Application of PIXE for a multi-element analysis of marine phytoplankton towards the development of a new biological assessment method for heavy metal pollution

Akira Satoh[1)], Koichiro Sera[2)], Hiroshi Sekiguchi[1)], Yoshihiro Iwata[3)]
Norihide Kurano[1)], Shigetoh Miyachi[1)]

[1)]Marine Biotechnology Institute
3-75-1 Heita, Kamaishi, Iwate 026-0001, Japan

[2)]Cyclotron Research Center, Iwate Medical University
348-58 Tomegamori, Takizawa, Iwate 020-0173, Japan

[3)]Department of Chemistry, Faculty of Education and Human Studies, Akita University
1-1 Gakuen-machi, Tegata, Akita 010-8502, Japan

Abstract

Particle-induced X-ray emission (PIXE) was applied for the determination of heavy metals accumulated in natural phytoplankton. We selected four Japanese marine sites to collect phytoplankton: Toni Bay and Kamaishi Bay (Kamaishi, Iwate) as non-polluted areas; and Shimotsu port (Shimotsu, Wakayama) and Toyama new port (Shinminato, Toyama) as polluted areas. After removing the zooplankton and visible dust by passing the seawater through an NXX13 plankton net (95-μm mesh aperture), the phytoplankton were collected on a polycarbonate filter (25 mm diameter, 1.0 μm pore size) by suction filtration. The filter was dried and subjected to scanning electron microscopy (SEM) and a PIXE analysis. The phytoplankton consisted of diatoms, dinoflagellates and coccolithophores were observed by SEM analysis on the filter prepared from 100 ml of Toni-Bay seawater. Heavy metals (Pb, Ni, Cu, Cr, Zn, Mn, Hg and As) could be detected by the PIXE analysis in almost all the cases tested, in which 50-200 ml each of respective seawater sample was filtered. There was a linear relationship between the amount of heavy metals on the polycarbonate filter (ng cm^{-2}) and the volume of seawater (25-200 ml) filtered (i.e. the amount of phytoplankton collected on the filter). Likewise, the PIXE analysis revealed that significant differences in heavy metal contamination between the polluted and non-polluted areas, and also among sampling sites in a polluted area depending on the location and seawater movement. These results indicate that a multi-element analysis of marine phytoplankton by PIXE would be a promising technique for biologically assessing and monitoring heavy metal pollution in the first link of the aquatic food chain.