

Identification of the different sources of contaminants in the metal impacted Gromolo Torrent and related marine sediments

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Introduction: The Ligurian territory is characterised by short watercourses with a high mean steepness. One of these torrent is the Gromolo Torrent, which springs from the Monte Roccagrande (850 m a.s.l.), and flows for 11.5 km through the Gromolo Valley before crossing the town of Sestri Levante and flowing into the Ligurian Sea. The abandoned Fe-Cu mine of Libiola, which was the most important sulphide deposit of the Ligurian Apennines, is located inside the Gromolo basin. Widespread Acid Mine Drainage (AMD) processes are active in the mine site, leading to the formation of acidic and metal-rich solutions. In two points of its course, the Gromolo Torrent receives AMD from the Libiola mine, and the extensive precipitation of amorphous Fe³⁺ oxy-hydroxides takes place.

The marine study area is characterised by the presence of the headland of Sestri Levante with two bays, the western one named "Baia delle Favole". The dynamics of the area is dominated by a permanent north-westward off-shore current flowing approximately along isobaths, and an eastward counter-current along the north coast with a resulting drift of the coastal materials from the West to East towards "Baia delle Favole".

The aims of this work are to 1) evaluate the metal mobility of colloidal river precipitates for about 7 km up to its mouth in the Ligurian Sea; 2) verify the contamination state of the marine bottom sediments off the mouth of the Gromolo Torrent ("Baia delle Favole" of Sestri Levante), and 3) identify the main sources and diffusion ways of contaminants based on the dynamics of the area, the mineralogy, and the sedimentary characteristics of the bottom sediments.

Methods: The precipitates of the Gromolo Torrent bed were sampled with a plastic syringe and stored in polypropylene bottles. In fluvial samples, pH and EC were measured in each of the 10 sampling site. 28 superficial bottom sediments samples were collected using a 5-L Van Veen grab. For each sampling site, turbidity, currents, pH, salinity, and EC were measured. Mineralogical composition was characterised by means of XRD, while bulk chemical composition was measured by ICP.

Results: The results evidenced that amorphous, metal-rich colloidal precipitates are present along the

entire course of the Gromolo Torrent until its mouth and control the dispersion of metals in the stream bed sediments. In particular, the observed concentrations of Cu, Zn, and Cd are at least ten times higher than the background values. Other elements, such as Pb, As, and Sb, were linked with human activities, as their concentrations increased as the Gromolo Torrent flowed across the town of Sestri Levante.

In the marine bottom sediments, the results showed the existence of a high contamination in Cd, Cu, and Zn inside the bay deriving directly from the input of the Gromolo Torrent, and strongly influenced by the dynamics of the area. The bottom sediment are principally characterised by coarse materials, mostly consisting of fine sand, with a percentage of the fine sediment increasing inside the bay, where the dynamics is low.

Discussion: The amorphous precipitates control the dispersion of some elements (Cd, Cu, and Zn), but they do not represent the only input of contaminants in the studied zone. Anthropogenic activities contribute to the release of elements of environmental concern, such as Pb, As, and Sb, and may become very important. Finally, also the sediments from another torrent, the Entella Torrent, may account for the high concentrations of some elements, such as Mn and V. The sources of contaminants are therefore different, and attention should be paid on these environmental concerns, since the studied area is characterised by high anthropic and touristic activities.

The main factor controlling the dispersion of contaminated sediments is the current. In fact, currents may concentrate or disperse sediments, leading to anomalously high concentrations of elements, as Cu and Zn at the mouth of the Gromolo Torrent.