Assessment of short-term radioactive contamination of river water resulting from the Chernobyl Accident

Constantin DOVLETE, Adam-Miklos HALASZ and Iolanda OSVATH

Environmental Radioactivity Laboratory, Institute of Environmental Research and Engineering, BUCHAREST **(Romania)**

A model is being developed at the Environmental Radioactivity Laboratory for the assessment of short-term consequences of direct contamination of rivers through deposition of radioactive material on the surface of the water. Using measurement data, the contribution of the Danube River as a source of contamination for the North-Western Black Sea in the first 2 weeks following the Chernobyl accident will be evaluated.

The model attempts to describe the time evolution of specific activity in river water, by taking into account contamination resulting from fall-out deposited on the river surface. It is a one-dimensional dispersion model which includes a correction for vertical diffusion (HALASZ, 1992). It is based on the following assumptions:

-The deposition rate is time-dependent and uniform along a given length of the river. Measured deposition data corresponding to the period of interest, are fitted to give a smooth deposition function, required as input.
-Water velocity, river depth, diffusion coefficients and sampling depth (depth up to which the inlet of the sampling recipient extends) are considered constant and required as input data.
-A mixture of up to 15 radionuclides is considered. For most of the daily samples only gross beta activities are available. Using the relative concentrations of radionuclides in deposition samples (resulting from gamma spectrometrical analyses), required as input data, calculations are made for the radionuclidic composition on time subintervals 80 that the corresponding gross beta activity approximates the measured values.

The model has been tested using sets of data obtined through measurement of fall-out and river water samples performed up to May 10, 1986, following the Chernobyl accident, as illustrated in Fig. 1 for the case of River Buzau.

Fall-out and river water samples have been collected with a frequency depending on the type of the sample, but at least once a day, at the stations of the National Environmental Radioactivity Surveillance Network. Immediate gross beta measurements have been performed on all the samples. For the fallout samples and for some of the water samples gamma emmiter concentrations have been determined also.

At the present stage of development, the model, applied to the existing data sets, gives a reasonable agreement with the observed delay between the peak values in deposition rate and specific activity in water. In most cases the calculated amplitude of water specific activity approximates well the measured values, but the corresponding decrease is slower than the observed one.

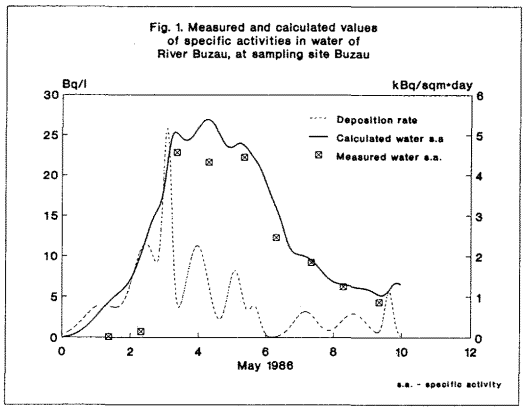

Fig. 1. Measured and calculated values of specific activities in water of River Buzau, at sampling site Buzau

The main processes governing the shape of the peak in water specific activity are radionuclide accumulation vs. decay and longitudinal transport.
The effect of the longitudinal diffusion is small for the given ranges of parameters. The influence of vertical diffussion is important for the range used for the vertical diffusion coefficient.
There are cases in which the assumption that deposition is uniform over a large surface is not appropriate.

The model is to be developed by taking into consideration suspended and bed sediments as well as input coming from the drainage area. A finer resolution deposition map will be produced and hydrological characterization of each case will be completed in order to improve the input data. Such data are presently prepared for a case study of the Danube River, much more complex due to the contribution of tributaries, which will permit an evaluation of the input of radioactivity into the Black Sea, resulting from the direct contamination of the river.

REFERENCES

HALASZ M.-A., 1992.- Model for dispersion of radioactive contaminants in rivers, to be published.

Inventories and vertical flux of transuranium nuclides in the Northwestern Mediterranean

Scott W. FOWLER, Victor E. NOSHKIN*, Janine GASTAUD and Jacques LA ROSA

IAEA Marine Environment Laboratory, MONACO **(Principauté)**

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.

REFERENCES

BALLESTRA S., BOJANOWSKI R., FUKAI R. & VAS D., 1984.- *International Symposium on the Behaviour of Long-lived Radionuclides in the Marine Environment*, pp. 215-232, CEC, Brussels.
FOWLER S.W., BALLESTRA S. & VILLENEUVE J.-P., 1990a.- *Cont. Shelf Res.*, 10 : 1005-1023.
FOWLER S.W., BALLESTRA S., LA ROSA J., HOLM E. & LOPEZ J.-J., 1990b.- *Rapp. Comm. int. Mer Médit.*, 32 : 317.
FUKAI R., BALLESTRA S. & VAS D., 1983.- *VIes Journées Etud. Pollutions*, pp. 95-101, C.I.E.S.M., Monaco.
PEINERT R.D., FOWLER S.W., LA ROSA J., MIQUEL J.-C. & TEYSSIE J.-L.- EROS 2000. Third Workshop on the Northwest Mediterranean Sea. *Water Pollution Research Report*, CEC, Brussels (in press).

* Present address : Lawrence Livermore National Laboratory, P.O. Box 808, Livermore, CA 94550, USA.
This work was supported by the CEC EROS 2000 Programme under MAST-0016-C (EBD).

R