ARUNDO DONAX L. FOR PHYTOSTABILIZATION OF AN INDUSTRIAL POLLUTED SOIL: PLANT PERFORMANCE AND VARIATIONS IN SOIL BIOLOGICAL FERTILITY

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Introduction: Assisted phytoremediation could be an alternative to conventional technologies for polluted soil remediation. It can ameliorate soil properties, preventing dispersion of pollutants by water or wind erosion and reducing PTMs mobility in environment (Adamo *et al.*, 2014; Fiorentino *et al.*, 2013). This work reports the results of a phytoremediation experiment aimed to assess *Arundo donax* (AD) adaptability to industrial soils polluted by Pb and Zn. Humic acids (H) were tested as improvers of plant performance and soil fertility.

Methods: A 2-year lysimeter (0.8 m^3) experiment was carried out on polluted soil (S) and soil-washing sludge (F) from the industrial site of Bagnoli-Coroglio (Naples, Italy), growing *A. donax* in open field conditions. Metal contents of S *vs* F were 159 or 286 mg Pb kg^{-1} and 333 or 1069 mg Zn kg^{-1}, respectively. Humic acids (H) were added to each substrate (0.5 g kg^{-1}) obtaining 4 treatments (FH, FNoH, SH and SNoH) arranged in a completely randomized design with 3 replicates. A not polluted agricultural soil, was used as control. Substrate samples were collected at the end of each growth season (bulk and rhizo-soil) to assess the abundance of *nifH* and *amoA* bacterial genes (qPCR) as well as the organic carbon content (OC). Shoots were harvested at the end of each growth cycle and rhizomes were collected at the end of the 2^{nd} cycle. Plant tissues were analysed for N (flash combustion), Pb and Zn (acid digestion and ICP-AES) content. All data were subjected to ANOVA analysis.

Results: On polluted substrates, shoot weight was lower than on control (Fig 1a) with H significantly reducing this gap. Tough not different from control, rhizome biomass was lower in S than in F probably due to the lower fertility of F (higher Pb and Zn content; lower biological activity) stimulating the emergency storage (Mann et al., 2013). Nitrogen content of culms (Fig 1b) increased in the 2^{nd} year on S, regardless of H application, while on F this was true only in presence of H.

Rhizomes and then leaves were the main Zn sink, with values always higher than control and a preferential allocation in the belowground tissues at higher soil Zn content. Pb was mainly stored in rhizomes with values on F substrate higher than control, while Pb content in culms was not different from control. On the whole, Pb and Zn content in aboveground tissues were lower than legal (UNI EN 14961-2) thresholds for wood-chipped (10 mg kg^{-1} and 100 mg kg^{-1}, for Pb and Zn, respectively).

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In S, SOC content (Fig.1c) of the rhizo-soil was always higher than bulk-soil, pointing out a positive effect of root activity on soil OC due to root exudates and microbes turnover. A positive effect of plant treatment on soil microbiological activity was recorded on both substrates, with a significant increase of abundance of N fixers (*nifH*) and ammonia oxidizers (*amoA*) in the 2**nd** year (Tab.1). H positively affected microbial population only in F whose rhizo-soil values were higher than bulk-soil in the 2nd year, probably because enhanced root activity limited the negative effect of PTMs on microbial growth.

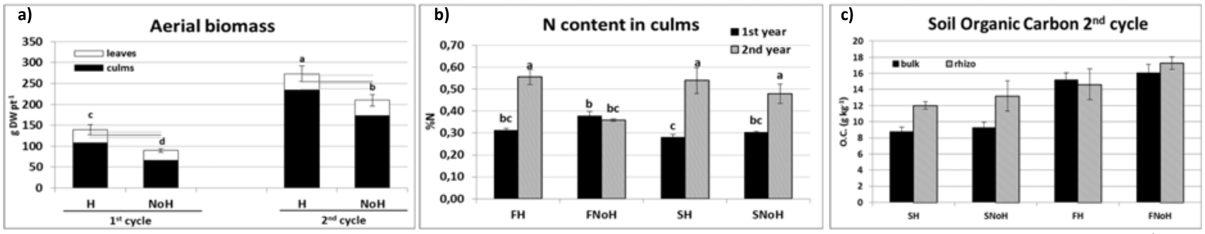

Figure 1. a) Effect of humic acids fertilization on the total *A. donax* biomass as sum of leaf (white bars) and culms (black bars) in the 1st and 2nd growth cycle; **b)** Effect of substrate x fertilization x year on N % content in culms; **c)** Effect of substrate x fertilization x bulk and rhizo-soil on soil organic carbon content in the 2nd year. Bars with different letters are significantly different ($p<0.05$). F: post washing sludge, S: soil, H: humic acids; NoH: no fertilization

Table 1. Effect of substrate x humic acids fertilization on quantification of functional genes involved in N cycling in 1st and 2nd growth cycle of *A.donax*: *nifH* (nitrogen fixation) and *amoA* (nitrification). Values with different letters are statistically significantly different ($p<0.05$). F: post washing sludge, S: soil, H: humic acids; NoH: no fertilization

	nifH (copies g^{-1} soil)				***amoA*** (copies g^{-1} soil)			
	1st year		**2nd year**		**1st year**		**2nd year**	
	Bulk-soil	Rhizo-soil	Bulk-soil	Rhizo-soil	Bulk-soil	Rhizo-soil	Bulk-soil	Rhizo-soil
SH	1.6E+04 c	3.6E+04 a	7.9E+04 c	1.0E+05 a	1.6E+03 b	5.2E+03 a	9.0E+03 b	1.5E+04 a
SNoH	1.8E+04 b	3.7E+04 a	8.8E+04 b	9.7E+04 ab	1.3E+03 b	5.1E+03 a	8.6E+03 b	1.1E+04 ab
FH	5.2E+02 d	5.1E+02 d	3.6E+03 e	8.8E+03 d	1.3E+02 d	2.1E+02 c	7.3E+02 c	9.0E+02 c
FNoH	4.3E+02 e	5.3E+02 d	4.7E+02 g	7.4E+02 f	1.3E+02 d	2.1E+02 c	2.3E+02 e	4.4E+02 d

Conclusion: *A. donax* is able to grow on industrial polluted soils with a slight reduction of biomass production (-20%) allowing to plan a profitable way to use industrial polluted sites, since biomass quality (i.e. contaminant content) is suitable for different technologies for material and energy recovery. This crop can restore chemical and biological fertility of polluted and degraded sites improving N availability, soil C storage and biotic activity of rhizosphere due to the root-soil interaction. H fertilization enhances plant growth limiting crop stress due to high soil PTMs content and low biological fertility.

References

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