TITLE: ROLE OF INDIGENOUS MICROORGANISMS IN THE BIOGEOCHEMICAL CYCLES OF IRON AND TRACE ELEMENTS IN RIVERS AFFECTED BY IRON MINE TAILINGS FROM FAILED DAMS IN MARIANA AND BRUMADINHO, MINAS GERAIS STATE, BRAZIL

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ABSTRACT:

On November 5th, 2015, Fundão Dam failed in Mariana Municipality, releasing 33-62 million m^3 of iron mine tailings in the environment. Tailings ran into Gualaxo do Norte, Carmo, and Doce Rivers all the way to the sea. On January 25th, 2019, failure of Dam I in Córrego do Feijão Mine released 12 million m^3 of tailings, hitting wildlife, rural and urban areas in Brumadinho Municipality before running into Paraopeba River. The huge inputs of fine-grained Fe(III) oxides to river sediments may affect the biogeochemical cycles of Fe and trace elements, which could result in increased concentrations of dissolved trace elements and impaired water quality. In this work, we access the roles of indigenous microorganisms on the biogeochemical cycles of Fe and trace elements in these rivers. To access the reductive dissolution of iron and manganese minerals by indigenous microorganisms, water and bottom sediments were collected in the rivers and used to make anoxic microcosms. Experimental microcosms contained glucose or yeast extract 3-20g/L, whereas controls contained no organics or were autoclaved. Results showed that dissolved Fe(II) concentrations increased along time in the microcosms containing organics and living microorganisms but not in controls, indicating that indigenous heterotrophic microorganisms coupled organics oxidation to Fe(III) reduction to Fe(II). Glucose elicited higher Fe(II) concentrations than yeast extract, reaching values more than 100 times that of controls after 28 days. High Fe(II) concentrations were related to mobilization of Mn, Al, Ba, Cd, Cu and/or Zn from sediments. To access the role of biofilms in mineral precipitation, glass coverslips were maintained within Doce River for 1-2 weeks to enable biofilm growth. Scanning electron microscopy coupled to energy-dispersive spectroscopy showed Mn oxides containing minor amounts of Al in the mucilage of green algae and diatoms. The Mn and Al in these minerals came from the pool dissolved in the river water. Our results suggest that indigenous dissimilatory iron-reducing and/or fermentative microorganisms couple oxidation of organic substrates to Fe reduction, leading to mobilization of Fe, Mn, Al and other trace elements from river sediments. Part of the resulting Mn and Al remains in solution until they precipitate at the mucilage of microalgae. Our results could explain the increased trace element concentrations in Doce River and tributaries and in Paraopeba River after dams failing.

Keywords: Doce River, Paraopeba River, Mariana, Brumadinho, Fe cycle