

The geochemistry of sediments at the catchment scale: the Loire basin as an example

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Introduction: The surface waters of the Loire drainage basin offer unusual opportunities for selected geochemical studies and opens fields to new research (see Millot et al., this volume). This is mainly because the Loire drains areas with two main types of bedrock – the silicate basement of the Massif Central and the sedimentary area of the southern Paris Basin (Fig. 1); the watershed is an inland basin partly industrialized and partly agricultural, where anthropogenic activities may contribute in varying degrees to the dissolved and suspended particulate loads [1 - 8]

The elemental composition of soil and sediment, as well as particle size and mineralogy, relate more or less systematically to the nature of the parent rock material and the degree to which this material has been weathered. Chemical weathering of the Earth's surface results in a large loss of the most soluble elements, whereas the least soluble ones essentially remain in situ [9]. Major and trace elements in surficial sediments or soil mainly reflect the insoluble products of weathering, or are present in secondary minerals reflecting the more reactive mineral products of weathering in the environment.

Methods: The whole sediment of the Loire River catchment was investigated in this study, starting with samples collected in small catchments upstream in the Massif Central (Fig. 1) and ending with samples from the estuary, some 1200 km far from the river source. Sediments along the Loire River (central France) were investigated by means of major and traces elements and several isotopes determined on the bulk sediment [1-4, 6] or the labile sediment fraction, or acid-extractable matter [5, 7-8]. A synthesis of the data on sediments in the Loire River catchment, is followed by a discussion of the sources and behaviour of elements in the aquatic environment, and their mobilization and spatial distribution using isotopes as geochemical tracers.

Results and Discussion: Weak correlation of increasing suspended particulate matter (SPM) concentration with increasing river discharge is identified (e.g. no cyclical relationship with river flow is observed). The existence of dams along the river implies that, whereas the SPM originates from the natural erosion of the watershed, the suspended load could be controlled by non-natural processes.

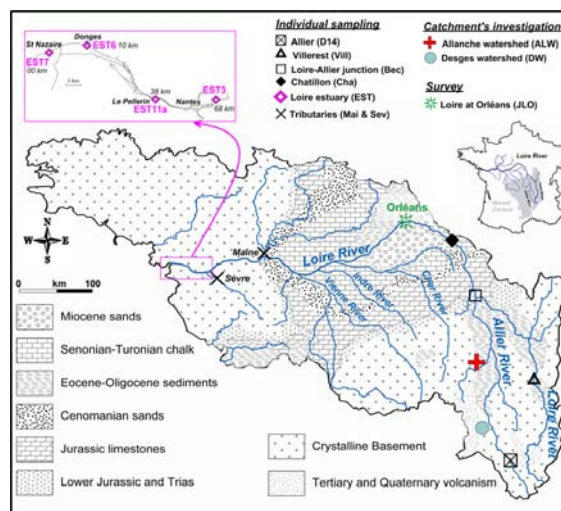


Fig. 1: Location map of the Loire Basin in France and simplified geological map with indication of the main tributaries. Also shown are the sampling points in the Loire watershed [4, 6, 7].

The relationship in SPM between the $^{87}\text{Sr}/^{86}\text{Sr}$ and Rb/Sr ratios clearly indicates binary mixing between the calcite and K-feldspar end-members but the relationship between the suspended particulate matter and dissolved load $^{87}\text{Sr}/^{86}\text{Sr}$ ratios confirms the considerable abundance of authigenic calcite primarily during low river flow. On the acid labile fraction Fe-Mn oxides act as the main carrier phase and most contributions result from bedrock weathering as confirmed by the Pb-isotope ratios, either in the upstream part of the Loire River, in the middle part of the basin, or in the estuary. The use of Pb-isotopic compositions showed an influence of agricultural-derived Pb inputs and a large input from Pb as a gasoline additive, particularly in the estuary (due to harbour activities).

References: [1] Négre and Deschamps (1996) *Aquat. Geochem.* **2**: 1-27; [2] Négre (1997) *Estuar. Coast. Shelf Sci.* **44**: 395-411; [3] Négre (1999) *Aquat. Geochem.* **5**: 125-165; [4] Négre and Grosbois (1999) *Chem. Geol.* **156**: 213-249; [5] Négre et al. (2000) *Chem. Geol.* **166**: 271-285; [6] Grosbois et al. (2001) *Aquat. Geochem.* **7**: 81-105; [7] Négre and Roy (2002) *Sci. Total Environ.* **298**: 163-182; [8] Négre and Petelet-Giraud (2012) *App. Geochem.* **27**: 2019-2030; [9] Gaillardet et al. (1997) *Chem. Geol.* **142**: 141-173.