Inventories and vertical flux of transuranium nuclides in the Northwestern Mediterranean

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One of the principal aims of the oceanic flux studies currently underway is to assess spatial and temporal variability of the biogeochemical cycles of important elements. Globally, data on the flux of transuranics are sparse, and such information is essential for quantifying the removal rates of these anthropogenic radionuclides in the water column. In this context, we undertook a time-series sediment trap experiment to measure the vertical flux of $^{239+240}$Pu and ^{241}Am at an offshore station in the Gulf of Lions.

METHODS AND MATERIALS

During the EROS 2000 "CYBELE" cruise, automated time-series sediment traps (0.125 m^2 opening) were moored at 200, 500, 1000 and 2000 m in a 2475 m deep water column (42°N 06°E) off the coast of Toulon, France. Each of the six collection cups sampled a 13-day period between 14 April and 1 July 1990. Preservation methodology, sample treatment and preparation, and radionuclide analytical techniques are reported elsewhere (FOWLER *et al.*, 1990a; PEINERT *et al.*, in press). Water column sampling and radioanalyses followed the methodologies of FUKAI *et al.*, (1983) and BALLESTRA *et al.* (1984).

RESULTS AND DISCUSSION

Transuranic concentrations in sinking particles and corresponding radionuclide fluxes are given in Table 1. At 200 m, $^{239+240}$Pu concentrations in particles increased by a factor of 4.4 (1.92 - 8.45 Bq kg^{-1}) during the course of the experiment. Corresponding ^{241}Am levels were more variable (x10) but did not follow the same temporal trend. During sample series II and III, no clear trend in radionuclide concentration with depth was evident except for ^{241}Am immediately following the major sedimentation pulse of phytoplankton aggregates which swept the water column between 27 April and 10 May (PEINERT *et al.*, in press). The maximum fluxes of $^{239+240}$Pu and ^{241}Am coincided with the period of maximum sedimentation indicating that mass flux was the main factor controlling transuranic flux. These fluxes corresponded closely to those measured off Corsica during spring 1986 (FOWLER *et al.*, 1990b) but were an order of magnitude lower than $^{239+240}$PU and ^{241}Am fluxes reported for fall 1983 in the high sedimentation regime of the Lacaze-Duthiers Canyon in the Gulf of Lions (FOWLER *et al.*, 1990a). Clearly, variations in transuranic flux depend to a large extent on the degree of sedimentation.

The average $^{239+240}$Pu and ^{241}Am flux through 200 m during the 2.5 month period was 0.688 and 0.273 mBq $m^{-2}d^{-1}$, respectively. Transuranic concentration profiles in sea water measured at this site during early May resulted in corresponding radionuclide inventories above 200 m of 5.91 and 0.526 Bq m^{-2}. If a steady state situation is assumed, such fluxes would lead to a residence time for $^{239+240}$Pu and ^{241}Am in the upper mixed layers of approximately 24 and 5.3 y, respectively. These residence times are considerably longer than those reported for a short-term (17 d) experiment in the Lacaze-Duthiers Canyon (FOWLER *et al.*, 1990a), and are probably more representative of average transuranic flux in the northwestern basin as a whole.

High resolution $^{239+240}$Pu profiles taken at this station and a nearby site (43°25'N 07°53'E) during 1989-90 have allowed comparing present day water column $^{239+240}$Pu inventories with those determined from similar measurements made in 1981-82 in the same region (FUKAI *et al.*, 1983; BALLESTRA *et al.*, 1984). The difference in inventories for the 8-year period results in a mean $^{239+240}$Pu loss from the water column of roughly 0.5 Bq $m^{-2}y^{-1}$. Our measured mean $^{239+240}$Pu flux through 2000 m (Table 1) of 0.24 Bq $m^{-2}y^{-1}$ indicates that a significant fraction of the removal is due to vertical transport by sinking particles.

TABLE 1. Concentrations and vertical fluxes of transuranics in the Gulf of Lions

Sample Series	Date (1990)	*Depth (m)	Mass Flux mg $m^{-2}d^{-1}$	$^{239+240}$Pu (Bq Kg^{-1})	$^{239+240}$Pu mBq $m^{-2}d^{-1}$	^{241}Am (Bq Kg^{-1})	^{241}Am mBq $m^{-2}d^{-1}$
I	14-27/04	200	127.6	1.92±0.25	0.245	0.46±0.22	0.059
II	27/04-	200	308.9	3.83±0.29	1.183	3.29±0.46	1.016
II	10/05	500	48.6	2.82±0.40	0.137	1.48±0.59	0.072
II		1000	242.3	4.73±0.37	1.146	2.50±0.49	0.606
II		2000	240.8	3.36±0.28	0.809	3.33±0.46	0.802
III	10-23/05	200	181.8	5.28±0.63	0.960	0.32±0.17	0.058
III		1000	120.9	3.33±0.44	0.402	1.85±0.30	0.224
III		2000	174.4	3.02±0.34	0.527	2.40±0.31	0.418
IV	23/05-05/06	200	71.8	5.91±0.81	0.424	2.14±0.85	0.154
V	05-18/06	200	61.4	7.60±0.92	0.467	2.52±1.04	0.155
VI	18/06-01/07	200	100.5	8.45±0.86	0.849	1.92±0.80	0.193

* Missing depths = insufficient sample for transuranic analyses.

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