STUDIES OF CONCENTRATION AND TRANSFER FACTORS OF NATURAL AND ARTIFICIAL ACTINIDE ELEMENTS IN A MARINE ENVIRONMENT.

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Natural (thorium and uranium) and artificial (plutonium and americium) actinides have been studied in a marine environment at the Swedish south west coast.

The actinides have reached the water from fall-out, run off from land, leaching, resuspension or by in situ build up. The partition of these elements between water, sediment and organisms was studied. Special concern was given to plutonium and americium.
Such investigations play an important role for predicting the fate of actinides released into the sea by dumping or wastes from nuclear industry. Their fate will depend on type of source and the physical and chemical parameters.

The brown algae Fucus vesiculosus and Fucus serratus was shown to be excellent bioindicators for actinide elements. Other investigations have frequently used mussles as bioindicator for transuranium elements.

MATERIALS AND METHODS

Fucus vesiculosus and F. serratus have been collected at the Swedish south west coast occationally during 1967-1976 (1). After 1976 a more regular collection has taken place.

During 1978 and 1979 several watersamples and sediment cores were taken.

The actinides were separated radiochemically by procedures published elsewhere (2). As radiochemical yielddeterminants ^{242}Pu, ^{243}Am, ^{232}Th and ^{229}Th were used. The alpha activity of samples electro deposited onto stainless steeldiscs were measured with surface barrier detectors for 1-20 days.

RESULTS AND DISCUSSION

The area studied is situated in an area around $56^{o}N$, $13^{o}E$. It could briefly be characterized as very shallow with strong currents, high resuspension and high organic particulate in the water.

ACTINIDES IN WATER

In table 1 the results for water samples are given. All values refer to unfiltered water. We find lower plutonium and americium concentrations compared to most other areas such as the Atlantic and the Mediterranean (3, 4). Our results are in agreement with investigations by Murray et. al. (5).

Bottomwater (19 m) shows higher plutonium and americium concentrations than surface water. The uraniumconcentration could be repre-

sentative for this brackish water (salinity 7-10 o/oo at surface). We can not observe any influence of transuranics from european reprocessing facilities although this has been done for ^{134}Cs (6).

We have not yet investigated the partition between particulate and soluble fraction of the actinides. We believe the transuranium elements are predominantly in a particulate form due to the high particulate load in this region.

Table 1. Actinides in water and Fucus

	^{228}Th	^{230}Th	^{232}Th	^{234}U	^{235}U	^{238}U	$^{239+240}Pu$	^{241}Am
Water (μBq/kg)								
Surface	450	270	70	18100	650	15900	14	3
Bottom (19m)							40	7
Fucus (mBq/kg) dry)	5000	400	90	12700	450	11100	190	53
CF (dry)	11000	1300	1300	700	700	700	13500	18000

ACTINIDES IN SEDIMENT

The results for sediment support the theory of rapid sedimentation for the transuranium elements in this area. The concentrations in surface sediments are a factor of 3-4 higher than for other regions contaminated from global fall-out. This in combination with the low concentrations in water gives a dry sediment/water activity concentration ratio for plutonium as high as 250 000.

The results varied much depending on site of collection, but in table 2 are given the average values for 6 representative cores. The integrated area content for these cores was estimated to 72 Bq/m^2 and 20 Bq/m^2 for $^{239+240}Pu$ and ^{241}Am respectively. This is much higher than expected from integrated fall-out at this latitude (48 and 13 Bq/m^2) indicating significant run off from land.

Table 2. Plutonium and americium in sediment cores. (Bq/kg dry)

Depth (cm)	$^{239+240}Pu$	^{241}Am	$^{241}Am/^{239+240}Pu$
0-2	80	18	0.20
2-4	79	17	0.23
4-10	12	4	0.32

Americium and plutonium show different vertical distributions. The activity ratio Am/Pu increase with depth although this ratio agrees with integrated fall-out in the integrated cores. This difference is explained by that americium has mainly been formed *in situ* by the decay of ^{241}Pu($T_{\frac{1}{2}}$=14.2 a). Plutonium deeper down is older and shows then higher Am/Pu ratio. We do not believe that this is an effect

of higher penetration for americium. Of the integrated area content for water and sediment only 0.3 % of plutonium and americium is present in the watercolumn. This is in large contrast to the situation for example in the Mediterranean (7).

ACTINIDES IN ALGAES

The results for actinides in Fucus can be seen in Table 1 and Fig. 1. All values refer to the date of collection. The measured ^{241}Am was corrected to the date of collection by using $^{241}Pu/^{239+240}Pu$ activity ratios measured in global fall-out (8). The $^{239+240}Pu$ concentration in Fucus has decreased during the period. Such a decrease is expected due to that the main fall-out delivery ocurred shortly after 1962.

^{241}Am on the other hand shows an increase during the same period. This increase must be related to the in situ build up of ^{241}Am ($T_{\frac{1}{2}}$= 433 a) from ^{241}Pu($T_{\frac{1}{2}}$=14.2 a) in the environment.

Most americium values fall below the expected ones from Am/Pu activity-ratios in integrated fall-out.

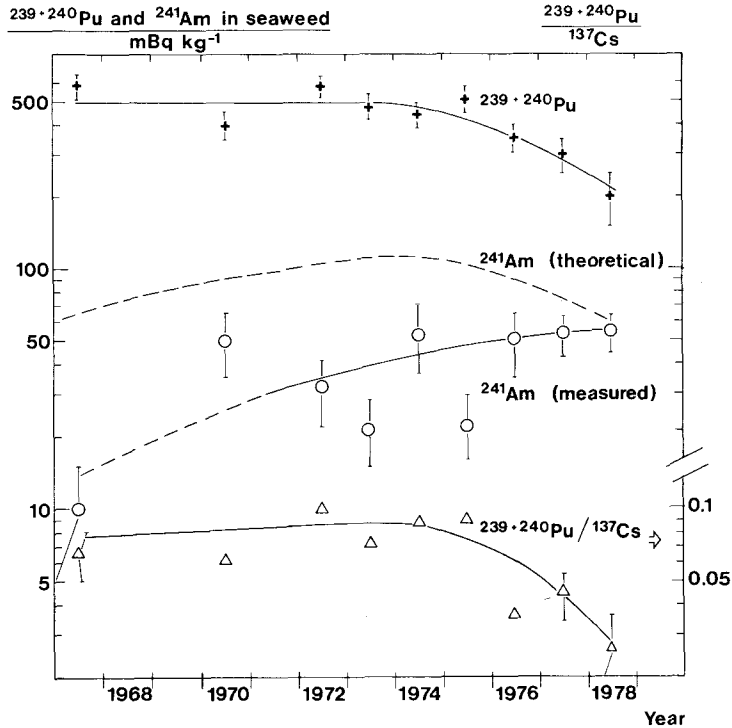

Figure 1. $^{239+240}Pu$ and ^{241}Am activity concentrations in Fucus during 1967-1978. The Pu/Cs activity ratio is also displayed.

Our results indicate that the concentration factor for americium from water to Fucus is higher than for plutonium. The processes in-

volved to reach water and organisms for *in situ* produced americium are different to those for plutonium.

The ^{137}Cs concentration in *Fucus* has been rather constant during 1967-1978 (1), resulting in a decreasing Pu/Cs activity ratio from 0.1 to 0.02 during the period.

By using ^{137}Cs values from Aarkrog et al (9) the $^{239+240}Pu/^{137}Cs$ activity ratio in water in 1978 was about 0.002-0.003. This illustrates the much higher uptake of plutonium than cesium by Fucus.

Recently Hodge *et.al.*(10) showed that uptake of actinides in particulate form by coastal marine organisms was significant. Our $^{234}U/^{238}U$ activity ratio in *Fucus* is about 1.14. The soluble element uranium shows the lowest concentration factor. Plutonium and americium which are expected to be predominantly in the particulate form, in this area, show the highest concentration factors. Our results indian organic particulate sorbtion of actinides by *Fucus*.

Of the thoriumisotopes ^{228}Th differs remarkably from the others. The lifespan for the algaes is not long enough to explain this high CF for ^{228}Th by *in vivo* build up from ^{228}Ra. This might indicate that ^{228}Th is brought into a more bioavailable form through the decay - chain ^{228}Ra-^{228}Ac.

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