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Comparative analysis of element concentrations and translocation in three wetland congener plants: *Typha domingensis*, *Typha latifolia* and *Typha angustifolia*

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ABSTRACT

This study analyzed the concentrations and distributions of Al, As, Cd, Cr, Cu, Hg, Mn, Ni, Pb and Zn in three different cattail species growing spontaneously in a natural wetland subject to municipal wastewater and metal contamination. The cattail species included *Typha domingensis*, *T. latifolia* and *T. angustifolia*. Results showed that all *Typha* species have similar element concentrations in roots, rhizomes and leaves, and similar element mobility from sediments to roots and from roots to leaves. This study corroborated three patterns of *Typha* species growing in metal contaminated environments: high tolerance to toxic conditions, bulk element concentrations in roots, and restricted element translocation from roots to leaves. This study showed that three different *Typha* species respond similarly to metal inputs under the same polluting field conditions. Given their similar metal content and similar biomass size, our results suggest that *T. domingensis*, *T. latifolia* and *T. angustifolia* may have comparable capacity of phytoremediation. High element uptake and large biomass make *Typha* species some of the best species for phytoremediation of metal contaminated environments.

1. Introduction

Heavy metals are a particular group of elements that, unlike organic pollutants, cannot be degraded through biological processes (Muhammad et al., 2009). Heavy metals are especially harmful in aquatic ecosystems where, once accumulated in bottom sediments, they begin to move up the food chain, often biomagnifying at higher trophic levels and ultimately causing various chronic and acute disorders in humans and animals (Gall et al., 2015). A major source of heavy metals is wastewater from agriculture due to herbicides and pesticides, and wastewater from industrial manufacture for the presence of raw materials (Dhote and Dixit, 2009). Numerous techniques have been developed to reduce the concentrations of heavy metals in the environment (e.g., chemical precipitation, membrane filtration), but most of them, although effective, proved expensive and non-ecofriendly (Olguín and Sánchez-Galván, 2012; Lara et al., 2014). As a result, the increasing need for remediation of contaminated sites led to develop cost-effective and eco-friendly biotechnologies like phytoremediation, which relies on naturally occurring plant species to extract, sequester and detoxify pollutants (Ali et al., 2013; Pandey et al., 2015; Rezania et al., 2016). Heavy metals, in particular, can be removed from contaminated soil, sludge, sediments and water, thanks to particular plants that uptake the pollutants through roots and translocate them to the upper parts of the plant (Wójcik et al., 2014; Sharma et al., 2015).

Wetland plants (or macrophytes) are widely investigated and used to treat metal contaminated surface water or remediate sites with elevated soil metal concentrations (Bonanno and Lo Giudice, 2010; Vymazal, 2011; Pandey, 2012; Bhatia and Goyal, 2014). Macrophytes, indeed, can filter out toxic metals from the surface water, often immobilize them in their sediments, and on the long term, return them to the geological part of the earth cycle (Odum, 2000; Prasad et al., 2006). Macrophytes suitable for phytoremediation are highly tolerant to heavy metal stress, have fast growth and large biomass, and can accumulate high metal concentrations in their tissues (Deng et al., 2004; Liu et al., 2016). Numerous studies showed also that uptake, accumulation and translocation of heavy metals may differ significantly among plant species (e.g., Fitzgerald et al., 2003; Yoon et al., 2006; Qian et al., 2012). Knowing the differences in heavy metal concentrations between macrophytes is thus fundamental not only to assess the suitability of one species instead of another for phytoremediation uses, but also to implement appropriate actions of ecological restoration and management, thus making phytoremediation more sustainable (Tack

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and Vandecasteele, 2008; Bonanno et al., 2013; Pandey et al., 2016).

Cattail species *Typha domingensis* Pers., *Typha latifolia* L., and *Typha angustifolia* L. are common, perennial and emergent macrophytes distributed worldwide in tropic and temperate wetlands, lakes and rivers (Smith, 1987). They prefer damp soils and shallow, slow and brackish waters, and can quickly dominate a wetland plant community by forming monotypic stands (Panich-Pat et al., 2004). *Typha* ssp. are herbaceous and rhizomatous plants that can be over 3-m high (Pignatti, 1982). Given their fast growth, large biomass, high tolerance to metal-contaminated sites, and high element uptake, *T. domingensis*, *T. latifolia*, and *T. angustifolia* have been widely and successfully employed for several phytoremediation uses such as phytostabilization, phytoextraction and water treatment in constructed wetlands (Leto et al., 2013; Mufarrege et al., 2014; Gomes et al., 2014; Pandey et al., 2014). Despite the numerous studies on the heavy metal phytoremediation capacities of *T. domingensis*, *T. latifolia*, and *T. angustifolia*, to date, it has not been possible to claim with enough scientific evidence whether or not such cattail species have similar accumulation and translocation capacities of heavy metals. This study analyzed the concentrations of nine heavy metals (Al, Cd, Cr, Cu, Hg, Mn, Ni, Pb and Zn) and one metalloid (As) in roots, rhizomes and leaves of *T. domingensis*, *T. latifolia*, and *T. angustifolia* growing spontaneously in a natural sewage- and metal-contaminated wetland. This study aimed to shed further light on the possible phytoremediation similarities of such cattails by comparing their element mobility and concentrations under the same polluting field conditions.

2. Materials and methods

2.1. Study area

The study area was an urban natural wetland located near the port of Catania (Sicily, Italy), (37°29′17.69″N; 15°05′09.54″E) (Fig. 1). Catania is the second largest town of Sicily with 315,000 inhabitants that rise up to 770,000 people if the metropolitan area is included. The study wetland is the estuary of a 6-km watercourse, which was channelized to receive the domestic discharges from Catania, and is mainly affected by municipal wastewaters, road run-off and dumping from adjacent industrial activities. In this wetland, *T. domingensis*, *T. latifolia* and *T. angustifolia* grow spontaneously and form dense mono-species populations (Fig. 2). This area acts as a constructed wetland and is subject to constant polluting inputs all the year round. The average annual flow is 1.5 m^3/s whereas annual rainfall and temperature are respectively 610 mm and 19.0 °C.

Fig. 2. Photo of sampling plots.

2.2. Sampling

Sampling was conducted in one-off trips conducted in April and

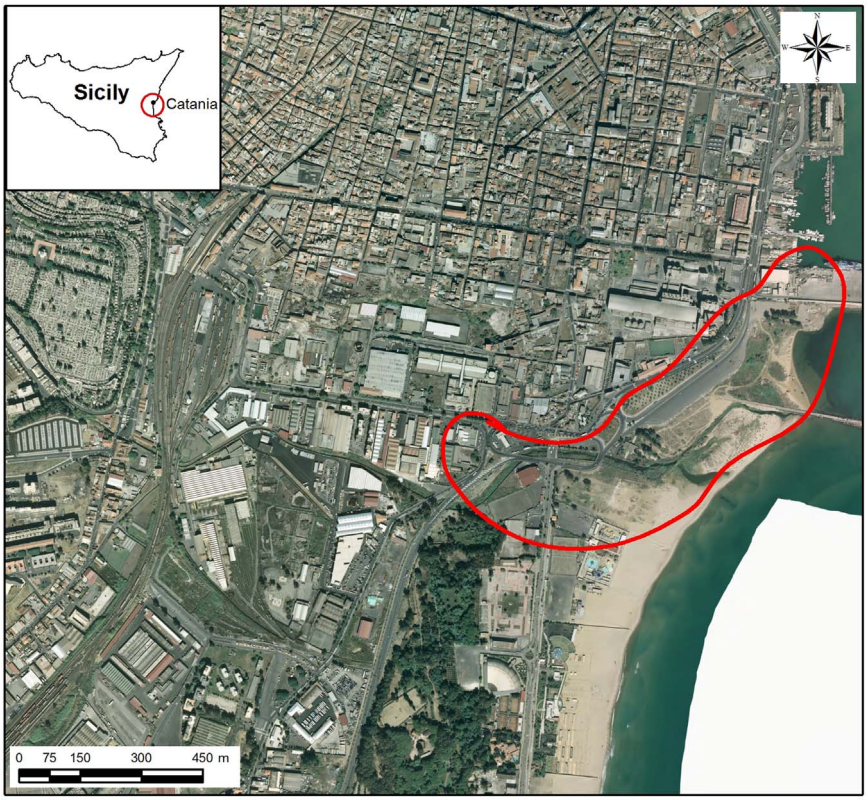

Fig. 1. Study area.