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EFFECTIVENESS OF PIG SLURRY TREATMENT BY ACTIVATED SLUDGE WITH REGARD TO SOME HEAVY METALS

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SUMMARY
The aim of our study was to investigate the levels of some metals of interest in different stages of treatment of pig slurry by activated sludge (influent, effluent and solid fraction) in relation to their release to the environment and its possible contamination. The presence and levels of heavy metals in pig excrements are a subject of concern as they may be discharged into the recipient (effluent), applied to the soil (solid fraction) and pollute the environment. The metals can penetrate the food chain of animals and humans. Our results showed that the effectiveness of removal of metals by the activated sludge system was high. Although limits for the presence of Pb, Hg, Cu, and Zn in surface water were exceeded in the effluent on some samplings no serious risk to surface water quality is envisaged with regard to its further considerable dilution in the recipient. The levels of dangerous heavy metals (Cd, Pb, Hg) in the separated solid fraction were far below the limits required for composted biosolids intended for application to agricultural land.

Key words: environmental protection, effluent, influent, heavy metals, pig slurry

INTRODUCTION
Our environment is polluted in many ways related to human activities. Its protection requires thorough knowledge of potential sources of pollution on which appropriate measures can be based (Ondrašovi 1977). One group of serious environmental pollutants are metals and their organic compounds, especially heavy metals. Many trace metals are natural constituents of the environment. Some of them are even necessary for the biological functions of organisms (e.g. Co, Cu, Mn, Mo, and Zn). Metals are emitted to the environment from many different sources, the most important ones being industries (mainly non-ferrous, power plants, iron and steel waste and chemical industries), agriculture (irrigation with polluted water, use of mineral fertilizers, contaminated manure, sewage sludge and pesticides containing heavy metals), waste incineration, combustion of fossil fuels and road traffic.

Heavy metals from different sources accumulate in the soil from which they can be mobilized by "triggers", such as acidification, and released to soil solution from which they can be taken up by soil organisms and plant roots, or leached to groundwater, thus polluting the food chain or affecting drinking water quality (Chiras 1991; Killham 1994; Ondrašovi ová 1998). With regard to contamination of soil with heavy metals cadmium (Cd), lead (Pb), chromium (Cr), copper (Cu), zinc (Zn), mercury (Hg) and arsenic (As) represent a problem of concern (Stanners and Bordeau 1995). The aim of our study was to investigate the levels of some metals of interest in different stages of treatment of pig slurry by activated sludge in relation to their release to the environment and its possible contamination.

MATERIALS AND METHODS
We investigated the removal of heavy metals from pig slurry during treatment with activated sludge. The wastewater treatment plant (WWTP) investigated operates on an intensive pig fattening farm and is designed for the treatment of 823 m^3/d of pig slurry. Before treatment all excrements from pig farm (capacity for 20 000 pigs) accumulate in a collection pit. In the first stage, the solid fraction (SF) of slurry (approx. 2.8%) was separated mechanically and the liquid portion was pumped to a sedimentation tank. After sedimentation it was treated chemically by addition of $Ca(OH)_2$ to pH 11±0.5. Then it was pumped to the biological stage and treated with activated sludge. The treated water (94% of the original volume) was discharged into the recipient (river). The remaining portion were sludges (3.2%) that were treated within the WWTP process and were not mixed with SF.

Determination of metals was carried out by the common AAS method in the solid fraction of slurry, influent to the WWTP, and the effluent which was discharged to the surface water. Altogether, 5 point samples were taken over the period of 2.5 years (January 1996 – June 1998). The content of dry matter (DM) was determined at 105°C. As the retention time was approx. 24 h, the samples of influent, effluent and the solid fraction did not correlate.

RESULTS AND DISCUSSION

Air-breathing animals get the majority of the environmental toxicants from feed and water but not all of them will be absorbed in the intestine and may leave the body in faeces. Treatment of such faeces in wastewater treatment plants may be associated with many problems and risk to the environment. Metals and other toxic chemicals are transferred to the solid fraction or wastewater sludge, and the application of this fraction to agricultural soil may result in the uptake and accumulation of toxicants by crops and grazing animals, eventually posing a threat to humans (Ondrašovi 1996). They may also adversely affect biological treatment processes, diminish the quality of receiving waters and threaten aquatic organisms. Metals present in water pass to sediments, where by means of microorganisms their organic derivatives are formed and pass to the food chain of fish and eventually of man.

The activated sludge treatment provides very good removal for toxic metals such as Cd, Cr, Cu, Zn, Ni, and Pb. Metals are generally concentrated in sludges due to their sorption to flocs. Their removal depends on pH, solubility and concentration of metals, organic matter, and solid retention time. The affinity of biological solids for heavy metals was found to follow the order Pb>Cd>Hg>Cr^{3+}>Cr^{6+}>Zn>Ni (Bitton 1995). Some natural materials with considerable affinity to heavy metals (zeolites) have been tested as additives to animal manure in different stages of its processing and disposal to decrease the load on the environment (Mumpton and Fishman 1977; Vargová 1999).

Our investigations focused on concentration of some metals (Cd, Hg, Pb, Cu, Zn, Fe, Ca, Mg, Mn) in pig slurry fed to the treatment system with activated sludge, in treated effluent, and the separated solids. The results obtained are presented in Table 1. The concentrations determined indicate a good removal of toxic metals by the activated sludge process. The content of heavy metals in the effluent was lower in the majority of samples than the concentrations of metals allowed in surface waters.

There were considerable variations in the level of most of determined elements. This can be explained by their supply in feed and mineral feed additives which differs according to pig categories and feed suppliers. As the age and composition of stock changes, the amount of these elements in the excrements changes, too. Moreover, some variations may be ascribed to the retention of excrements in the collection pit different affinity of metals solids and the way of mixing and pumping the raw slurry before the treatment.

Table 1. The levels of metals in different stages of the WTP at a pig farm

Parameter	Influent mg/l	Effluent mg/l	Solid fraction mg/kg
Iron (Fe)	14.4 - 33.1	0.7 – 2.3	178 – 2286
Manganese (Mn)	2.1 – 4.9	0.02 – 0.15	7.9 – 229
Calcium (Ca)	178 – 351	71 – 161	2610– 15 405
Magnesium (Mg)	96 – 189	69 – 91	570 – 2690
Mercury (Hg)	0 – 0.011	0 – 0.005	0.003 – 0.025
Cadmium (Cd)	0.012 – 0.8	0.006 – 0.01	0.137 – 1.74
Lead (Pb)	0.02 – 1.7	0.02 – 0.23	0.533 – 5.813
Copper (Cu)	0.5 – 2.0	0.025 – 0.104	5.81 – 39.64
Zinc (Zn)	0.32 – 14.5	0.12 – 0.44	36.5 – 197.6
Dry matter (%)	0.85 - 1.34	0.06 – 0.26	13.9 – 18.39

Copper and zinc may be rather poisonous to aquatic biota. Their effect depends also on water hardness. Fish and invertebrates have been reported to be affected by Cu levels as low as 10-20 g Cu/l (hardness: 100 mg $CaCO_3$/l) so they should be kept below 40 g Cu/l. With regard to zinc the recommended water standards for fish are below 300 g Zn/l in water with a hardness of 100 mg $CaCO_3$/l but below 30 g Zn/l in water with a hardness of 10 mg $CaCO_3$/l (Stanners and Bordeau 1995).

Cadmium ranks among the most hazardous metal pollutants. It has a very high accumulation coefficient. Its levels in surface waters should not exceed 10 g/l. The accepted daily human intake level of cadmium recommended by WHO is as low as 64 g.
Considerable portion of lead is removed by sorption on base sediments. Although lead is easily transported over long distances through the atmosphere, it seems to have high tendency to concentrate in the vicinity of the point discharge. Its concentration in surface water should not exceed 50 g /l.

Mercury is a heavy metal poison whose influence is cumulative and whose effects on neurological behaviour are notorious. Because of this an intense effort is under way to trace the sources of all mercury pollution in order to eliminate them. However, the toxicity of Hg very much depends on its physical and chemical state. In river sediments it may be transformed to more toxic and mobile forms which are more fat-soluble and can penetrate the blood/brain and placental barrier of animals. Methyl mercury has a biological half-life of approximately two years, and will thus accumulate in the food chain. (Backlund *et al*. 1993). The maximum acceptable limit of Hg for surface water is 0.5 g /l.

In our study the limit value in the effluent was not exceeded for Cd but it was surpassed in 3 out of 5 cases for Pb and Hg. The Cu level were higher in 3 out of 5 and Zn in one out of 5 samples. The increased levels of Pb and Hg coincided in two samplings. However, the effluent is diluted considerably after its discharge so serious problems should occur. Examination of sediments downstream from the point of discharge could provide some additional valuable information.

The separated pig slurry solids are most frequently applied to the soil. However, with regard to its potential microbiological and parasitological contamination, they should be treated biothermically before application to cropland (Pa ajová *et al*. 2000). The levels of heavy metals in the compost obtained should not reach thresholds which can damage either soil fertility or the food chain (Tab.2). Our determinations showed that the levels of heavy metals in SF from the examined WWTP were far below the limits presented in Table 2. Therefore no serious accumulation of Cd, Pb, Hg or some other metals may be expected after manuring the crops with this substrate. However, when some bulking materials are used for composting of this fraction, care should be taken that they are of good quality also with regard to the content of heavy metals.

Table 2. Examples of pollutant limits for biosolids applied to land

Pollutant	USEPA (1994B) – USA			STN 46 5735 – Industrial Composts – SR	
	CCL mg/kg	PCL mg/kg	CPLRL kg/ha	Class I mg/kg DM	Class II mg/kg DM
Arsenic	75	41	41	10 [A]	20 [A]
Cadmium	85	39	39	2	4
Chromium	3000 [B]	1200 [B]	3000 [B]	100	300
Copper	4300	1500	1500	100	400
Lead	840	300	300	100	300
Mercury	57	17	17	1.0	1.5
Molybdenum	75	-	-	5 [A]	20 [A]
Nickel	420	420	420	50 [A]	70 [A]
Selenium [C]	10	36	100	ND	ND
Zinc	7500	2800	2800	300	600

CCL – ceiling conc. limits; PCL – pollutant conc. limits; CPLRL - cumulative pollutant loading rate limits; Class I, Class II – frequency of application differs according to contamination and pH of soil. Class II cannot be used for manuring of crops intended for direct consumption

[A] Determined when higher contamination may be expected

[B] May be deleted from the rule based on court remand consideration

[C] Selenium limits may be changed pending court remand reconsideration

REFERENCES

BACKLUND, P., HOLMBOM, B. and LEPPÄKOSKI, E. (1993). *In* 'The Baltic Sea Environment' Session 5. (Ed. L. Rydén) pp. 36 (Uppsala University, Uppsala, Sweden).

BITTON, G. (1994). 'Wastewater Microbiology' pp 478 (Willey/Liss, Inc., New York).

CHIRAS, D.D. (1991). Environmental Science pp 549 (Benjamin/Cummings Publ. Co, Inc., California, USA).

KILLHAM, K. (1994). 'Soil Ecology' (Cambridge University Press).

MUMPTON, F.A. and FISHMAN, P.H. (1977). *J.Anim. Sci*., **45**, 1188-1203.

ONDRAŠOVI OVÁ, O. (1998). Contamination of Water Resources with Wastes from Animal Production and its Possible Affects (In Slovak). Dissertation Thesis, Košice.

ONDRAŠOVI , M., ONDRAŠOVI OVÁ, O., VARGOVÁ, M. and KO IŠOVÁ, A. (1997). ‘Environmental Problems in Veterinary Practice’ (UVM Košice).

ONDRAŠOVI , M., PARA, ., ONDRAŠOVI OVÁ, O., VARGOVÁ, M. and KO IŠOVÁ, A. (1996). Veterinary Care About the Environment (In Slovak) (DataHelp Košice).

PA AJOVÁ Z., VENGLOVSKÝ, J., SASÁKOVÁ, N. and PLACHÁ, I. (2000). *In* ‘X International Congress on Animal Hygiene’, Maastricht, the Netherlands, pp 1051-5.

STANNERS, D. and BOURDEAU, P. (1995). Europe’s Environment, The Dob íš Assessment. (EEA, Copenhagen).

VARGOVÁ, M. (1999). The possibilities of using natural zeolite clinoptilolite in the process of treatment of pig slurry, PhD Thesis (UVM Košice).

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