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HEALTH RISK AND ENVIRONMENTAL POLLUTION IN RELATION TO REMOVAL OF HEAVY METALS BY WASTE WATER TREATMENT

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Introduction

Intensification of agriculture and the growth of human and farm animal population in the recent decades exacerbated some problems arising from increased production of wastewaters, their treatment and the solid fraction and sludges produced by this treatment. The content of heavy metals and other trace elements in waste waters from agriculture and sewage raises concern with regard to environmental pollution and potential contamination of aquatic and soil ecosystem and eventually to animal and human health (Epstein 2002). While some metal compounds are essential to animals and humans, other are known to be toxic and the environmental impact of many of them remains to be elucidated.

The study conducted investigated potential risk to animal and human health associated with re-use of solid fractions produced by WWTPs treating animal slurry and sewage, focusing on cadmium, lead, copper and zinc.

Material and methods

The investigations were carried out in two WWTPs involving the influent and effluent and the solid fractions, one treating excrements from 20 000 fattening pigs and waste waters from village with less than 2000 inhabitants (WWTP-1) and the second treating urban waste waters from a conglomeration of approx. 100 000 inhabitants with very little proportion of industrial pre-treated waste waters (WWTP-2). Both treatment systems include mechanical and aerobic biological stages. The pig solids are stored for different period of time and applied to agricultural land and the anaerobically treated sewage sludge is used as an additive to horticultural substrates or for recultivation and other agricultural purposes.

The level of cadmium, lead, zinc and copper in the influents effluents and biosolids was determined monthly over a 6-month period by AAS equipped with a graphite furnace and background correction (Unicam Solar 939) using the methods of Kocourek (1992). All metal concentrations were obtained on a wet weight basis and the results for solids were recalculated per dry matter (dm). The data are presented as minimum, maximum, mean (SEM) and SD in influent, effluent and the sludge and removal efficiency (RE) was calculated for both WWTPs.

The results were evaluated statistically with the software Microsoft Excel 7.0.

Results and discussion

Inputs of metals to urban waste water occur from three generic sources: domestic, commercial and urban runoff. Faecal matter typically contains 250 mg $Zn.kg^{-1}$, 70 $mg.kg^{-1}$, 5 mg $Ni.kg^{-1}$, 2 $mg.Cd.kg^{-1}$ and 10 mg $Pb.kg^{-1}$(dm). The majority of potential toxic elements in raw sewage are partitioned during treatment into the sewage sludge and the effluent. Approximately 70-75% of Zn, Cu, Cd, Cr, Hg and other metals in raw sewage is removed and transformed to the sludge and concentration of these elements in the final effluent would be expected to decrease by the same amount. The data on potentially toxic element content in the effluent are limited due to low concentrations, often below detection limits (European Communities, 2001).

Cadmium as highly toxic metal ranks among the most hazardous metal pollutants. Cd has accumulated in some plants to levels that may be hazardous to humans. Its concentration in vegetable grown on cadmium polluted soil was higher, for example 47-340 fold in potatoes, 25-144 in rice, 9 fold in carrot, 205 in cabbage and 43 fold higher in lettuce compared to products grown on unpolluted soil Koréneková et al. (2002). The concentration of **lead** in biological tissues corresponds to the environmental pollution and varies significantly with geographical area and demographic factors. It has no known essential role in an organism and its accumulation in tissues may cause several health hazards including neurotoxicity, hematotoxicity and reproductive disturbances (Rodmilans et al., 1996, Skalická et al., 2002). **Copper** is an essential trace element that is widely distributed in animal and plant tissues. The general population may be exposed to increased levels of copper in drinking water. Liming of sludge to pH of 12 increases mobility of Cu and Ni and therefore also leaching of these metals (Scancar et al., 2001). **Zinc** is a cofactor in scores of metalloenzymes and is therefore an essential element but may be toxic at high levels of exposure. WHO recommended a PMTDI (provisional maximum tolerable daily intake) of 60 mg/day..

The levels of these metals determined in our study are presented in Tables 1 and 2.

Table 1. Partitioning of selected heavy metals in WWTP - 1

Metal	Influent (mg/l)		Effluent (mg/l)		RE (%)	Solid fraction (mg/kg dm)	
	Min - max	Mean ± SD	Min – max	mean ± SD		Min - max	mean ± SD
Cd	0.01-0.80	0.29±0.31	0.006-0.01	0.008±0.002	97.3	0.6-15.2	7.45±5.90
Pb	0.02-1.70	0.66±0.71	0.02-0.23	0.125±0.082	80.3	3.8-45.2	35.38±15.68
Cu	0.50-2.10	1.22±0.64	0.03-0.10	0.067±0.035	94.5	37.5-45.2	41.40±2.42
Zn	0.32-14.5	7.15±5.86	0.12-0.44	0.27±0.12	96.2	201.2-310.2	252.40±34.96

RE – removal efficiency

Table 2. Partitioning of heavy metals in WWTP – 2

Metal	Influent (mg/l)		Effluent (mg/l)		RE (%)	Solid fraction (mg/kg dm)	
	Min – max	Mean ± SD	Min – max	Mean ± SD		Min – max	Mean ± SD
Cd	0.002-0.009	0.006±0.002	<0.001		83.3	2.60-12.4	8.00±3.74
Pb	0.12-0.19	0.16±0.03	0.001-0.005	0.003±0.001	98.1	62.4-195.5	151.65±41.99
Cu	1.02-1.08	0.72±0.50	0.038-0.046	0.043±0.003	94.0	172.5-299.2	258.97±45.95
Zn	0.80-1.91	1.23±0.43	0.012-0.018	0.014±0.002	98.9	1110.4-790.3	1464.9±248.32

RE – removal efficiency

Our results showed that a relatively high removal (80.3-98.9%) of the observed inorganic micropollutants was reached in both WWTPs. Higher concentration of metals was present in the influent to WWTP-1 which was reflected also in the quality of the effluent. The effluent from WWTP-2 complied with the acceptable limits for Cd, Pb and Zn in surface water only the levels of Cu were approximately double. The effluent from WWTP-1 exceeded these limits but complied with the values acceptable for water for irrigation with respect to Cu and Zn but the levels of Pb (50 μg/l) and Cd (5μg/l) were exceeded in 5 out of 6 samplings. However, with regard to considerable dilution of the effluent in the recipient any serious problems should not be expected.

WWTP sludge contains far more heavy metals and other trace elements than artificial fertilisers. They may accumulate in the soil from which they can be mobilised by “triggers”, such as acidification, and released to a soil solution from which they can be taken up by soil organisms and plant roots, or leached into groundwater. Some crops take up heavy metals from the soil to such levels that plants may become unfit for animal and human consumption (Gallo 2002).

National regulations in the Slovak Republic about application of sewage sludges to soil limit the concentration of Cd to 10 mg/kg dm, Pb to 750 mg/kg, Cu to 1000 mg/kg and Zn to 2 500 mg/kg dm. The levels of investigated metals in solids were below these limits except for cadmium which was the main element of concern and exceeded the limit in three samples of sludge from WWTP-1 (12.5, 15.2, 11.8 mg/kg) and two from WWTP-2 (10.4, 12.4 mg/kg). This risk may be increased when applying sludges to soil in industrially polluted areas where they may affect plants and animals and therefore the entire food chain.

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