SUBMARINE BAUXITIC TAILINGS DISPOSAL: A CASE STUDY IN CORINTH GULF, CENTRAL GREECE

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Abstract
A Submarine Tailings Disposal (STD) system operates on the northern flank of the Corinth Gulf , discharging bauxitic tailings on the shelf of the Gulf. A deposit of three high relief mounds has formed at a water depth of about 100 m. The surface of the mounds suffers from instabilities and tailings are transported as slumps down-slope. The tailings are dispersed on the shelf floor and are directed through the channels and canyons of the slope, to the basin floor where they form thin intercalating layers. Tailings have increased significantly the level of heavy metals in the study area.
Keywords: Metals, Pollution, Sediment Transport, Eastern Mediterranean

Introduction
On the northern margin of the Corinth Gulf, in Antikyra Bay, is located a bauxitic processing plant, Aluminium of Greece, which has contributed significant amounts of bauxitic tailings to the marine environment through a submarine tailings disposal system (STD). Throughout 20 years period, four (1982-83, 1987, 1994, and 2007) multidisciplinary environmental surveys were carried out in Antikyra Bay and in the Corinth Gulf basin, in order to monitor the STD system [1,2,3] and study the dispersion and transport mechanism of bauxitic tailings as well as the distribution of heavy metals concentration. The STD system discharges red mud slurry as the by-product of the aluminum production. Though the STD system the tailings are piped out at water depth of 100 -120m.

Results-Discussion
On the shelf the tailings have formed three high-relief overlapping mounds at the mouths of the pipelines, modifying significantly the bathymetry of the seafloor (Fig.1).

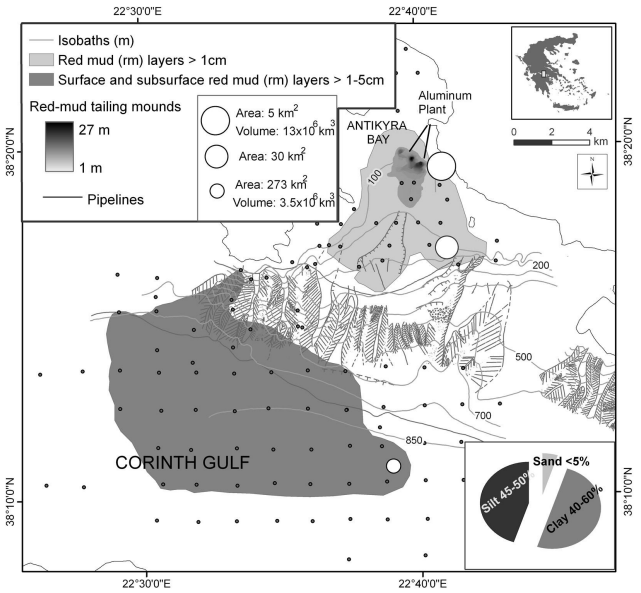

Fig. 1. Morphologic map of the central Gulf of Corinth showing the spatial distribution of bauxitic tailings. Inset shows the bulk granulometric composition of the tailings.

The mounds have wedged down-slope margins. The high rates of accumulation at the mouth of the pipelines, in association with the high seismicity of the area facilitate the instability of the mounds and the initiation of gravitative mass movements (such as slumps) as it is indicated by the surficial patterns of arcuated scarps. The red-mud tailings disperse from the mounds on the shelf floor in a down-slope direction and form an elongated main surface deposit. The distal tailings deposit is distributed down-slope from the main deposit as far as the shelf-break and thins out to 1 cm. The bauxitic tailings are transported as gravity–driven mass flows through the numerous channels incising the slope, to the basin where they are being deposited, at a depth of 800 - 850 m on a smooth and flat seafloor. On the base of slope and the basin floor, the red bauxitic tailings have formed successive layers, which intercalate with natural sediments. The "red-mud" tailings and the intercalated natural sediment, consist of medium to fine-grained sediments. The tailing deposits are highly enriched in Fe_2O_3, TiO_2, Cr_2O_3, Ni, Co, Pb and Cu compared to the surrounding natural sediments, while the natural sediments are characterized by higher concentrations of Mn, Zn and $CaCO_3$. The concentrations of Fe_2O_3, TiO_2, Cr_2O_3, Ni, Co, Pb and Cu are highest the mouths of the outfalls in Antikyra Bay (Table 1) and they decrease towards the basin. Therefore the tailings during their transport as gravitational mass flows from the outfalls as far as their final deposition site on the basin are subjected to mixing with natural sediments.

Tab. 1. Metal concentrations of bauxitic tailings and natural sediments in the study area

	Antikyra Bay		Corinth Gulf Basin	
	Red Mud	Natural Sediments	Red Mud	Natural Sediments
	Mean	**Mean**	**Mean**	**Mean**
Fe (%)	35.8	8.0	35	5.3
Cr (ppm)	3441	172	1120	62
Ti (%)	5.4	0.5	2.3	0.3
Ni (ppm)	1624	213	1147	66
Co (ppm)	103	37	92	21
Pb (ppm)	162	64	131	18
Cu (ppm)	133	83	133	48
Hg (ppm)	5	-	2.8	-
Al (%)	13.1	4.7	12.1	7.0
Ag (ppm)	9.6	0.5	7.3	-
V (ppm)	673	160	571	157
Cd (ppm)	10	0.2	7.9	-
Si (%)	5.6	35.3	6.5	26.9
Mg (%)	-	6.1	-	4.9
Mn (ppm)	1325	4883	2914	4714
Zn (ppm)	108	108	135	292

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