

# Study of water and sediment interactions in the Das Velhas River, Brazil – Major and trace elements

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## Abstract

Surface adsorption of metallic elements in aqueous solution by colloidal hydroxides affects the transport of elements in surface water systems. The study of the adsorption ability and the chemistry of hydroxides is important to the knowledge of the geological area, effluent and sewage treatments, and environmental management. In areas of ore exploitation, surface waters are subject to modifications of physicochemical properties: pH, dissolved oxygen, conductivity and alkalinity. A comparative study of the concentration of major and trace elements in water and sediment samples of the Das Velhas River, Brazil, was conducted using instrumental neutron activation analysis – INAA, and Inductively coupled plasma with mass spectrometry - ICP-MS. Water samples were collected and acidified *in situ* inducing a change in the natural pH, and consequently in the dispersion of metallic elements associated with Fe hydroxides (colloids) and with the particles in suspension. Results show the differentiated behaviour of the metal elements because of their chemical forms (cations or anions), solubility degree, Fe and rare earth elements (REEs) concentrations and pH variations.

## Introduction

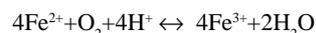
Surface adsorption of metallic elements in aqueous solution by colloidal hydroxides is a well-known phenomenon, and it is suspected to be an important process affecting the transport of trace elements in natural water systems (Benjamin and Leckie, 1981). The properties of colloid adsorption and the surface chemistry of hydroxides have been important for geology, analytical chemistry, water and wastewater treatment, and environmental management. Surface waters in mining area basins are very sensitive to disturbances such as acidification, which is directly linked to the phenomenon of oxidation (Toulhoat and Beaucaire, 1993). The distribution of elements in suspended matter and sediments along the course of a river, is generally controlled by natural processes: the relative importance of elemental transport phases, oxidation, precipitation and sedimentation of mineral species through the varying physicochemical conditions of the environment (Allen et al., 1993).

The physicochemical behaviour of many elements can be modified by changing water pH. Thus, the concentrations of all transition metal elements are considerably increased in acid waters.

The impurities commonly found in most natural waters in contact with mineral soils, and rocks in colloidal form are clay, silica (SiO<sub>2</sub>), ferric oxide (Fe<sub>2</sub>O<sub>3</sub>), aluminum oxide (Al<sub>2</sub>O<sub>3</sub>), and manganese dioxide (MnO<sub>2</sub>) (Tchbanoglous and Schroeder, 1987).

The Fe colloids, main product of pyrite (FeS<sub>2</sub>) oxidation, have good adsorption capacities for many transition metals. Consequently, the potential environmental impacts of these colloids have been carefully studied by Alauxnegrel et al. (1993). Other hydroxides, such as those of aluminium, manganese and silica, can also adsorb a great number of chemical species (Dzombak and Morel, 1990).

Oxidation-reduction reactions are important in natural systems, since these reactions may lead to other reactions with contaminants which may be present. The oxidation of iron (Fe<sup>2+</sup>) to (Fe<sup>3+</sup>) can be represented as follows:



Thus, depending on the oxidation-reduction potential, and on the solution pH, iron may exist either as Fe<sup>2+</sup> or as Fe<sup>3+</sup>. Oxidation of Fe<sup>2+</sup> is very slow below pH 6. At pH 3, half-times for the oxidation of Fe<sup>2+</sup> are around 1 000 d, while in the case of pyrite oxidation, by Fe<sup>3+</sup>, half-times of 20 to 1 000 min were observed by Stumm and Morgan (1981). The ability of iron to be oxidised or reduced in natural environments markedly affects its geochemical cycle and the cycles of other aqueous elements. Minear and Keith (1982) state two rules which govern the fixation and mobilisation of iron in solutions:

- Oxidising conditions promote the precipitation of iron, reducing conditions promote the solution
- Acid conditions generally promote the solution of iron, alkaline conditions promote the precipitation of iron.

Colloidal dispersions have electrical properties which are intimately associated with their ability to adsorb ions in solution, molecules of the medium, or both. There are many different forces that determine the stability of colloidal dispersions. The most important ones are Van der Waals dispersion forces, electrostatic forces and a diffuse electrical double layer around each colloidal particle (Ven, 1989, Tchobanoglous and Schroeder, 1987).

Cation and anion adsorption in hydroxides is highly dependent on pH. Cation adsorption increases strongly, from zero to 100% with increasing pH in the range of 5 to 7.5, while anion adsorption is more important at low pH since it decreases slowly with increasing pH (Dzombak and Morel, 1990, Allen et al., 1993). These phenomena are shown in Fig. 1.

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