Five Years After the Fukushima-Daiichi Nuclear Accident; Has the Coastal & Marine Environment of Thailand Been Radioactively Effected?

Y.Tumnoi[1], W.Tumnoi[2], N.Nakkaew[1], C.Khrautongkieo[1], and S. Udomsomporn[1]
[1]Office of Atoms for Peace
[2]Silpakorn University

Introduction

In March 2011, 150-160 PBq of ^{131}I and 10-15 PBq of ^{137}Cs were released into the atmosphere from the damaged Fukushima-Daiichi Nuclear Power Plants and eventually deposited in the Pacific Ocean. Highly contaminated fresh and seawater were also released to the sea with 4 to 27 PBq of ^{137}Cs[1]. They were widely dispersed and accumulated in different marine organisms (Figure 1)[2]. Five years later, ^{137}Cs became a main radiation dose contributor in marine biota and the ocean will remain contaminated for years cause contaminated groundwater is seeping from the damaged reactors into the ocean.

Thai coastal and marine environment might be contaminated by ^{137}Cs from the Fukushima fallout and contaminated sea water. Thus, this recent work aims;

- to reveal any significant changes in ^{137}Cs radioactivity in the marine environment before and after the accident
- to assess ^{137}Cs radiation doses and radiological risk in marine species studied
- to reveal any possible genetic effects in marine biota caused by ^{137}Cs

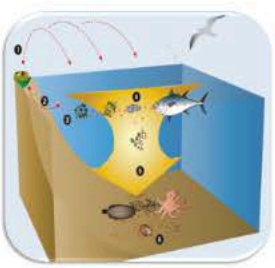

Figure 1 Radionuclide accumulation pathway in the marine environment[2]

Method

1.Sampling locations & Sample collection

20 L of seawater and 50 kg of marine biota were collected from the Gulf of Thailand and the Andaman Sea from 2012 to 2016 (Figure 2).

2.Sample Preparation & ^{137}Cs Measurement

- Seawater: Ammonium Molybdophosphate technique was used followed by gamma spectrometry (Figure 3).
- Marine biota: Radiochemical technique in conjunction with Ashing and Freeze drying were used prior to gamma analysis.
- ^{137}Cs radioactivity data from this work were compared with ^{137}Cs data from the previous work to reveal ^{137}Cs elevations in the marine environment after the recent accident.

3.Dose and Risk Assessment

- Dose Assessment: ^{137}Cs doses in the marine animals were estimated using ERICA Tool.
- Risk Assessment: ^{137}Cs doses obtained were compared with the dose limit of 10 μGy/hr.

4.Genetic Effects

Blood were taken from 20 green mussels/site for revealing radiation effects on their genetics using Comet Assay technique[3] (Figure 4). DNA damage was reported as %Tail DNA, if less than 10%, there will be no damage.

Figure 2 Sampling locations of seawater and marine biota in the Andaman Sea and the Gulf of Thailand

Figure 3 Seawater Preparation for ^{137}Cs measurement using AMP technique and gamma spectrometry

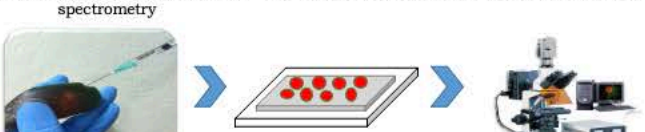

Figure 4 Haemocyte preparation for Image Processing and Comet Scoring

Results

1.^{137}Cs Radioactivity in the seawater & the marine biota

The total number of 162 and 105 of seawater and 6 different marine species, respectively, were collected from the Gulf of Thailand and the Andaman Sea from 2012 to 2016.^{137}Cs levels in the seawater ranged between 1.21 ± 0.44 and 1.60 ± 0.79 mBq/L with an average of 1.36 ± 0.17 mBq/L (Figure 5). No elevated ^{137}Cs radioactivity was observed when compared to the seawater analyzed during 1989-1991[4] (Figure 5). Averaged ^{137}Cs concentrations (Bq/kg_{ww}) in the marine biota were reported below;

Saccostrea commercialis 0.02 ± 0.01 Bq/kg_{ww}, 4.15×10^{-6} μGy/hr

Perna viridis 0.09 ± 0.05 Bq/kg_{ww}, 1.40×10^{-5} μGy/hr

Anadara granosa 0.06 ± 0.01 Bq/kg_{ww}, 8.74×10^{-6} μGy/hr

Loligu duvauceli 0.08 ± 0.03 Bq/kg_{ww}, 1.24×10^{-5} μGy/hr

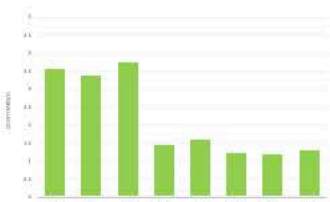

Figure 5 ^{137}Cs concentrations in the seawater between 1989-2016

Saurida elongata 0.15 ± 0.12 Bq/kg_{ww}, 2.62×10^{-6} μGy/hr

Nemipterus hexodon 0.17 ± 0.08 Bq/kg_{ww}, 9.34×10^{-6} μGy/hr

2.Dose and Risk Assessment

The averaged ^{137}Cs dose rates (μGy/hr) received by 6 marine species were shown above and all values were well below 10 μGy/hr. Therefore, radiological impacts either at individual or population levels can not be observed.

3.Genetic Effects

Three different DNA patterns in the haemocytes tested were revealed (Figure 6). % Tail DNA of the mussels from Chonburi, Surat Thani, and Ranong provinces ranged from 1.52 + 0.32 to 2.56 + 0.65 implying that there is no DNA damage. While %Tail DNA of 64.33 + 5.11, a severe DNA damage, was found when haemocytes were exposed by genotoxicants (Figure 7).

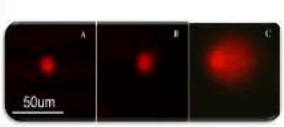

Figure 6 No DNA damage (A), Minor DNA damage (B), and Severe DNA damage (the positive control) (C)

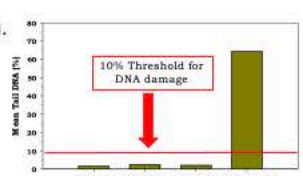

Figure 7 % Tail DNA in the haemocytes of the mussels from 3 provinces and from the positive control

Conclusion

- An elevated ^{137}Cs concentration in the seawater and 6 marine species from the Gulf of Thailand and the Andaman Sea was not found when compared to those measured during 1989-1991.
- ^{137}Cs radiation doses in the investigated animals are well below 10 μGy/hr.
- Radiation effects on their genetic, health, and population would not occur which is consistent with no DNA damage observed.
- It can be concluded that Thai coastal & marine environment has not been radioactively contaminated by the Fukushima-derived radionuclides.
- However, the monitoring program is still required to protect our marine environment from long-term radiation hazards from the FDNPP accident and from any future nuclear accidents in the Asia-Pacific region.

Acknowledgements

1.Pollution Control Department, Ministry of Natural Resources and Environment
2.Department of Fisheries, Ministry of Agriculture and Cooperatives

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