METAL FEATURES IN SEDIMENT FROM A MEDITERRANEAN RIVER BASIN (TAFNA RIVER, ALGERIA): Hydrological and anthropic influences

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Introduction

Metals from the Tafna river sediment have been investigated from upstream to downstream in two contrasted hydrological conditions. The enrichment factor indicated a medium to moderate contamination, except in the upstream part of the basin in relation with local anthropic sources. Indeed, this contamination appeared to be strong usptream particularly for Pb, Cd and As in stations from the medium river course. Point sources were detected for Pb, and for others it highlighted that the dam is a metal time bomb since it accumulates/releases the contaminants downstream after storm event periods, as illustrated by the higher concentration in sediments during high water flows. A PCA evidenced the strong link of naturally derived elements (Co, Ni, Cr, Cu) to Al-oxides or clays, whereas the more anthropogenic derived elements were linked to Fe and Mn oxides (As and Zn), to COP (Pb), and to Phosphorus (Cd).

Methods

The Tafna basin (NW of Algeria, 7245 Km² of which 27% belongs to Morocco in the upper part) is drained by the Tafna river and its 2 main tributaries, the Isser river being the major in the dowstream part (Fig. 1). Hydrological regime is Mediterranean alternating heavy storm events and severe droughts. Calcareous soils dominate while salt soils are encountered in the downstream part (Khaldi, 2005). Some forests, sparse vegetation and pasture are mainly in the upper basin, while irrigated crops occupy the rest. Several anthropic activities may impact the water quality along the river: four main industrial sites and the presence of 5 main dams (Fig.1) ensuring water supplies along the river course. These dams are sparsely empty during high water periods, leading to the discharge dowstream of accumulated sediment.

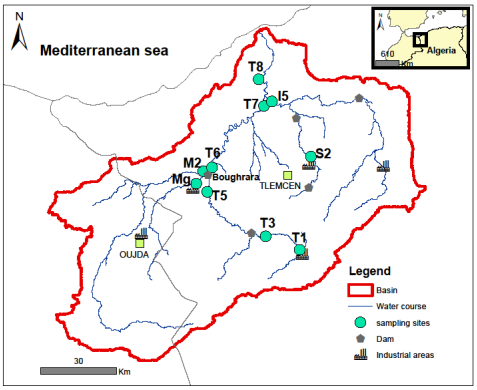

Fig. 1. Map of the Tafna river basin

Bottom sediments from 10 stations (Fig. 1) have been sampled during a low water period and a high water period, after a major flood event (June and October 2014, respectively). T1 and Mg are located upstream next industrial sites, S2 after a garbage dump; M2 et T5 control the inputs of Boughrara dam (the most important one and known to exhibit water contamination, Taleb, 2004) and T6 the dam output; T7 is downstream a large cultivation area, I5 is the outlet of the downstream tributary and T8 is the Tafna outlet station. Sediment samples were dried then sieved using a nylon sieve, and then crushed in an agate mortar prior to the mineralization procedure, performed at the EcoLab cleanroom on the <63µm fraction using a mixture of $HF/HNO_3/H_2O_2$. Major and trace elements were analyzed using an ICP-OES and ICPMS at the EcoLab/OMP, Toulouse. The metal concentration recovery from the standard SUD-1 was 85% to 110%. The contamination level was evaluated by the enrichment factor (EF) calculated using Al and UCC as a normalizing element and reference material, respectively. Finally, a PCA was performed using a log-transform concentration ratio.

Results

The metal concentrations in the sediments are moderate if compared to other similar conditions in Europe (Mediterranean basin, or draining carbonates, Ferrand, 2012; N'Guessan et al, 2009), except in the upper part of the basin (T5, T1) or in the middle part (T6, T7). Yet, as confirmed by EF (Fig. 2), contamination depends on the element: it is severe for Pb (upstream), Cd, As and Zn (in the middle part), whereas other metals are not (EF#2), or only moderately enriched. Except As (and to a less extent Zn), no enrichment is detected in sediment from the two tributaries. Upstream Pb enrichment is significantly reduced after the dam (T5) following the dilution effect of M2 input. On the opposite, As, Cd and Zn enrichment has strongly increased possibly as a result of a secondary source after storm event remobilization of particles resuspension from the dam (i.e. Coynel et al., 2007). The concentration increase during high water flows is a general pattern (Fig. 3) for all the stations, except in the upper stations (T1, T5) for Pb. These sites are highly contaminated by local influence of the last main gasoline stations on a road before the desert. Here, storm events dilute Pb in the sediments and contribute to transfer downstream this element which is mainly associated to particles.

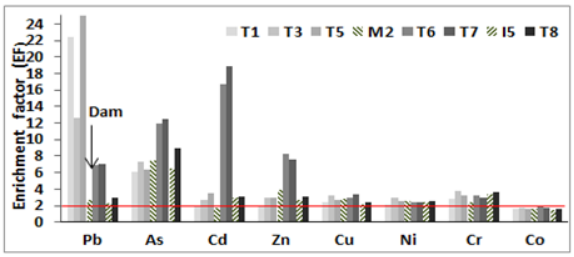

Fig. 2. Metal enrichment in sediments

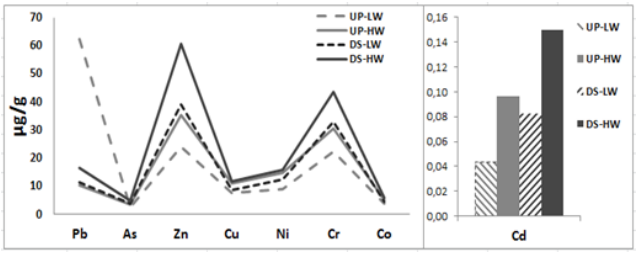

Fig. 3. Metal concentrations: after storm event, HW; low water (LW); upstream (US); downstream (DS).

The PCA (Fig.4) highlights a set of moderately anthropogenic influenced metals (Ni, Co, Cu, Cr) linked to Al-oxides and/or clay minerals, while As and Zn are associated to Mn and Fe oxides, Cd to phosphorus (indicating a potential fertilizer source to be confirmed, T6 and T7 sites), and Pb to COP (assuming a strong control of organic matter). In the Tafna outlet (T8), contamination in sediment remains low due to Isser dilution and/or has been washed to the Mediterranean Sea by successive storm events (Martinez-Santos et al., 2015).

Conclusion

The Tafna river sediments exhibit low to high metal contamination levels depending on the stations and the metals. Various sources and control parameters were identified. Hydrological events and dams have a strong impact on the contamination transfer downstream.

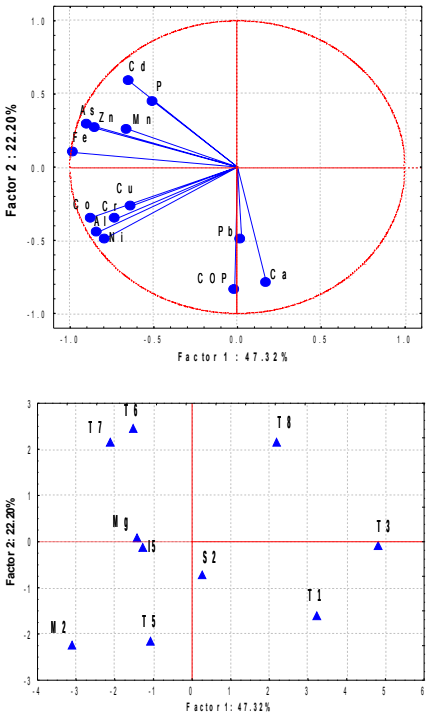

Fig. 4. ACP for metals and stations

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