PHYTOTOXITY OF WASTE WATERS WITH Cr AND Ni

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Abstract: The dry and fresh biomass and metal concentration (Cr, Ni) in roots and shoots of mustard (*S. alba* L.) seedlings was evaluated in laboratory experiments with three types of washing waste-waters from cutlery production line. All tested washing waters reduced root dry mass, where-as the dry mass of shoots was either not affected or it increased. The effect of tested washing waters was stronger on fresh mass production than on dry mass production. This indicates problems in water reception and translocation. While the accumulation of Cr was higher in the roots, Ni was distributed equally through the whole plant seedling. Cr uptake in the roots and shoots was in average about 1.7 and 7.3 times, respectively, lower than that of Ni. Ni percentage uptake from washing waters in the roots and shoots was nearly equal and range from 10.2 to 15.8%.

Key words: Cutlery washing waste-waters; Cr; Ni; phytotoxicity; mustard

1. Introduction

Phytotoxicity assessment plays an important role in environmental monitoring and risk assessment of metal-contaminated places. Since, only a few guidelines are available for the assessment of heavy metal phytotoxicity (RÖMBKE and MOLTMAN, 1996) quality-controlled toxicity data using standardized methods are actually quite rarely reported in the literature. EFROYMSON *et al.* (1997) developed toxicological benchmarks for screening the effects of contaminants which have the potential to arouse concern. This included the effect of certain heavy metals on terrestrial plants, and they also reviewed phytotoxicity data derived from experiments conducted in nutrient culture and spiked soils. Phytotoxicity tests generally use toxicological endpoints such as root and shoot growth, biomass production and germination percent. However, physiological responses of plants to toxic metals consist not only of growth and production inhibition, but also in changes intensity of various physiological parameters which are not standardized yet (HARTLEY-WHITAKER *et al*., 2001). Also, relationships between metal toxicity and metal tissue concentration have so far been poorly characterized.

2. Material and methods

Mustard (*Sinapis alba* L.) seeds were germinated in Petri dishes with 17-cm diameter and filter paper and plastic net on the bottom (SVETKOVÁ and FARGAŠOVÁ, 2007). Tested washing waste-waters were used in five various concentrations and tap water (80 $mg.l^{-1}$ Ca, 27 $mg.l^{-1}$ Mg; pH = 7.3 ± 0.05) was used for their dilution. After 10 days growth the plants were divided into roots and shoots and fresh mass was immediately weighed. The plant material was then dried (t = 80 ^{o}C) to a constant weight.

For metal accumulation plant samples (including control plants) were taken after 10 days of exposure. The seedlings were removed from tested waste-waters. Different plant parts (roots, shoots) were separated manually and dried at 80 ^{o}C for 24 h. Dried shoot and root tissues were mineralized by mixture of concentrated HNO_3/H_2O_2 (4/1, v/v) and heating in sealed teflon containers at 160 ^{o}C for 2 h in oven. The final solutions were analyzed for Ni and Cr concentration by ET-AAS (Cr) and F-AAS (Ni) (AAS; Varian, spectr. AA, Australia, GTA 110, with Zeeman 220 background correction).

The tested samples were three different waste-waters from washing reservoirs of cutlery production line mainly polluted by heavy metals (Cr, Ni). The total metal and non-extractable organic compounds (NEC) contents are shown in Table 1. First two reservoirs (R1, R2) collected waste-waters from degreasing baths, where the cutleries are degreased from residual oils and furniture creams, while the third reservoir (R3) collected waters from the final cutlery washing pool.

Table 1. Composition of tested washing waste-waters from cutlery production line

Sample	Cr ($mg.l^{-1}$)	Ni ($mg.l^{-1}$)	NEC[a] ($mg.l^{-1}$)
R1	41.6	50.2	1.78
R2	18.8	6.52	2.24
R3	0.3	0.255	6.49

[a] NEC - non-polar extractable compound

All phytotoxicity tests were carried out in triplicate and included a control. Quality control data were considered acceptable to control charts and other established criteria. ADSTAT 2.0 software was used for statistical evaluation.

3. Results and Discussion

The overall adverse effect of Cr and Ni on the growth and development of plants may be serious impairment of the uptake of mineral nutrients and water, which leads to deficiency in the shoots. Wilting of various crops and plant species due to Cr toxicity has been reported (TURNER and RUST, 1971), but little information is available on the exact effect of Cr and Ni on water relationships in higher plants. When the relationship between dry and fresh mass was determined here-in, the dry mass fraction was increased parallel with increasing of washing waters concentration. This indicates a reduction in water uptake and possibly also translocation through the plant. Water content was reduced very rapidly in comparison to that in control seedlings, and this occurred mainly in the roots where water content varied with tested water concentrations (Fig. 1.). Water content in the shoots was not significantly reduced in the presence of tested waste-waters. It can be concluded that tested washing waste-waters with Cr and Ni inhibited water absorption by the root, but not water translocation into the upper seedlings parts. These results agree with the CHATTERJEE and CHATTERJEE (2000) conclusion, that excess Cr decreases the water potential and transpiration rates and increases diffusive resistance and relative water content in leaves of cauliflowers.

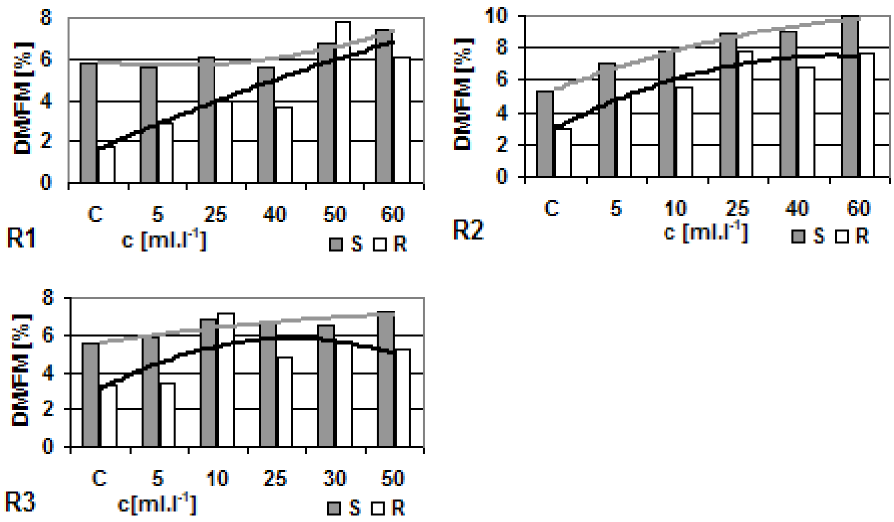

Fig. 1. Relation between dry (DM) and fresh mass (FM) [%] and their polynomic trend lines after 10 days growth of *S. alba* seedlings in the presence of tested washing waste-waters from cutlery production line (S – shoot; R – root; C – control); mean of three determinations, standard deviation 6% or less.

The results from the uptake of Cr and Ni from washing waste-waters from cutlery production line in the roots and shoots of *S. alba* seedlings are introduced in Tab. 2. While the accumulation of Cr was higher in the roots, Ni was distributed equally through the whole plant seedlings. However, PRASAD (1998) observed that Cr is accumulated rather in the shoots (stems and leaves) than in the roots, our results are in agreement with those introduced by CARRY *et al*. (1977). Ni accumulates uniformly in roots and shoots (PRASAD, 1998) and this is in good agreement with our results. While Cr is not considered as essential element for plant nutrition (SHARMA *et al*., 1995), Ni is classified as trace and essential trace element (BROWN *et al*., 1987). Cr was from tested washing waters accumulated in both plant parts in lower amount than Ni, and its percentage uptake range from 6.8 to 8.7 and 1 to 2.5 % for roots and shoots, respectively. Its percentage uptake in the roots and shoots was in average about 1.7 and 7.3 times, respectively, lower than that of Ni. Ni percentage uptake from washing waters in the roots to shoots was nearly equal and range from 10.2 to 15.8%.

SINGH *et al*. (2004) described differences in the metal accumulation in the different parts of plants and suggested on different cellular mechanism of bioaccumulation and translocation of metals. The high accumulation of metals (Cr, Fe, Zn and Mn) particularly in the root tissues of *H. annuus* may be due to complexation of metals with the sulfhydryl groups resulting into less translocation of metals to upper part of the plant, which vary from one metal to another. Similar conclusions can be done from our study of Cr accumulation from washing waste-waters to roots and shoots of *S. alba* seedlings. Cr translocation from roots to shoots of *S. alba* was in our study minimum as well as that introduced for cauliflower by CHATTERJEE and CHATTERJEE (2000). The reason of the high accumulation in roots of the plants could be because Cr is immobilized in the vacuoles of the root cells, thus rendering it less toxic, which may be a natural toxicity response of the plant (SHANKER *et al.*, 2004).

Table 2. Uptake of nickel and chromium from washing waste-waters after 10 days growth into the roots and shoots of *Sinapis alba* seedlings

Roots						
Reservoir	Initial conc. in the waste-water (mg. l^{-1})		Cr		Ni	
	Cr	Ni	Conc. tissue (mg.g^{-1} DM[a])	% uptake	Conc. tissue (mg.g^{-1} DM[a])	% uptake
R1	0.376	0.377	0.0258	6.8	0.0595	15.8
R2	0.312	0.130	0.0213	6.9	0.0148	11.4
R3	0.15	0.013	0.0130	8.7	0.0013	10.2
Shoots						
Reservoir	Initial conc. in the waste-water (mg.l^{-1})		Cr		Ni	
	Cr	Ni	Conc. tissue (mg.g^{-1} DM[a])	% uptake	Conc. tissue (mg.g^{-1} DM[a])	% uptake
R1	0.520	0.628	0.0051	0.98	0.0873	13.9
R2	0.282	0.098	0.0041	1.45	0.0103	10.5
R3	0.15	0.013	0.0038	2.5	0.0014	10.4

[a] DM – dry mass; All the values are means of triplicates after reduction of control; Standard deviation 6% or less

Resistance to Ni and its translocation through plant depends on plant species. While some plants are introduced as Ni hyperaccumulators other are very sensitive and introduced as non-accumulators (FREEMAN *et al.*, 2004). In the cytoplasm, high levels of free nickel are generally avoided by removal of the metal ions to the vacuoles and by the formation of complexes with organic acids. If the nickel level remains high, it inevitably binds organic macromolecules and denatures them. Ni is transported to underground plant parts by the oxygen atoms either as metal complexes of organic acids or as hydrated cations (SALT *et al.*, 2002). While BARMAN *et al.* (2000) introduced its higher accumulation in the roots of *Cyperus difformis* L. and *Chenopodium ambrosiodes* L., PANDEY and SHARMA (2002) observed in *Brassica oleracea* L. plants higher nickel accumulation in shoots. This statement confirmed results obtained during accumulation tests with washing waste-water here-in. In previous study with Ni accumulation in *S. alba* roots and shoots FARGAŠOVÁ (1998) and FARGAŠOVÁ and BEINROHR (1998) confirmed higher Ni accumulation in the shoots than in the roots when Ni concentration in the shoots was about twice as high as that in roots. This was not confirmed during our study when Ni accumulation in the shoots was equal to that in the roots and no significant differences were confirmed in accumulated metal amounts from medium.

4. Conclusions

It is concluded from present study that washing waste-waters from cutlery production line are quite toxic to plants and they reduced biomass and influence water and metal translocation through the plant. On the basis of this study high toxicity of the presented waste-waters from the metal surface finishing was confirmed and justness of their liquidation as hazardous wastes by legally assigned persons was confirmed.

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