Geophysical Research Abstracts
Vol. 17, EGU2015-10665-1, 2015
EGU General Assembly 2015
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Physico-chemical tracers of iron oxides in the Seine watershed

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Magnetic iron oxides and sulphides present in suspended matter in river flows (SPM) correspond to the input from soil erosion and contribution from the anthropogenic activities such as industry or agriculture. As ferruginous compounds are potential heavy metal-bearing, the understanding of their behavior is essential to evaluate mobilization, alteration and reattachment mechanisms.

This study focuses on the Seine River (France) and its watershed that mainly covers agricultural area at the exception of a highly populated and industrial area in its middle course, the Paris region. Sampling has been conducted on a monthly interval during a year (2011-2012) along the Seine River (9 sites) and six tributaries (1 site per river).

The correlation of the sampled SPM mass to the mean water flow during the sampling period shows that the SPM in tributaries is correlated to the specific water flow whereas no relationship is observed along the Seine. Such a result may be attributed to a sampling bias for the Seine large flows or more likely to the impact of the river anthropization on the SPM. The Orge River, a minor tributary shows a constant high concentration of SPM, attributed to the renaturing of its course.

The magnetic signal, based on hysteresis parameters, shows low saturation remanent magnetization (Mrs) values for the upper course of the Seine and the Aube River that flow through agricultural area in sedimentary formations (0.7-0.9 nAm^2/mg). Downstream of the Seine/Aube confluence, the Mrs values of the Seine remain at the same level as the flow rates are similar in both streams. The next tributaries (Yonne, Loing and Marne) show higher Mrs values (1.5-3 nAm^2/mg) attributed to a signal resulting from different sources, such as: i) industrial activities for the Marne that flows through similar formation as the upper Seine and Aube; ii) substrate and industrial activities for the Loing and Yonne that originate from a granitic region and flow through some industrial area (city of Sens). These contributions result in higher Mrs values in the Seine after the confluences as the flows of these tributaries are at least equivalent to that of the Seine (Yonne) or to half of it (Marne). The Orge River presents very high values (4.5-7 nAm^2/mg) but does not influence the Seine Mrs values as its flow is very low (less than 1% of the Seine). Downstream of Paris, the Mrs values are higher (3-7 nAm^2/mg), indicating additional anthropogenic input associated to a high level of urbanization. These values rapidly drop (1.6-5 nAm^2/mg) after the confluence of the Oise River that shows low Mrs values (1.6-3 nAm^2/mg). As the Oise flow represents only one third of the Seine flow at the confluence, another process than dilution must be sought, as for example the input of sewer treated water with very low SPM that can represent up to 20% of the Seine flow.

Further characterization of the magnetic properties is under investigation to identify the grain-size and magnetic minerals of these SPM with different Mrs values.