MAIN RADIONUCLIDES OF CESIUM, PLUTONIUM AND STRONTIUM IN THE NORTHERN ADRIATIC SEA (1990 - 92)

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Temporal trends of radiocesium isotopes were presented in the past in papers (TRIULZI *et al.*, 1992; 1994) that dealt mostly with the influence of the Chernobyl accident on the eastern Mediterranean Sea. In this work investigations were extended to other important radionuclides such as plutonium and strontium isotopes (DESIDERI *et al.*, 1994) that contribute together with Cs-137 to the radiocontamination of the Mediterranean area because of their long environmental persistency.

Although the distribution of Sr-90, Cs-137, Pu-238 and Pu-239+240 was obtained in different ecosystem components such as seawater, pelagic and benthic organisms and sediments, major emphasis was put on the detection of the above-cited nuclides in sediment samples, due to the importance of the sediment compartment as the final point of pollution accumulation.

For this reason, samples of sediment from different strata (mostly 0-3 cm and 12-15 cm) were collected from sampling stations along transects off the main Adriatic cities during May 1990 (NONNIS MARZANO and TRIULZI, 1994). A complete mapping of radionuclide concentrations has therefore been obtained for an area located between the Gulf of Trieste and Ancona.

Samples of sediment and macrofauna were also collected in the Sacca di Goro, a salt marsh environment of the Po river delta, with the aim of comparing the marine and estuarine biogeochemical behaviour of the radionuclides. For this reason two stations were chosen inside the Sacca, a central station influenced by the tidal current and river-sea exchanges, and a recovered one with slow hydrological motion (BONDAVALLI *et al.*, 1994).

Concentrations of Sr-90 and Pu-239+240 in benthic marine organisms were generally very low, and in particular for the Pu-239+240 very close to the limits of detection. Concentrations of Sr-90 ranged between <0.5 and 1.7 Bq/kg dry while values of Pu-239+240 were variable between <0.003 and 0.093 Bq/kg dry.

However as reported above, special emphasis was put on the distribution of these isotopes in the sediment layer where concentrations were more readily detectable. In fact, concentrations of Sr-90 in the open sea sediments ranged between 1.5 and 6.44 Bq/kg dry for the surface strata and between <1.5 and 2.13 Bq/kg dry for the underlying layers. Lower concentrations were detected for the plutonium isotopes with values of Pu-239+240 in the ranges 0.21-1.23 Bq/kg dry and 0.08-1.47 Bq/kg dry for the top and underlying strata, respectively. Mean concentrations of Pu-238 were around 0.03 Bq/kg dry for both strata.

Results obtained from samples collected in the two stations of the Sacca di Goro were lower than those determined in the open sea area. Sr-90 concentrations were in the range 1.9-2.8 Bq/kg dry, Pu-238 was below the detection limits (<0.1 Bq/kg dry) and Pu-239+240 was in the range 0.05-0.15 Bq/kg dry. Nevertheless concentrations of Cs-137 and Cs-134 were much higher in this estuarine environment compared to the ones detected in the open Adriatic Sea.

Pu-238/Pu-239+240 ratios varied between 0.02 and 0.06 whereas Sr-90/Pu-239+240 ratios were in the range 5-26. These values were in good agreement with data reported by PENTREATH (1987) for the marine environment in the preChernobyl period. It is well known that the Chernobyl event has scarcely affected the Sr-90 and Pu-239+240 levels already present in the environment. In fact, fallout depositions of these isotopes during the Chernobyl period were negligible in comparison to the levels of radiocesium.

On the other hand, the Cs-137/Sr-90 ratios varied between 1 and 4 in the marine environment and were around 25 in the salt marsh. The Cs-137/Pu-239+240 ratios ranged from 5-25 in the open sea and between 466 and 600 in the Sacca di Goro. The estuarine environment therefore appeared to be a strong accumulating area of Cs-137 whereas concentrations of Sr-90 and plutonium isotopes were lower than levels detected in the Adriatic.

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STABLE ELEMENT DISTRIBUTION STUDY IN MEDITERRANEAN TUNA BY NAA METHODS

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Instrumental neutron activation analysis (INAA) and γ-spectrometry, as well as fast radiochemical separation methods have been used for the determination of Cr, Ag, Sc, Co, V, Cs, Zn and As in bluefin tuna (*Thunnus thynnus thynnus*) from the Mediterranean Sea. The distribution of the elements was examined in muscle, liver and gut content of this pelagic fish. The stable trace elements investigated possess corresponding fission and/or neutron induced radionuclides, and some of these elements are of known biological significance for marine organisms. It was found that most of elements determined in tuna are concentrated in the liver of the fish.

Neutron activation analysis have been applied succesfully to date for the determination of many stable elements in various marine species (PAPADOPOULOU, 1992; BERNHARD, 1978). It is known that stable elements and radionuclides of anthropogenic origin entering into the oceans are accumulated by different marine organisms. The work done with tuna has been mainly related to the estimation of Hg and Se although certain other elements have been reported (IDOE 1972, FAO/UNEP 1986). To the best of our knowledge there is relatively little information as regards the distribution of stable trace elements in organs and tissues of tuna. In this paper we report concentrations of Cr, Ag, Sc, Co, V, Cs, Zn and As in tuna from five areas of the Mediterranean, determined by NAA methods. This work has been done in the frame work of UNEP/IAEA Project 1998 EP. Tuna fish samples (N=13) were collected in 1977 off the French Mediterranean coast. Sample identification and separation were done according to FAO Fisheries technical reports. From each fish, muscle, liver and gut content were separated. Moreover kidney, intestine tract and genital organs from two individual fish were also taken. The samples were lyophilised and homogenised prior to analysis. INAA and γ-spectrometry were applied for the determination of Cr, Ag, Co, Sc, Cs, and Zn while fast radiochemical separation based on solvent extraction and NAA methods were used for the determination of As and V (PAPADOPOULOU, 1972; PAPADOPOULOU *et al.*,1973 & 1978). The results obtained from this study are listed in Table 1. The values of trace element content given in this Table represent the mean value from 2-3 individuals from each sampling area.

Comparison of the element-distribution patterns in muscle and liver showed that these are mostly localised in the liver with the exception of Cs where higher values were found in muscle tissue. The high values of the elements found in gut content are most likely related to the food consumed by the fish. Taking in concideration that tuna is a pelagic fish of economical interest, it is of importance to protect the population from undesirable effects which might be caused, eventually, by the incorporation of toxic and/or radioactive trace elements entering the ocean. The baseline data reported herein could be useful for comparison with future information on the state of pollution of these areas in the Mediterranean.

TABLE 1. Stable element content in Bluefin tuna from the Mediterranean Sea

SAMPLING AREA (FRANCE) Tissues	Cr	Ag	Sc	Co	V	Cs	Zn	As
			(ng/g dry weight)				(£g/g d.w.)	
MENTON								
Muscle	92	8.7	0.30	10	48	60	17	6.3
Liver	210	130	0.67	230	130	70	85	23
Gut cont.	920	120	39	82	540	63	92	44
ANTIBES								
Muscle	75	11	0.46	9.4	6.1	140	177	8
Liver	140	230	0.64	220	110	67	100	48
Gut cont	660	120	21	52	350	370	130	28
MONACO								
Muscle	130	8.6	0.16	9.0	30	160	17	10
Liver	260	50	0.36	300	110	40	100	38
Gut cont.	510	15	3.1	47	980	250	140	11
BAY DES ANGES								
Muscle	130	8.7	0.29	13	26	140	12	7.1
Liver	150	200	4.0	270	73	86	110	20
Gut cont.	470	9 4	23	45	640	84	44	6.5
CANNES								
Muscle	87	12	0.35	4.8	20	140	9.0	10
Liver	250	260	3.5	310	170	89	130	18
Gut cont.	290	260	12	58	350	40	290	38

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