Performance of bioaugmentation-assisted phytoextraction applied to metal contaminated soils: An ecological engineering approach for constructed wetlands

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Context

Since the end of the XIXth century, copper salts (Bordeaux mixture) are applied to vineyards against mildew. Despite more sustainable practices in agriculture, it seems illusory, however, to expect that such practices will quantitatively prevent copper leakage from agrosystems (Reichenberger *et al.*, 2007). Significant quantities escape agrosystems at the outlet of watersheds. In vineyards in particular, runoff may cause erosion during storm events accompanied by leakage of pesticides via both water and soil particles. One part of contaminants accumulates in sediments of storm basins, the other part only passes in transit. Biological pesticide mitigation has been observed and related to the role of natural macrophyte colonizers together with their associated microflora. Nevertheless, pesticide mitigation requires optimization in most cases since copper concentrations at the outlet of storm basins usually exceeds legal threshold limits for natural water.

Phytoextraction is an emerging soft technology, the only one able to extract *in situ* metals from soil or sediment. Macrophytes, such as *Phragmites australis* can accumulate copper (Bragato *et al.*, 2006). Unfortunately phytoextraction needs time as a consequence of the low metal availability which can be enhanced by means of soil bioaugmentation by microorganisms producing siderophores, biosurfactants and/or organic acids (Braud *et al.*, 2006). The combined use of macrophytes and bacteria for copper extraction has not yet been reported in the context of constructed wetlands.

Objectives and methodologies

The study consisted in selecting the best "microorganism-plant-sorbent" association, the core of the depollution system, in order to extract copper from sediments and mitigate copper load in storm basins outlet waters. Native bacteria from SB were selected for their tolerance to a mixture of copper and herbicides and for their ability to produce siderophores. Macrophytes have been tested for their ability to extract copper. A selection of low-cost sorbents able to retain copper in spite of low hydraulic retention times has been carried out. The association of these three selected components has been studied in storm basin-scaled microcosms filled with a sand-sediment mixture to a better understanding of the depollution process feasability.

Results

Among the 564 isolates extracted from a stormbasin sediment that were tolerant to copper and herbicides, 209 were genetically distinguished by RISA-RFLP analysis. 84 were able to produce siderophores and 21 complexed specifically copper. Isolate 106, a bacterial consortium, was selected for the process implementation on the base of its ability to complex copper and dissipate herbicides at high rates (Bois *et al.*, 2011). On the 3 studied macrophytes, *Phragmites australis* accumulated more copper in aerial parts (16 up to 59 $mg.kg^{-1}$), at the higher sand-sediment contamination rate (500 mg $Cu.kg^{-1}$). Furthermore, copper translocation factor calculated for this plant showed higher rates (9.6%) than *S. lacutris* (2%) and *Typha latifolia* (0.7%). *P. australis* is the macrophyte selected for the following experiments. Finally, sugar beet pulp has been selected as the best copper sorbant in mixture with herbicides and in a complex matrix (44% sorption rate at a contact time of 6h) (Huguenot *et al.*, 2010). Microcosm experiments that associated the best three components were carried out in order to establish the most favorable conditions for copper mitigation in outlet waters, and to enhance phytotextraction rate with bioaugmentation. Results showed that sugar beet pulp located at the outlet of microcosms reduced significantly (20 %) copper amounts in outlet waters to reach a mitigation rate of 95%. Copper extraction in aerial parts of *P. australis* has been improved by a factor of 1.7 thanks to an intermittent water load, with drying and rewetting periods along with repeated inoculations. At the outlet of the microcosms, copper mitigation is well observed but phytoextraction efficiency has to be improved: only 2 % of applied copper was extracted in 190 days by *P. australis*.

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