

Θαλασσογραφικά - Thalassographica	(1986)	9	23-28
-----------------------------------	--------	---	-------

GAMMA-SPECTROSCOPY IN MARINE SEDIMENTS AND ORGANISMS
FROM A MINING WASTE DISPOSAL AREA

H. FLOROU¹ and P. KRITIDIS²

1. National Centre for Marine Research, GR-166 04 Hellinikon,
Athens, Greece.

2. National Research Centre for Physical Sciences, GR-153 10 Aghia Paraskevi, Athens, Greece.

ABSTRACT

Composite samples of *Mullus barbatus*, *Solea vulgaris*, *Nephrops norvegicus*, *Macropipus depurator*, have been measured for low level radioactivity due to nuclides of uranium and thorium series, ⁴⁰K and the fallout radionuclide ¹³⁷Cs. The samples have been collected from an area where the waste from a great mineral factory are deposited, as well as from a free disposal reference area, and the concentrations of the above mentioned radionuclides were measured by gamma-spectrometry. No significant influence has been observed in the levels of radioactivity in the examined organisms while sediment samples appear above average levels of ²³⁸U-radioisotopes.

INTRODUCTION

This study is associated with a more general project of the N.C.M.R. concerning the variety of environmental impacts on the northern Evoikos Gulf due to the systematic sea disposal of mineral by-products of a Fe-Ni ore processing plant to the gulf. Every year about 2.500.000 tn of mineral waste are discharged into the gulf (Fig. 1). This deposition has an apparent influence as the concentrations of heavy metals in the sediments, (VOUTSINOY, 1985), sea water (Final Report LARKO, 1985) and organisms of this area (FLOROU and CATSIKI, 1985). The scope of this study is to determine whether there is also an influence to the marine environment of the gulf due to natural radioactivity since according to SIOTIS and WRIXON (1984) all rocks, soils and minerals contain to a greater or lesser extent the radionuclides potassium-40 and those in the uranium-238 and thorium-232 series. The concentrations of fallout radionuclide ¹³⁷Cs is studied for comparison reasons with other areas in the Greek peninsula.

Therefore mineral waste samples, sediments and organisms have been collected from this area, as well as from a reference area in the gulf and the

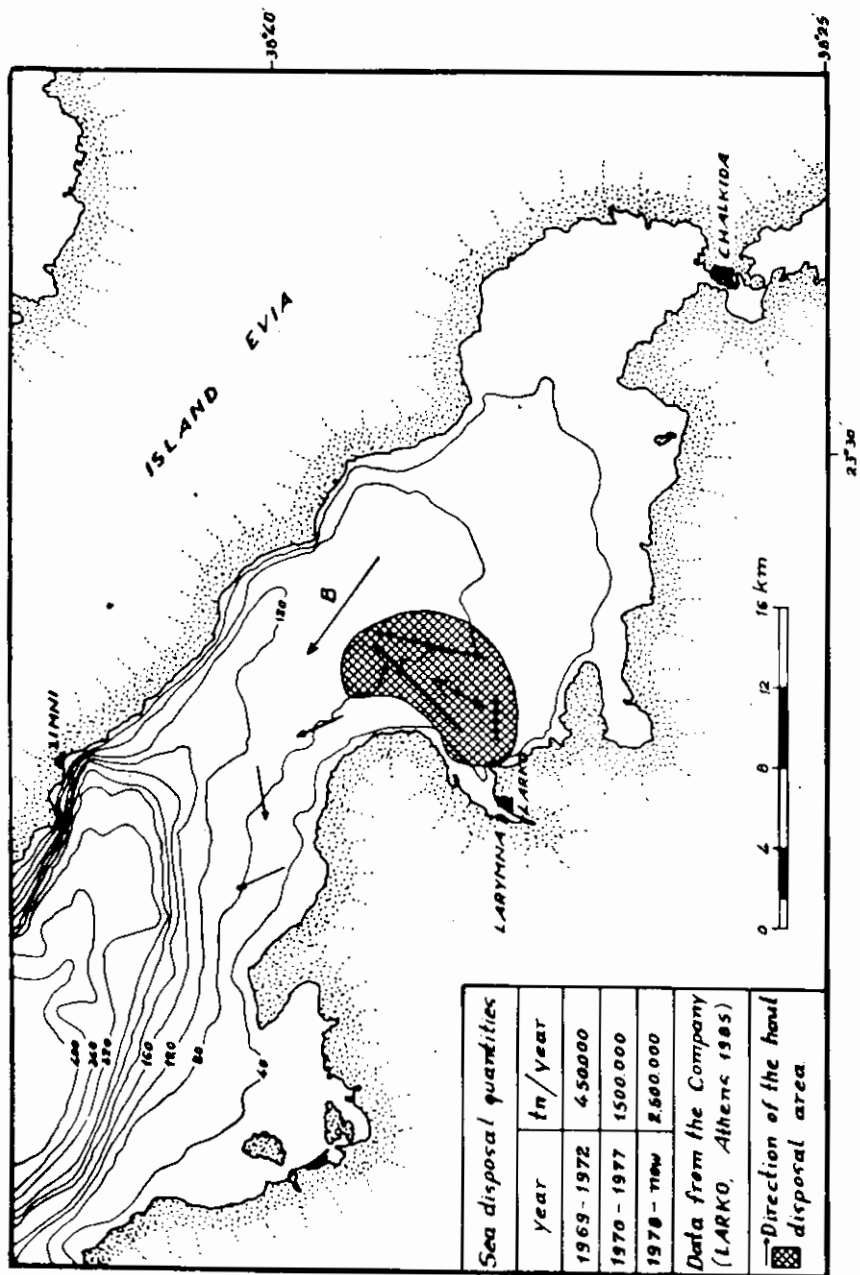


Fig. 1: The sampling area in North Evoikos Gulf.

concentrations of the above mentioned radionuclides were determined. The reported radiotoxicity of the radionuclides varies from moderate for ^{222}Rn , high for ^{234}Th , ^{228}Ac , ^{137}Cs to very high for ^{226}Ra , ^{228}Th (IAEA, 1973).

SAMPLING, TREATMENT AND MEASUREMENTS

During 1984 summer samples of marine organisms were collected using a 400 HP motorboat towing a net with a cod-end mesh of 14 mm between stretched knots. Each haul lasted about 1 hour and covered an area of about 2 square miles at a depth of 80-90m. The trawling covered two sampling areas (Fig. 1), A with mineral waste disposal, and B without.

Two demersal species of fish, *Mullus barbatus* (Linnaeus, 1758), *Solea vulgaris* (Quensel, 1806), and two benthic species of crustacea *Macropipus depurator* (Linnaeus, 1758), *Nephrops norvegicus* (Linnaeus, 1758), were selected as quantitatively representative organisms of the examined region. The sediment samples from the two sites were collected by a Van Veen grab of 0.1 m² collection surface. Before their disposal Ore samples and mineral waste samples were collected (Tabl. I). An amount of the whole body of the samples from each species was ashed at 400°C for 3h. Sediment, ore and waste samples were dried at the same temperature for 1-2 h. All the samples were homogenized and screened (IAEA, 1970). The measured mass was about 25 g for ash and 100 g for sediment samples. A high resolution gamma-spectrometry system with a Hp-Ge co-axial detector of 20% efficiency with respect to 3×3 NaJ detector was used for the measurement of the samples. The energy of photopeaks measured for each radionuclide and the detection limits are given in Table I. The concentrations were calculated by a computer program (MINEV *et al.*, 1983).

RESULTS AND DISCUSSION

The results are given in Table I. It is noteworthy noting that the samples were not sealed and ^{222}Rn is not in radioactive equilibrium with ^{226}Ra .

It appears that the treatment of the ore leads to a considerable increase of the concentrations of ^{234}Th and ^{222}Rn (respectively to ^{226}Ra), in the mineral by-product and to a slight but reliable increase of the concentrations of ^{228}Ra and ^{228}Th . This might be due to the mixing of the ore with lignite (an amount of 14% per total mixture weight) during the ignitions procedures (TECHNICAL ANNALS, 81). This lignite has been found to contain above average levels of uranium and these higher concentrations are reflected in the ash (SIOTIS and WRIXON, 1984; PASTEFANOU, and CHARALAMBOUS, 1978), but we need more information in order to ensure it.

Usually high concentrations of ^{234}Th have been observed in the samples of fine grain by-product. A second measurement after 75 days shows a decrease of ^{234}Th activity which indicates the absence of support by the parent ^{238}U . We

Table I: Concentrations of natural radionuclides and ^{137}Cs in sediments and organisms from Larymna Gulf.

SAMPLE	^{234}Th	^{222}Rn (^{226}Ra) [*]	^{228}Ra (^{228}Ac)	^{228}Th	^{40}K	^{137}Cs	Special gravity of the measured mass mass g/c ³
Ore	10±9	6±1	7±1	7±3	110±7	N.D.	1.72
Mineral by-product before disposal	28±4	25±1	12±2	13±2	120±5	N.D.	1.77
Sea-bed sediment sample	25±4	23±1	13±2	17±4	115±11	N.D.	2.05
fine grain by-product at coolant out-put	1070±70	27±11	18±12	11±7	330±70	5±5	0.30
The same sample measured after 75 days	130±100						
Reference sediment sample	50±20	7±2	N.D.	8±2	78±15	N.D.	0.85
<i>Hacropipus depurator</i>							
Site A	15±7	N.D.	6±4	N.D.	460±20	N.D.	
Site B	11±7	N.D.	N.D.	N.D.	420±20	N.D.	
<i>Nephrops norvegicus</i>							
Site A	17±34	3±5	6±10	2±4	670±40	1.5±1	
Site B	30±33	4±4	7±14	N.D.	710±30	2.5±1	
<i>Mullus barbatus</i>							
Site A	30±40	N.D.	7±7	N.D.	1180±40	4±1	
Site B	20±40	N.D.	N.D.	3±2	1150±40	3.5±1	
<i>Solea vulgaris</i>							
Site A	15±15	2±2	2±6	N.D.	708±30	3±1	
Site B	—	—	—	—	—	—	
Energy of photopeak used KEV	63.3	609.4	911.1	583.1	1460.7	661.6	
	92.6	295.2**	968.9**	238.6**			
		352.0					
Detection limit: mineral sample***	7	1.1	1.5	1.1	9	0.4	
biological ash	20	3.5	4.8	3.3	30	1.2	

NOTES:

* Not in radioactive equilibrium with ^{226}Ra .

N.D. Not detected

** Gamma rays of daughter nuclides

*** Except sample of fine grain by-product

must take into account that the special gravity of this sample is extremely low and this contributes to the high value per mass weight.

The concentrations of ^{222}Rn , ^{228}Ra and ^{228}Th in the reference sediment are considerably lower than those in the mineral by products and the sea-bed sediment samples.

^{40}K concentrations are about the same in the ore and the mineral waste samples, while they are lower in the reference sample. No significant differences were observed between the radionuclide concentrations in the marine organisms collected from the two regions, with the exception of a certain increase of ^{40}K in *M. barbatus*, from the site A, but in the same range in fish samples collected from other areas of the Aegean Sea (FLOROU *et al.*, 1985).

^{137}Cs resulting from world wide fallout, has been detected in all the samples of *N. norvegicus*, while it is below the detection limit in all *M. depurator* samples. The values are comparabable with those in organisms from other areas in the Greek peninsula (FLOROU *et al.*, 1985). With respect to the two types of contamination through the sea water directly or via the food chain, we can say that there is no influence on the levels in organisms living in the gulf. Nevertheless, we must take into account that the area of mineral deposition is limited and the organisms migrate daily looking for food as well as during all the different stages of their life development. Besides the benthic organisms which compose the food of the examined species are smaller in size and fewer are in lower abundance in comparison with those in other areas of the gulf, because they do not have enough time to complete their growth between two successive depositions of the mineral waste (NIKOLAIDOU *et al.*, 1985). Probably, this has an influence on the levels of organisms-predators through the different food webs.

CONCLUSIONS

It seems that the disposal of mineral by-product in Larymna Gulf does not affect significantly the concentrations of natural radionuclids in the marine organisms studied, although the concentrations of the U-Ra-series and Th-series radionuclides in the mineral by-product are generally higher compared with those in the reference sediments.

ΠΕΡΙΛΗΨΗ

Οι συγκεντρώσεις της σειράς ουρανίου και της σειράς του θορίου, του ^{40}K και του τεχνητού ραδιονουκλιδίου του «fallout» ^{137}Cs , εξετάστηκαν με την μέθοδο της γ-φασματομετρίας, σε σύνθετα δείγματα των ειδών *M. barbatus*, *S. vulgaris*, *N. norvegicus*, *M. depurator*. Τα δείγματα συνελέγησαν από μία περιοχή απόθεσης παραπροϊόντων επεξεργασίας μεταλλεύματος και από μία περιοχή αναφοράς.

Στους οργανισμούς δεν παρουσιάστηκαν σημαντικές διαφορές μεταξύ των δύο περιοχών, ενώ στα ιζήματα εμφανίστηκαν αυξημένες συγκεντρώσεις των ραδιονουκλιδίων του ^{238}U στην περιοχή της απόθεσης των παραπροϊόντων.

REFERENCES

- FLOROU, H., KRITIDIS, P., DANALI-COTSAKI, S., BARTZIS, J., 1985. Concentrations of natural and artificial radionuclides in marine samples from selected areas around the Greek Peninsula. *Papp. Cpm. int. Mer Medit.*, 29 (7): 199-201.
- FLOROU, H. and CATSIKI, A.V., 1985. Bioaccumulation of Fe, Ni, Cr some selected marine organisms. CEP Consultants Ltd Edinburg, U.K., *Proceedings*, 1:359-362.
- IAEA., 1970. Reference methods for marine radioactivity studies. TRS, No. 116, Vienna, 285 p.
- IAEA., 1973. Safe handling of radionuclides. Safety Series, No 1, Vienna, 129 p.
- «LARKO»., 1985. Final Report on the impact of a mineral factory in the Northern Evoikos Gulf. Greece. N.C.M.R. Athens. (in Greek).
- MINEV, L., KRITIDIS, P., UZANOV, I., THEOFILOV, S., 1983. Calibrations standards for low level scintillation gamma spectrometry. *Nation. Conf. of standards in the system of metrological support to the industry*, Plovdiv. Bulgaria, 17-19 November, 1983.
- NIKOLAIDOU, A., ZENETOU, A., PANCOUCCI-PAPADOPOULOU, A., 1985. Effects of the mining wastes on the benthic biocoenoses in the Northern Evoikos gulf. Final Report «LARKO», N.C.M.R., Athens, (in Greek).
- PAPASTEFANOU, C., and CHARALAMBOUS, S.T., 1978. On the radioactivity of fly ashes from coal power plants. *Z. Naturforsch.*, 34 a: 533-537.
- POLIKARPOV, G.G., 1966. *Radioecology of Aquatic Organisms*. North-Holland Publishing Company. Amsterdam. (Translated from Russian), 314 p.
- SIOTIS, I. and WRIXON, A.D., 1984. Radioecological Consequences of the use of fly ash in building materials in Greece. *Radiation Protection Dosimetry*. Nuclear Technology Publishing, 7: 101-105.
- TECHNICAL ANNALS., 1981. Proceedings of the symposium on the mineral resources in Greece, 3-4 (in Greek), 147 p.
- VOUTSINOY, F., 1985. Chemical analyses in surface sediments sampled from the Northern Evoikos gulf. Final Report «LARKO», N.C.M.R., Athens, (in Greek).