radionuclides from nuclear power generation activities and other nuclear technologies application may cause pollution to the marine environment. The risks become more significant since most of the newly built nuclear power plants are located near shores or rivers due to their cooling requirements (Skwarzec et al., 2001). Therefore, it is necessary to monitor the presence and the distribution of released radionuclides as long-lived artificial radionuclides is distributed worldwide through nuclear accidents (Skwarzec et al.,2001; Topcuoglu 2001; Malek et al.,2004). Among the radionuclides, ^{137}Cs is a famous fission product radionuclide which prone to be entered via food chain and has long physical half-life, high fission yield and high bioavailability (Gungor et al., 2001; Topcuoglu, 2001; Malek et al., 2004). Whereas Cd is also a common metal found in anthropogenically contaminated aquatic environments and is toxic to aquatic biota at elevated levels (Alquezar 2008).

Toxic heavy metal accumulation by marine organisms is a complex dynamic process, which is determined by both environmental and physiological factors such as water chemistry, size, contamination of feedstuffs, feeding intensity, position in the food chain etc. (Kryshev, 2000; Smith et al., 2002). After leaving the contaminated area, biota eventually loses much of their activity. A study on the elimination of toxic elements from marine organisms is needed to gather data for the assessment of the expected levels of

contamination to predict the time required for marine organisms to be adequately free from contamination through biological elimination and physical decay (Malek et al., 2004).

Anadara granosa may serve as good indicators of ecological conditions, since they are long-lived, forage at different trophic levels, integrate effects of lower trophic levels, and are reasonably easy to identify in the field - but more importantly, need to be non-migratory or territorial to reflect local environmental conditions (Alquezar et al., 2008). *Anadara granosa* are known as bloody cockle because of the hemoglobin blood pigment (D.V. Bal and K.V. Rao, 1984) and become favorite seafood locally consumed due to high nutrient content. Thus, we have conducted a study to determine the transfer factor or occasionally referred to as bioaccumulation and depuration of Cs and Cd in cockles as a first step for establishing baseline data which later can be used to estimate health risk to human through the consumption of contaminated seafood.

Research Objective

1. To determine ^{137}Cs and ^{109}Cd transfer factor for cockle (*Anadara granosa*) using radiotracers.
2. To determine dose responses specific and appropriate to cockle (*Anadara granosa*).

Research Methodology

Sampling

Anadara granosa (whole body wet weight of 16.90±1.10 g and shell length of 3.22±0.15 cm) which was collected from the coastal Kapar (Kg. Tok Muda), Selangor were thoroughly cleaned and acclimatized to laboratory conditions (static aquaria, constantly aerated; salinity ~20.0‰; 24.4±1.2 °C; light/dark cycle: 10h/14h) for a week prior to experimentation. They were fed daily with marine microalgae concentrates (*Nannochlorpsis sp.*) in an attempt to ensure good health.

Radiotracers and counting method

The radiotracer ^{134}Cs ($t_{1/2}$ = 2.066 year, in 0.1 M HCl containing 10 µg of Cs per ml) and radiotracers ^{109}Cd ($T_{1/2}$ = 464 days, in 0.5 M HCl) were purchased from Isotope Products Laboratories, USA. Radioactivities were measured using high-resolution gamma spectrometry systems consisting of a coaxial Germanium P-type detector (Ortec, USA) connected to a multichannel analyzer and a personnel computers employing spectral analysis software (Gamma Vision 6.01). For detector calibration, gamma multinuclides standard solution (comprising ^{210}Pb, ^{241}Am, ^{109}Cd, ^{57}Co, ^{123}Te, ^{51}Cr, ^{113}Sn, ^{85}Sr, ^{137}Cs, ^{88}Y and ^{60}Co) with known activities, prepared by Isotope Products Laboratories, USA (source no. 1290-84) was used. The performance of this instrument is monitored regularly to ensure it is fit for the purpose (Yii et al., 2003). Radioactivities of the samples were determined by comparison with known standards of appropriate geometry and were corrected for background and physical decay of the radiotracers. Seawater samples and the whole blood cockle were generally counted for 2 minutes.

Experimental procedures

Thirty individuals of *Anadara granosa* of equal numbers were placed in two separate glass aquaria (17x18x27 cm^3) containing 5 liters of filtered seawater each. They were exposed for ~30 days to the ^{134}Cs and ^{109}Cd radiotracer, respectively. The seawater was changed and the radiotracers were respiked daily, to ensure constant level of radionuclide concentrations in seawater and remove exometabolites. Temperature, salinity and pH of the seawater were recorded daily. To determine the uptake kinetics, *Anadara granosa* from each aquaria were sampled and counted daily. At the end of the bioaccumulation periods, they were transferred to the uncontaminated seawater for ~30 days prior to counting for determination of radiotracer depuration. *Anadara granosa* from each aquaria were sampled and counted daily to follow radiotracer loss kinetics.

Data analysis

Result gained from the bioaccumulation experiment is expressed in term of concentration factor, which is defined as counts per minute per gram of the whole organism divided by counts per minute of the radionuclide per milliliter of seawater. It can be describe by a single-component first-order kinetic order model (Topcuoglu, 2001; Gungor et al., 2001; Batlle et al., 2005; Alquezar et al., 2008) using the equation

$$C_t = C_{ss} (1-e^{-kt})$$

Where C_t is the whole body concentration factor value at time t, C_{ss} is the concentration factor at equilibrium and k is the biological elimination rate constant. Concentration factor, CF is a parameter which could predict the accumulation of radiotracers in the organisms.

$$CF = \frac{\text{Specific activity in wet animal (Bq/g)}}{\text{Specific activity in seawater (Bq/g)}}$$

Meanwhile, the loss kinetic in whole organism can be described by a single-component first order loss kinetic order model (Gungor et. al., 2001; Batlle et al., 2005; Alquezar et al., 2008) using the equation

$$A_t = A_o e^{-\lambda t}$$

or by a 2-component exponential model

$$A_t = A_{os} e^{-\lambda_s t} + A_{ol} e^{-\lambda_l t}$$

Where A_t is the percentage of the day zero whole body radionuclide content (A_o) remaining at time (t) days, λ is the excreation rate (d^{-1}), s is the subscribed for the short lives component and l is the subscribed for the long lived component.

Result & Discussion

Uptake kinetics

Whole-body uptake of ^{134}Cs and ^{109}Cd are shown in Fig. 1. The uptakes initially increased rapidly and followed by a more gradual accumulation. ^{109}Cd radiotracer was found to be accumulated in cockles and achieved steady state much later than ^{134}Cs. Furthermore, the concentration factor (CF) of ^{109}Cd in cockles exposed to spiked seawater (CF=12) was nearly 12 times higher than the CF of ^{134}Cs (CF=0.8). It has been considered that *Anadara granosa* did not show accumulation of Cs over the experimental time. It would be accumulate more slowly in marine ecosystems, and this is in agreement with the less affinity of ^{134}Cs found in seagrass *P.oceanica* (CF=1.1) and alga *C.taxifolia* (CF=1.4) (M.Warnau et al., 1996) and in mussels: *Mytilus galloprovincialis* with CF ranging from 2.80-2.57 (Gungor et al., 2001) and also was found to be not accumulated in *Anadara granosa* (Srisuksawad K and N. Prasertchiewchan, 2007).

Loss kinetics

The loss kinetics of ^{109}Cd and ^{134}Cs from seawater by cockles are as shown in Fig. 2. The loss of ^{109}Cd and ^{134}Cs from cockles exposed to spiked seawater was still incomplete after 10 days. However, cockles exposed to ^{109}Cd have the lowest (19%) total loss (i.e. 81% remaining) after 10 days, whereas those exposed to ^{134}Cs have the highest (69%) total loss (i.e. 31% remaining).

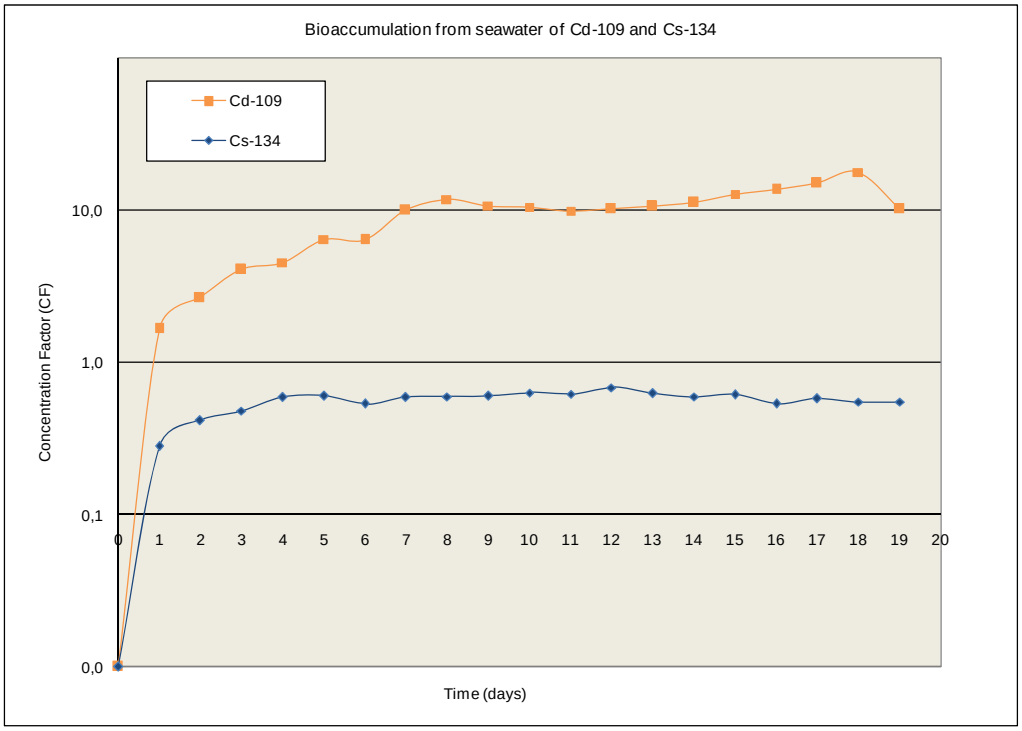

Fig. 1. Uptake of ^{109}Cd and ^{134}Cs in cockles from seawater over 19 day

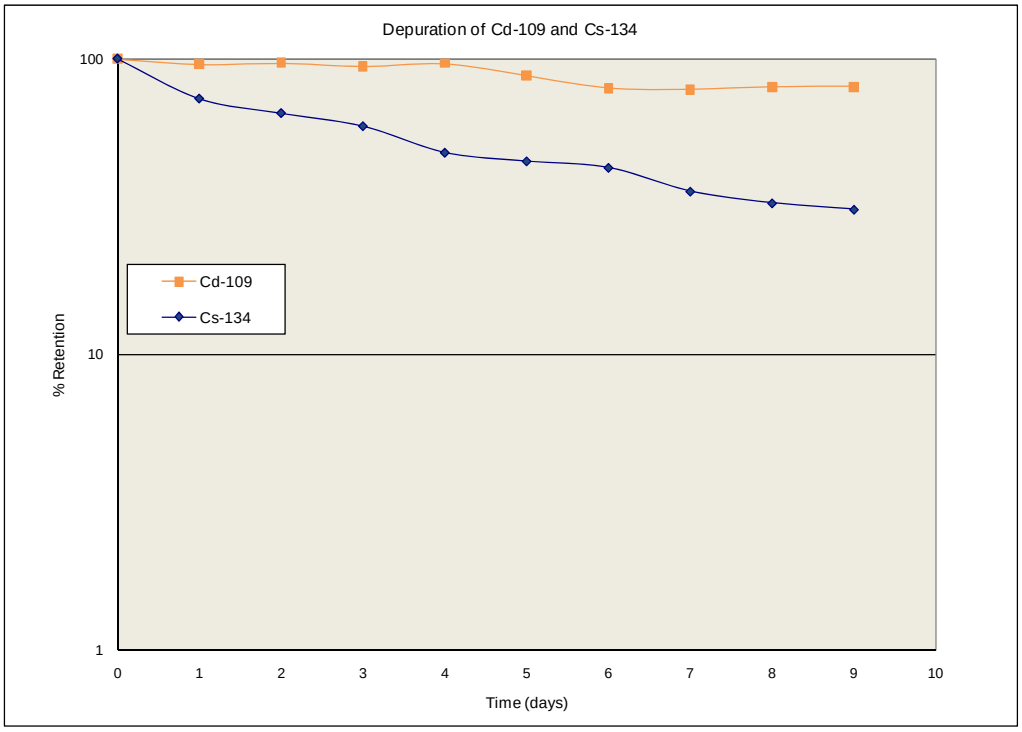

Fig. 2. Percentage loss of ^{109}Cd and ^{134}Cs in cockles from seawater over 10 days

Conclusions

Bioaccumulation experiments for cockles were undertaken successfully. This study provides entirely new information on ^{109}Cd and ^{134}Cs bioaccumulation process in cockles. These experiments will also illustrate the paths of radioactive element intake and evaluate the effects of radionuclide bioaccumulation in the human body.

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