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Short communication

Nano-mineralogy of suspended sediment during the beginning of coal rejects spill

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HIGHLIGHTS

- We investigated the distribution of sediment of a large river basin.
- The advanced methodology constrained the parameter values of the sediment simulation.
- Applied nano-mineralogy approach for selecting composite fingerprints in Brazil.
- Combined geochemical and fallout nanoparticles fingerprint for adequate management advice.

GRAPHICAL ABSTRACT

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ABSTRACT

Ultrafine and nanometric sediment inputs into river systems can be a major source of nutrients and hazardous elements and have a strong impact on water quality and ecosystem functions of rivers and lakes regions. However, little is known to date about the spatial distribution of sediment sources in most large scale river basins in South America. The objective of this work was to study the coal cleaning rejects (CCRs) spill that occurred from a CCRs impoundment pond into the Tubarão River, South Brazil, provided a unique occasion to study the importance and role of incidental nanoparticles associated with pollutant dispersal from a large-scale, acute aquatic pollution event. Multifaceted geochemical research by X-ray diffraction (XRD), High Resolution-Transmission Electron microscopy (HR-TEM)/(Energy Dispersive Spectroscopy) EDS/(selected-area diffraction pattern) SAED, Field Emission-Scanning Electron Microscopy (FE-SEM)/EDS, and Raman spectroscopy, provided an in-depth understanding of importance of a nano-mineralogy approach of Aqueous Pollution Scenarios. The electron beam studies showed the presence of a number of potentially hazardous elements (PHEs) in nanoparticles (amorphous and minerals). Some of the neoformed ultrafine/nanoparticles found in the contaminated sediments are the same as those commonly associated with oxidation/transformation of oxides, silicates, sulfides, and sulfates. These data of the secondary ultra/nanoparticles, puts in evidence their ability to control the mobility of PHEs, suggesting possible presentations in environmental technology, including recuperation of sensitive coal mine. The developed methodology facilitated the sediment transport of the catchment providing consistent results and suggesting its usefulness as a tool for temporary rivers management.

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1. Introduction

Sediment rivers transport depends on a great number of factors, the most important of which are the amount of available water, discharge, precipitation, topographical and environmental features of the terrain, basin geology, magnitude of human impact, and amount of sediment or load that the river or stream can carry. Coal beneficiation is a process where pollutants are removed prior to combustion. This statement is appropriate to both man made aquatic systems, such as nanoparticles (NPs) in water treatment plants and distribution systems (Ma et al., 2014), and natural aquatic systems, such as rivers and groundwater (Johnson et al., 2014; Novikov et al., 2006). Nano-mineralogy of sediments transport is important in order to characterize conditions and process governing water quality, invertebrate and fish habitat, reservoir sedimentation and coastline dynamics.

In coal mining areas, especially on active mines, various types of water streams are created. Lahars follow the path of river valleys. Our chance to work the latter, underrepresented type of influence in a major aqueous pollution scenario came in March 2015 during a CCRs spill into the Tubarão River, Santa Catarina State, Brazil (Fig. 1). The resulting flow of fines CCRs and water was estimated to contain 18–29 Mt of CCRs flowing into the Tubarão River, when the leak was finally and successfully capped. In general, CCRs can cause elevated concentrations of potential hazardous elements (PHEs) in surface water and potentially in groundwater (Oliveira et al., 2013, 2012a,b; Quispe et al., 2012; Ribeiro et al., 2013, 2010; Saikia et al., 2014, 2015; Sanchís et al., 2015; Silva et al., 2009, 2012). The saturated sediment water flow of the rivers flowing from the coal mining areas is characterized by a mass-wave movement such as debris flow, which is linked with the features of the water flow in the channel. In addition fine and nanometric coal derived sediment intrusion has also been identified as a major factor contributing to significant benthic ecosystem alterations, polluting aquatic biota.

This paper focused in understanding nanoparticles occurrence (minerals and amorphous phases) in sediments using advanced analytical methods to systematically measure the role of NPs associated with PHEs in a major aqueous contamination scenario, sediments samples from the Tubarão River. Few sediment transport works have been conducted in Brazil and these have mostly for coastal environments.

2. Materials and methods

Sediment transport is one of the fundamentals processes that shape the geophysical environment. In the case of the South America countries, coal and metal mining has been identified as a

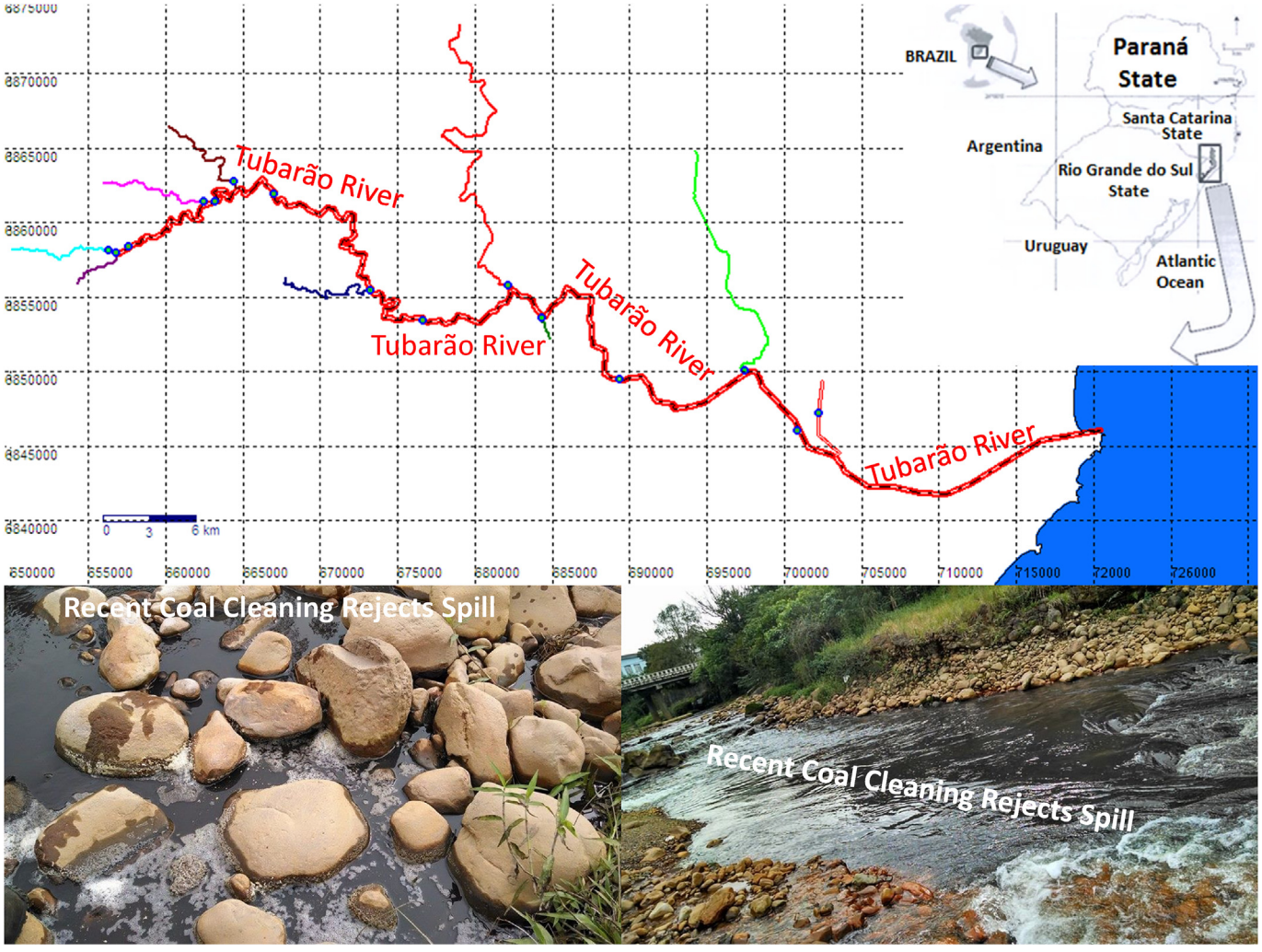

Fig. 1. Location of sampling sediments stations in the Santa Catarina State (Southern Brazil).