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HEAVY METALS ACCUMULATION IN WASTEWATER SLUDGES*

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The Authors* have classified the metals contained in waste substances into toxic (Hg, Cd, Pb, Ni) and those considered by them as nontoxic (Zn, Cu, Cr) in the food chain. This statement being much simplified may be easily misunderstood. Obviously, as a rule, all the sludges and wastes should be utilized, but it seems that wastes from metal-finishing plants ought to be only tipped on special landfills and not used as fertilizers or soil conditioners.

The second critical remark refers to table 1, since the "harmless" metals shown to be the most numerous are however only roughly discussed.

According to MEINCK [7], the toxic concentrations of Cr, Zn and Cd for microorganisms and fish are very low, the threshold value being 0.1 ppm.

Limiting concentrations of Cu, Cr^{6+}, Zn, and Ni, are given by IMHOFF [6] for biocenosis of activated sludge and methane bacteria which are very sensitive to the variations in factors affecting the anaerobic fermentation.

Considering that the population of microorganisms in upper layers of soil is extremely high, the toxic effect in this medium is also significant, even in the presence of other factors (buffering capacity, alkalinity, ion-exchange capacity etc.) lowering this effect.

Some indices and data are known from the literature: HIRSCHHEYDT [5a] has stated, that the doses (in kg/ha) of heavy metals contained in sludges Zn — 1607, Cr — 1111, Ni — 531, and, Cd — 148 seriously inhibited the growth of plants or totally destroyed the cultures.

From the data presented by CHUMBLEY [2], DEAN and SMITH [3], HASLER [4], POLETSCHNY [8] and WALKER [9] it follows, that the concentrations of heavy metals in sludges may reach high values, and that zinc concentrations dominate quantitatively. The most detailed information is given by DEAN [3]. The concentrations of these metals accumulated in soil, plants and even in human organisms, have been shown by HASLER [4], HIRSCHHEYDT [5b] and POLETSCHNY [8]. A particularly high concentration of zinc has been stated in human

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body. So far, however, the role of this element in human organism has not been fully elucidated.

CHUMBLEY [2], KIRCHHAM (via [1]) and WALKER [9] have stated a cumulative effect of the said metals on living organisms (including the soil organisms). Chumbley introduced the so-called zinc-equivalents based on the ratio Ni:Cu:Zn = 8:2:1.

WALKER [9] formulated the guidelines for the use of sludge on land in Maryland, which run as follows:

"Maryland is currently using Zn equivalents concept for establishing safe total sludge loading rates for land. It currently is recommending additions of sludge with Zn equivalents up to 2.5% of the CEC and assumes a soil pH of 6.5. This proposal recommends one-fourth the amount of a given sludge on land as the following Environmental Protection Agency (EPA) proposal, which would permit sludge additions to land with Zn equivalents up to 10% of the CEC and assumes a soil pH of 6.5 or greater for 3 years;

EPA: Total sludge (dry tons per acre) that may ever be

$$\text{applied (until research shows otherwise)} = \frac{32700 \times \text{CEC}}{\text{ppm Zn} + 2\ \text{ppm Cu} + 4\ \text{ppm Ni} - 200}$$

CEC — cation exchange capacity of soil in meq/100 g,
ppm — mg metal per kg dry weight of sludge,
Equation demonitator — Zn equivalents which takes into account the greater plant toxicities of Cu and Ni.

As a rough guide based on the EPA formula, sludges with Zn equivalents of 4000 and 8000 can be applied to soils at total dry ton per acre rates equivalent to 8 and 4 times the soil CEC, respectively".

According to CHUMBLEY [2], the doses of sludge as fertilizer with 250 ppm Zn equivalents should not exceed 565 kg/ha and assuming 30 years of agricultural use of the given area, the annual dose should be as low as 565:30 $\leqslant$ 19.5 kg/ha.

In conclusion, the author would like to underline, that the sludge toxicity should be the more carefully determined the more general is the paper.

REFERENCES

[1] CEBULA J., *Handling and disposal of Wastewater sludges in mixture with refuse*, Doctor's Thesis, Wrocław Technical University 1974 (unpubl., in Polish).

[2] CHUMBLEY C. G., *Permissible levels of toxic metals in sewage sludge used on agricultural land*, A. D. A. S., Advisory Paper No 10, Ministry of Agriculture, Fisheries and Food, Wolverhampton, England, 1971 (via [9]).

[3] DEAN R. B., and SMITH, J. E., *The properties and composition of sludges*. Paper presented at the Seminar on Methodology for Monitoring the Marine Environment, University of Washington, Seattle, Washington, October 1973 (preprint).

[4] HASLER A., *Über die Eigenschaften von Klärschlamm und seine Eignung als Düngemittel*, [In:] 1. Ergänzungskurs Landwirtschaftliche Klärschlamm-Verwertung, Dübendorf 1974, p. 8.

[5] HIRSCHHEYDT A. von., *Jahresberichte 1970 (a) und 1976 (b) der Zentralstelle für Fragen der Beseitigung und Verwertung von Abfallstoffen im Pflanzenbau*, Dübendorf 1971, p. 27, and 1977.

[6] IMHOFF K., and IMHOFF K. R., *Taschenbuch der Stadtentwässerung*, 24th Edition, R. Oldenburg, Munich 1976.

[7] MEINCK F., STOOFF H., and KOHLSCHÜTTER, H., *Industrial Wastes* (Ścieki przemysłowe – a Polish translation from the 4th German Edition), Arkady, Warsaw 1975.

[8] POLETSCHNY H., *Kastenversuch zum Anbau landwirtschaftlicher Kulturpflanzer auf ausgefaultem Klärschlamm,* [In:] *Grundkurs Landwirtschaftliche Klärschlamm-Verwertung,* Dübendorf 1971, p. 39.

[9] WALKER J. M., *Sewage sludges — management aspects for land application,* Paper presented at the North-Central Regional Conference-Workshop „Educational Needs Associated with Utilization of Wastewater Treatment Products on Land", Michigan State University, East Lansing, Sept. 1974 (preprint).