# INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS OF THE BED LOAD SEDIMENTS, SAMPLED FROM THE ROMANIAN DANUBE RIVER, DURING 1993


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In a previous paper of GEORGESCU *et al.* (1979) it has been outlined the importance of the stable macro and micro elements concerning the transport and transfer of the radionuclides between water, suspended matter, sediments and biota. In this paper, samples of sediments from the significant verticals of the Romanian Danube river were collected as follows : Svinitza and Orsova (entrance of Danube river in Romania), before the Turnu-Severin dam and there after at Bechet in front of the Nuclear Power Plant KOZLODUI (kms. 705 and 678).

Samples were dried in an electric oven at 105°C, then homogenized in an agath mortar. Chemical analyses were performed for Al, Mg, Mn, P, Si and Ti. Loss of weight at 1000°C varied between 13.30% at Svinitza to 3.64% at Bechet km 678. For INAA, about 100 mg of each sediment sample in thin aluminium foil together with the Reference Materials were irradiated at the VVR-S Reactor of Bucharest, at a flux of $10^{11}$-$10^{12}$ n/cm$^2$.s. The measurements were performed with a HPGe detector of 2.2 keV at $^{60}$Co coupled to a multichannel analyser.

At Svinitza-Orsova, the highest values are to be observed concerning the As, Br, Sb, Rare Earths, Th, U, Zn, while after Turnu-Severin dam, the chemical pollution is rapidly decreasing (Table 1).

Table 1. Instrumental Neutron Activation Analysis and Chemical Analysis* of the sediment samples from the Danube river during 1993.

| Element | Svinitza (8.04.93) | Orsova (8.04.93) | Turnu-Severin (9.04.93) | Bechet (km 705) (17.04.93) | Bechet (km 687) (17.04.93) |
|---|---|---|---|---|---|
| Al* (%) | 7.59 ± 0.23 | 7.30 ± 0.22 | 4.76 ± 0.14 | 4.04 ± 0.12 | 2.85 ± 0.09 |
| As (ppm) | 25.5 ± 0.50 | 23.6 ± 0.50 | 6.10 ± 0.30 | 7.30 ± 0.30 | 7.50 ± 0.30 |
| Ba (ppm) | 347 ± 41 | 530 ± 50 | 417 ± 40 | 364 ± 36 | 363 ± 35 |
| Br (ppm) | 5.5 ± 0.4 | 6.8 ± 0.6 | 1.8 ± 0.4 | 1.0 ± 0.3 | 0.9 ± 0.3 |
| Ca (%) | 2.18 ± 0.20 | 5.05 ± 0.25 | 4.57 ± 0.22 | 4.15 ± 0.20 | 1.78 ± 0.11 |
| Ce (ppm) | 72.5 ± 1.5 | 67.5 ± 1.4 | 24.3 ± 0.6 | 27.5 ± 0.6 | 18.1 ± 0.5 |
| Co (ppm) | 18.3 ± 0.6 | 18.6 ± 0.6 | 11.5 ± 0.3 | 8.7 ± 0.3 | 6.1 ± 0.2 |
| Cr (ppm) | 161 ± 6 | 161 ± 5 | 349 ± 7 | 56 ± 1 | 99 ± 2 |
| Cs (ppm) | 9.5 ± 0.5 | 9.1 ± 0.5 | 2.5 ± 0.2 | 1.7 ± 0.2 | 0.9 ± 0.1 |
| Eu (ppb) | 990 ± 85 | 867 ± 81 | 509 ± 45 | 566 ± 52 | 418 ± 40 |
| Fe (%) | 4.34 ± 0.06 | 4.11 ± 0.06 | 2.24 ± 0.04 | 1.52 ± 0.02 | 1.16 ± 0.02 |
| Hf (ppm) | 4.4 ± 0.2 | 2.8 ± 0.2 | 2.0 ± 0.1 | 1.9 ± 0.1 | 1.5 ± 0.1 |
| K (%) | 1.70 ± 0.05 | 1.60 ± 0.05 | 2.24 ± 0.07 | 0.95 ± 0.04 | 0.92 ± 0.04 |
| La (ppm) | 26.1 ± 0.4 | 31.7 ± 0.5 | 9.2 ± 0.2 | 13.0 ± 0.3 | 7.8 ± 0.2 |
| Lu (ppb) | 940 ± 90 | 326 ± 20 | 217 ± 12 | 152 ± 9 | 146 ± 8 |
| Mg*(%) | 1.23 ± 0.04 | 0.89 ± 0.03 | 0.65 ± 0.02 | 0.52 ± 0.02 | 0.52 ± 0.02 |
| Na (%) | 0.57 ± 0.01 | 0.50 ± 0.01 | 1.37 ± 0.02 | 1.07 ± 0.01 | 0.93 ± 0.01 |
| Mn*(ppm) | 387 ± 11 | 542 ± 15 | 775 ± 22 | 620 ± 20 | 620 ± 20 |
| Rb (ppm) | 113 ± 10 | 99 ± 9 | 57 ± 5 | 44 ± 4 | 39 ± 4 |
| P* (ppm) | 131 ± 3 | 611 ± 13 | 350 ± 10 | 305 ± 10 | 305 ± 10 |
| Sb (ppm) | 4.4 ± 0.2 | 4.0 ± 0.2 | 0.3 ± 0.1 | 0.3 ± 0.1 | 0.3 ± 0.1 |
| Sc (ppm) | 13.8 ± 0.1 | 13.4 ± 0.1 | 9.2 ± 0.1 | 5.2 ± 0.1 | 3.9 ± 0.1 |
| Si* (%) | 20.22 ± 0.40 | 19.70 ± 0.40 | 33.63 ± 0.67 | 31.61 ± 0.63 | 37.25 ± 0.75 |
| Sm (ppm) | 6.54 ± 0.06 | 5.53 ± 0.05 | 2.17 ± 0.02 | 2.47 ± 0.03 | 1.50 ± 0.02 |
| Ta (ppb) | 850 ± 130 | 650 ± 127 | 356 ± 72 | 476 ± 95 | 242 ± 60 |
| Tb (ppb) | 1000 ± 150 | 730 ± 156 | 410 ± 82 | 375 ± 74 | 196 ± 41 |
| Ti* (%) | 0.28 ± 0.01 | 0.23 ± 0.01 | 0.48 ± 0.01 | 0.39 ± 0.01 | 0.45 ± 0.01 |
| Th (ppm) | 27.0 ± 0.2 | 10.3 ± 0.2 | 4.4 ± 0.1 | 3.9 ± 0.1 | 2.2 ± 0.1 |
| U (ppm) | 3.6 ± 0.5 | 2.4 ± 0.4 | 1.3 ± 0.2 | 1.2 ± 0.2 | 0.8 ± 0.2 |
| Yb (ppm) | 5.3 ± 0.6 | 2.4 ± 0.2 | 1.9 ± 0.1 | 1.1 ± 0.1 | 1.0 ± 0.1 |
| Zn (ppm) | 356 ± 20 | 539 ± 45 | 142 ± 12 | 80 ± 8 | 49 ± 5 |


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# A STUDY OF THE APPEARANCE OF MUCILAGINOUS MASSES IN THE WATERS OF THE NORTHERN ADRIATIC COASTLINE FROM 1988 TO 1992


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This paper presents research carried out during the five-year period between 1988 and 1992 on the waters along the coastline of the Marche, a region of Italy, situated on the western shores of the Adriatic sea. These five years were of unique interest due to the presence of mucilaginous masses on the water surface.

The presence of mucilaginous masses in the area of the Northern Adriatic between Istria and Ancona is a well-known phenomenon, with the first records dating back to 1729. This material tends to appear at widely-spaced time intervals of up to twenty or thirty years (FONDA UMANI *et al.*, 1989) and only rarely does it appear on the surface for two or three years in succession. A study of this phenomenon in the years considered ('88-'92) thus seemed of particular interest, since in this period the mucilaginous masses appeared in three different years (1988-1989-1991). The mucilage appeared neither on the sea bottom nor along the water column in the years 1990 and 1992. Many hypotheses have been put forth regarding the formation of this gelatin-like matter. A likely hypothesis is that benthic diatoms, under certain climatic conditions (such as lack of wind, calm seas, elevated water temperatures) which can appear as early as the first months of spring, give rise to aggregations of mucilaginous particles along the water column which tend to rise to the surface. The level of nutrients in the water, which is related to the amount of rainfall and flow of river water, seems to have a certain impact on this phenomenon, in that it can lead to alterations or imbalances in the nitrogen-phosphorus ratio. Mucilage is present in various morphological forms, from very small amorphous aggregations (the so-called "marine snow"), to strips of various lengths or large "flakes" (HERNDL and PEDUZZI, 1988). Mucilage is often present in the form of sea snow on the sea bed, especially in the open sea (20 to 30 miles from the coast), but does not normally form masses or rise to the surface.

The research carried out in the years considered in this report has permitted the evaluation of the time required for the appearance and the spreading of mucilaginous masses.

**1988 :** In the month of August, mucilages appeared "en masse" in the sea area between Istria and Ancona, for the first time since approximately 1930. The phenomenon continued until September.

**1989 :** In this year the phenomenon appeared with unusual intensity in the months of July, August and September. An examination of the time requirement for its appearance demonstrated that these mucilaginous masses are carried along the Marche coast by a North-South current which circles the Adriatic in a counter-clockwise direction. In this period, deaths of benthic organisms took place. Our research, however, ruled out the possibility of anoxic or hypoxic phenomena in these waters and the death of these organisms, for the most part molluscs, was due to the vast amount of algal wastes which deposited on the sea bed (PENNA *et al.*,1993).

**1990 :** Absence of mucilages on the bottom and along the water column.

**1991 :** Reappearance of mucilages in a form different from that of the preceeding years. These mucilages appeared to rise to the surface almost simultaneously in the entire area of the Northern Adriatic from Istria to Ancona. No episodes of anoxia were reported for this year.

**1992 :** Absence of mucilages along the water column. Appearance of modest quantities of marine snow in small "flakes" on the sea bed.

Although the research carried out does not permit us to draw firm conclusions as to the causes leading to the production of mucilage, we are able to affirm that their appearance on the surface is fostered by certain climatic conditions and by reductions or imbalances in the levels of nutrients present in the sea water. Furthermore, it is of note that anoxic and hypoxic phenomena did not develop on the sea bed or along the water column in the presence of the mucilaginous masses (Fig. 1-2).

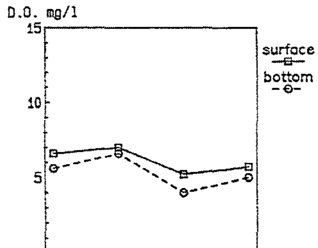


Fig.1 D.O. Variation on the surface and on the bottom in the August-September of 1989 along the Marche coast, from Tavollo to Cesano at 500 m from the coast.

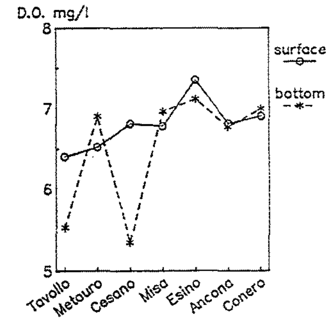


Fig. 2 D.O. Variation on the surface and on the bottom in the July of 1991 along the Marche coast, from Tavollo to Conero at 3000 m from the coast.

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