Journal of Ecosystem & Ecography
ISSN: 2157-7625

Short Communication Open Access

A Modelled Hazardous Evaluation of Caesium on the Blue Mussel Mytilus Edulis Shows the Potential Effects of Nuclear Wastewater Discharge on Aquatic Ecosystems

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Abstract

To assess the potential environmental consequences of nuclear wastewater containing radionuclides, the toxic effects of cesium (Cs) on the blue mussel Mytilus edulis were investigated experimentally. To mimic the effects of radiocesium, a simulated experimental system of stable cesium (133Cs) was set up, and its heavy metal property was emphasised. The mussels were exposed to a 133Cs concentration gradient for 21 days before being eliminated for another 21 days. Exposure to 133Cs caused effective bioaccumulation with distinct features of concentration dependence and tissue specificity, with hemolymph, gills, and digestive glands identified as the most target tissues for accumulation. Although the elimination period was beneficial in reducing the accumulated 133Cs, the remaining tissue concentrations remained significant.

Keywords: Cerium; Blue mussel; Marine ecosystem

Introduction

The Japanese government's announcement that it will begin an initiative within two years to release 1.25 million tonnes of radioactive wastewater from the crippled Fukushima Daiichi Nuclear Power Plant (FDNPP) into the ocean over a 30-year period has sparked worldwide interest. Although the Japanese government promised that radioactive wastewater would be safe because of its low concentration after treatment, people and other countries are still concerned that radionuclides left in wastewater would endanger marine safety and human health. [1-3].

Methods

Mushroom farming

Because stable nuclides and radioactive nuclides have identical chemical properties and biological properties that have ionic toxic effects on organisms, many studies choose stable nuclides as substitutes for radioactive nuclides due to the safety of field testing (Ding et al., 2016; Lai and Luo, 2019). To simulate the effects of radiocesium, a simulated experimental system of stable Cs (133Cs) was set up (e.g., 134Cs, 137Cs). The preliminary acute toxicity experiment used CsCl (analytical purity) as the source of 133Cs, and the median lethal dose (96 h-LD50) was determined to be 4.5 mM. (Supplementary Material). Based on the 96 h-LD50, three sublethal exposure concentrations were determined: 4.5 M, 45 M, and 450 M.

The acclimated mussels were randomly selected and equally divided into four experimental groups during the experiment: the control group (without 133Cs), the low concentration group (4.5 M), the middle concentration group (45 M), and the high concentration group (450 M). Each group had one tank with 63 individuals, and the density was approximately 250 mL/mussel. The exposure lasted 21 days, with water replenished daily with an equal amount of 133Cs. Following the exposure period, the treated mussels (n = 9) in each group were collected at random and transferred into clean seawater without the addition of 133Cs for the 21-day elimination period. [4-6].

133Cs-induced changes in M. edulis feeding and metabolism

On the 21st day, nine mussels were randomly collected and divided into three equal parts from each group for analysis of feeding and metabolism at the individual level after 133Cs exposure. The filtering rate (FR) was calculated using the Wilding and Maltby method (2006). The oxygen consumption rate (RO), ammonia-N excretion rate (RN), and O:N ratio all indicated the metabolic mode. Sun et almethod .'s was used to analyse RO (2016). RN was calculated using AA3 continuous flow analysis. The O: N ratio was calculated using Widdows' formula (1978). Furthermore, paraffin sections with H. E. staining were used to observe the impairment of the digestive gland, which indicated a change in digestion.

133Cs-induced changes in M. edulis hemocytes

On the seventh, fourteenth, and twenty-first days of exposure, nine mussels were randomly selected from each group to determine the immune responses of hemocytes in M. edulis exposed to 133Cs. Following extraction, the haemolymph of three mussels was pooled and kept on ice until analysis. The sample pre-processing for testing various indicators was carried out in accordance with Jiang et al. (2017), with minor modifications (Supplementary Material). Only on the 21st day were flow cytometer (FCM) analysis and micronucleus (MN) assays performed.

Discussion

The other property of radiocesium, aside from radiation, showed clearly detrimental effects on marine mussels even with a short exposure time and low exposure concentration. Although no macroscopic alterations in individuals were found, damage occurred first from the microbiospectrum of tissue and cells, with metabolic

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Received: 03-Feb-2023, Manuscript No jee-23-88810; **Editor assigned:** 06-Feb-2023, Pre-QC No: jee-23-88810 (PQ); **Reviewed:** 20-Feb-2023, QC No: jee-23-88810; **Revised:** 22-Feb-2023, Manuscript No: jee-23-88810 (R); **Published:** 28-Feb-2023, DOI: 10.4172/2157-7625.1000378

Citation: Mongruel Z (2023) A Modelled Hazardous Evaluation of Caesium on the Blue Mussel Mytilus Edulis Shows the Potential Effects of Nuclear Wastewater Discharge on Aquatic Ecosystems. J Ecosys Ecograph 13: 378.

activities and immune function being the main targets of attack. It should be noted that marine organisms are typically hierarchical, and subtle changes in the microbiospectrum would enlarge and eventually be present at the macro level. According to the consolidated findings, the discharge of nuclear wastewater containing radionuclides would harm marine organisms and jeopardise the safety and sustainability of marine ecosystems. [7, 8].

Conclusion

With the help of a user-defined regime, the forest management module simulates even-aged or uneven-aged silvicultural systems and starts a naturally growing or artificially planted forest stand. It provides a thorough set of guidelines that control the time and scope of planting, thinning, and clear-cutting for certain tree species [9, 10].

Acknowledgement

The Pilot National Laboratory for Marine Science and Technology (QNLM) "Fourteen Five" major project (2021QNLM040001), the Natural Science Foundation of China (42106139), and the Zhejiang Environmental Protection Scientific Research Plan Project all provided financial support for the research (2019A003). The authors expressed gratitude to all lab members for their assistance.

Potential Conflicts of Interest

No conflict or competing interests in the publication of this paper.

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