MONITORING RADIONUCLIDES IN MARINE ORGANISMS

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ABSTRACT

Concentration of stable elements corresponding to important radionuclides was determined by inductively coupled plasma atomic emission spectrometry (ICP-AES) and inductively coupled plasma mass spectrometry (ICP-MS) for various marine organisms to find indicator organisms for environmental monitoring. Both analytical techniques indicated linearity over a range of concentrations covering 2-4 orders of magnitude. Detection limits of elements by ICP-MS were 10 or 100 times higher than those of ICP-AES, although the precision and accuracy of ICP-MS was slightly inferior to that of ICP-AES. For quantitative analysis of elements with medium mass numbers (chromium, manganese, iron, nickel, copper, zinc, etc.), matrix interferences in ICP-MS were caused mainly by overlaps of spectra from coexisting elements in biological samples. The presence of background ions from atmosphere, water, and argon plasma interfered with determination of some isotopes. Most elements of high mass number could not be determined by ICP-AES because of its poor detection limits, whereas ICP-MS indicated high sensitivity and low background for elements of interest. We used ICP-MS analysis to determine the specific accumulation of certain elements in organs or tissues of 30 marine organisms.

INTRODUCTION

Bioaccumulation of high concentrations of certain elements is considered a useful indicator for monitoring radionuclides in the marine environment. To find effective indicator organisms, we are analyzing for stable elements corresponding to radionuclides in various marine organisms by means of atomic absorption spectrometry, neutron activation analysis, inductively coupled plasma atomic emission spectroscopy, and particle-induced x-ray emission.

METHOD

We evaluated the use of inductively coupled plasma mass spectrometry (ICP-MS system VG Elemental PlasmaQuad PQ2 system; VG

Elemental, England) for determining the high mass elements (140-240 amu). The apparatus showed multielement detection capability (more than 50 elements), low detection limits (10-100 ppt), wide dynamic ranges (six orders of magnitude), good precision (relative standard deviation = 1-2%), satisfactory accuracy, and the ability to directly determine isotopes.

RESULTS

Figure 1 shows the mass spectrum of rare earth elements in the branchial heart of an octopus *(Octopus vulgaris)*. Ion peaks, e.g., those for lanthanum, cerium, and praseodymium, were clearly visible. By studying other marine species we found that the branchial heart of cephalopods specifically accumulates rare earth elements. The highest concentration of cerium was in the branchial heart of *O. vulgaris* and ranged from 160 to 900 ng/g wet wt (430-4200 ng/g dry wt). Because the concentration of uranium in Japanese coastal sea water was 3-4 ng/ml (Table 1), the concentration factor for uranium in the branchial heart was calculated to be 10^3; the radioactivity of ^{238}U in that tissue was as high as 62 mBq/g. Table 1 also shows uranium concentrations in other marine organisms.

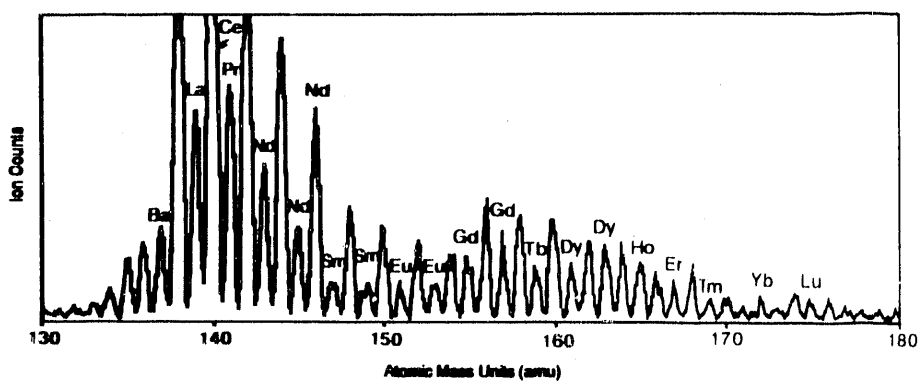

Figure 1. Mass spectra of rare earth elements obtained by inductively coupled plasma mass spectrometry (ICP-MS) for the branchial heart of *Octopus vulgaris;* amu = atomic mass units.

DISCUSSION

The branchial heart of cephalopods also accumulates other elements, for example, cobalt (Ueda et al., 1979), as well as the actinide elements

(Guary et al., 1981). Thus, we believe this organism is an important indicator of marine pollution by radionuclides.

Table 1. Concentrations of ^{238}U in marine organisms and in Japanese coastal sea water.

Species	Organ or Tissue	Concentrations (ng/g wet wt)	Concentrations (μBq/g wet wt)
Fish			
Paralichthys olivaceus	Muscle	0.32	4.0
Lateolabrax japonicus	Muscle	0.25	3.1
Molluscs			
Octopus vulgaris	Arm muscle	0.25	3.1
	Liver	85	1050
	Branchial heart	5000	62000
Mytilus edulis	Soft part	16	200
Algae			
Hizikia fusiforme	Whole body	500[a]	6200[a]
Ulva pertusa	Whole body	10[a]	120[a]
Sea water		3-4 ng/ml	36-48 μBq/ml

[a]Uranium concentrations in algae expressed as dry weight.

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