

# Total and hexavalent chromium removal in a subsurface horizontal flow (h-SSF) constructed wetland operating as post-treatment of textile wastewater for water reuse

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## ABSTRACT

In this study we investigated total and hexavalent chromium removal in an h-SSF constructed wetland (CW) planted with *Phragmites australis* and operating as post-treatment of effluent wastewater from an activated sludge plant serving the textile industrial district of Prato (Italy). Two measurement campaigns were carried out in 2006 and 2008–2010 in which more than 950 inlet and outlet samples were analyzed. When inlet and outlet concentrations were compared one to the other, the latter were found to be significantly lower than the former ( $p < 0.001$ ); during the entire period of investigation, removal of hexavalent chromium equal to about 70% was achieved. Outlet concentrations ranged between values lower than the quantification limit ( $0.5 \mu\text{g L}^{-1}$ ) and  $4.5 \mu\text{g L}^{-1}$ , and in all cases were therefore lower than the limit indicated for hexavalent chromium in the Italian regulation for water reuse ( $5 \mu\text{g L}^{-1}$ ). The comparison of the removal efficiencies achieved for hexavalent and trivalent chromium during the two campaigns suggested that the removal of the former can be sustained in the long term, while for the latter, the treatment efficiency is more sensitive to the age of the CW, being that it is based on trivalent chromium retention in the reed bed.

**Key words** | hexavalent chromium, horizontal subsurface-flow constructed wetland, total chromium, water reuse

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## INTRODUCTION

The treatment of wastewater deriving from textile districts is an issue of great environmental importance owing to the complexity of the removal of chemicals involved in this industrial process, and to their toxicity. Moreover, textile industry consumes a large quantity of water (about 10–50 L are required per kilogram of textile, depending on the type of processing), consequently producing large volumes of wastewater. Therefore, for textile districts more than for other kinds of industry, it is of paramount importance to have a wastewater management system capable of ensuring water reuse. In order to achieve this goal the quality level of the effluent must meet the stringent limits enforced by the Italian regulation for water reuse (Ministerial Decree of the Italian Republic n.185/2003).

One of the chemicals most widely used in the textile industry is chromium, which exists in aquatic environments in either the trivalent Cr(III) or hexavalent Cr(VI) oxidation states. The toxicity of chromium is highly dependent on its oxidation state; in fact, the hexavalent form is known to be toxic to many plants, animals and microorganisms, and several data in the literature indicate that the exposure to certain levels of Cr(VI) can promote cancer development (Nethercott *et al.* 1994; Wang *et al.* 1997; Environmental Protection Agency 1998). Conversely, the trivalent form is significantly less harmful and is an essential trace nutrient in the human diet (Anderson 1989, 1997). According to these facts, limits for water reuse of 100 and  $5 \mu\text{g L}^{-1}$  are established by the above-mentioned Italian regulation for total and hexavalent chromium, respectively.