Land application of liquid municipal wastewater sludges

The paper by Manson and Merrit [*Jour. Water Poll. Control Fed.*, 47, 20 (1975)] was read with much interest, particularly the data on the heavy metal content of the sludge from Celina, Ohio. If one assumes a dry matter content of the sludge of 5 percent, then the heavy metal contents per kilogram of dry matter are as follows: Cd, 12 mg; Cr, 17,600 mg; Cu, 520 mg; Ni, 3,800 mg; and Zn, 1,280 mg. The contents of Cd, Cu, and Zn are quite normal, but those of Cr and Ni seem to be extremely high. This is especially true of Ni, which is rather easily taken up by plants, in contrast with Cr. The purpose of this discussion is to describe briefly experiments that indicate that sludge with such a high nickel content is dangerous for agricultural use.

During the last few years, more than 40 sludges of different origin were tested for their value for agricultural use by replacing 0, 1, 2, 5, 10, 20, 50, and 100 percent of a normal sandy soil with sludge, which was, if necessary, dried beforehand, ground, and moistened again to a water content suitable for plant growth. The rates of application were so chosen that it was possible to study, in one experiment, the effect of the sludge as a fertilizer (low rates), as a soil amendment (medium rates), and as soil (100 percent sludge). The higher rates were also used to predict what would happen if lower applications were repeated again and again.

The experiments were carried out in 1-l plastic pots. The growing period of the crops was 4 to 8 wk. At least three crops were grown in succession. In the first crop, the N-effect of the sludge may be so dominant that heavy metal effects do not appear, because these effects appear only at the highest sludge rates. If the sludge has a high N content, there may be no growth of the crop at all at the highest sludge rates. Therefore, after the first crop and all following crops, excesses of nitrogen and possibly other soluble salts, which normally do not occur in high concentrations in the sludge because they leave the wastewater works with the effluent, were removed by washing the soil-sludge mixtures with 2 l demineralized water/pot. Every crop received a normal PK dressing but only half a nitrogen application so that a positive as well as a negative nitrogen effect of the sludge could appear. Some sludges (especially heat-treated ones) had a negative nitrogen effect on the first crop. Also, in that case, there may be hardly any growth of the crop at the highest sludge rates.

When dominant N-effects have disappeared, heavy metal effects may appear, depending on the heavy metal content of the sludges. In Figure 1, there is no heavy metal effect of sludge from the town of Assen. It is a normal picture for sludge from household wastewater. In Figure 2, there is a clear heavy metal effect of sludge from Leiden. In this case, this effect was almost certainly caused by nickel. The symptoms, some 2 wk after the emergence of the crop (oats, Figure 3), are typical for excess nickel, as was learned from experiments with pure, soluble heavy metal salts. The nickel content of this sludge was 934 mg/l. In the discussor's opinion, this is very high for nickel. The contents of other heavy metals of the sludge in question were also high (Zn, 5,533; Pb, 637; Cu, 1,084; Cd, 135 mg/l). Probably, they also contributed to the negative effect.

If there are no abnormal symptoms in the appearance of the crop or negative effects on the crop yield, there still may be a distinct change in the chemical composi-

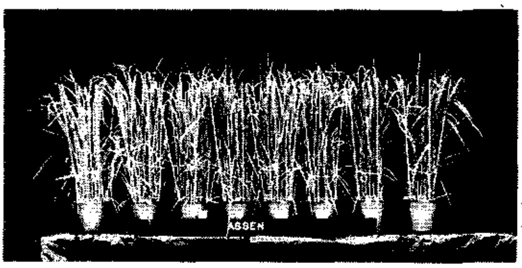

FIGURE 1.—Soil-sludge mixtures with (left to right) 0, 1, 2, 5, 10, 20, 50, and 100 percent sludge from Assen. No heavy metal effects in the crop (oats).

tion of the crop. This is shown in Figure 4 for sludges from Eindhoven and Leiden. The sludge from Eindhoven also had rather high heavy metal contents (Zn, 3,326; Pb, 1,050; Cr, 1,294; Cu, 2,080; Cd, 284; Ni, 274 mg/l), but there were no special symptoms in the appearance of the crop nor a negative effect on crop yield. In this case, the crop was grass from which seven cuts were harvested. The total yields of dry matter in grams per pot are given in Table I.

The experiment was carried out in the same way as mentioned before, except that the content of the pot was 5 l and the number of replications five in order to harvest enough material for a complete analysis. Treatment with 100 percent sludge from Leiden yielded insufficient material for such an analysis.

In Figure 4, contents of different elements are expressed as a percentage of the control. It is clear that sometimes the contents of macroelements (Na and Cl in sludge from Eindhoven) rose rather sharply, particularly for some minor elements, especially Ni (up to 145-fold in the

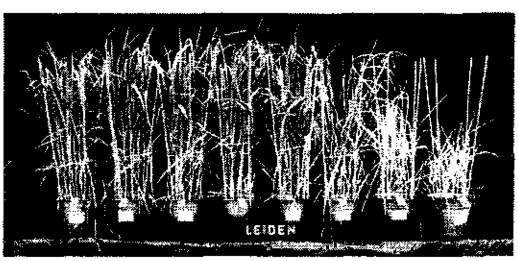

FIGURE 2.—Soil-sludge mixtures with (left to right) 0, 1, 2, 5, 10, 20, 50, and 100 percent sludge from Leiden. Negative heavy metal effects at the highest sludge rates.

TABLE I.—Yield (g/pot dry matter) of Seven Cuts of English Ryegrass Grown on Mixtures of a Sandy Soil and Wastewater Sludges from Eindhoven and Leiden

Sludge (%)	Eindhoven	Leiden
0	80.0	80.0
1	85.1	87.2
2	84.9	88.9
5	89.4	94.0
10	98.8	98.5
20	105.7	100.9
50	104.5	90.4
100	89.0	4.2

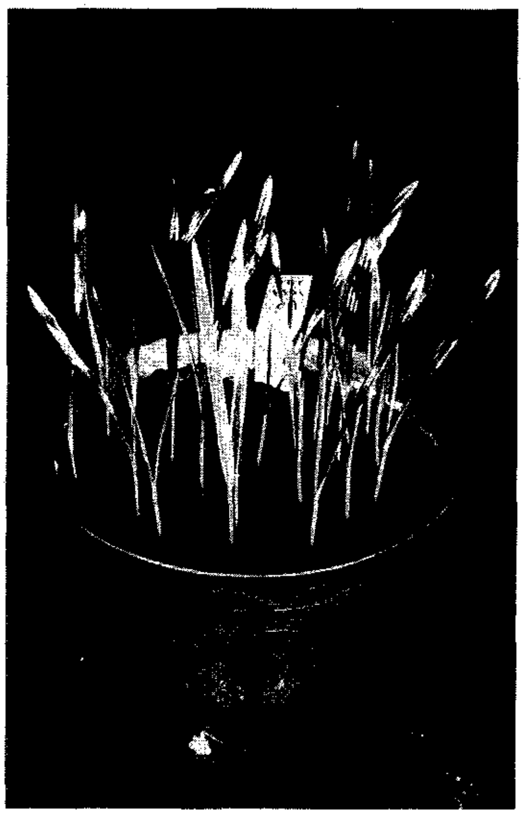

FIGURE 3.—Symptoms of heavy metal damage in the crop some 2 wk after emergence.

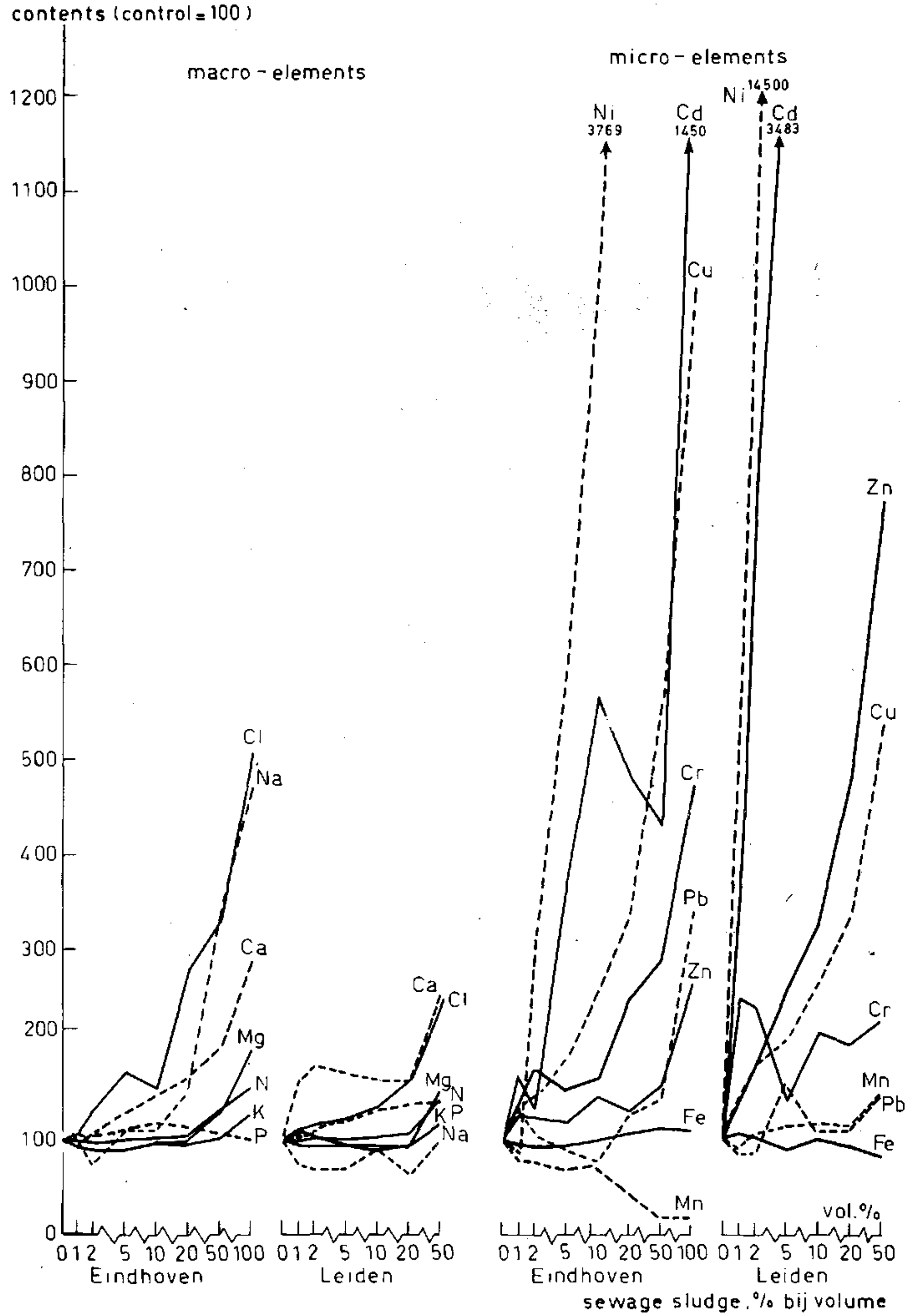

FIGURE 4.—Contents of macro- and microelements in grass as a percentage of control (soil without sludge).

case of sludge from Leiden), Cd, Cu, and Zn. Sometimes, there was a decline of the manganese content (to 15 percent of the control with sludge from Eindhoven).

Although little is known about the consequences of high heavy metal contents in crops to the consumer, farmers in the Netherlands are advised to use only sludges containing no more than 2,000 mg/l Zn, 500 mg/l Cu, 50 mg/l Ni, and 10 mg/l Cd on a dry matter basis and to apply, on the average, not more than 2 tons of dry matter/yr/ha on arable land and 1 ton/yr/ha on grassland. No more than 200 tons/ha should be used for arable land and 100 tons for grassland. If the contents of heavy metals are higher, the quantities should be lowered accordingly.

Another reason to use rather low quantities of wastewater sludge in agriculture is that heavy metal damages tend to become greater with time. Acidification of the substrate by nitrification of nitrogen that is liberated from sludge may be the reason for this. Drainage water analysis showed that the usually rather high amount of lime in wastewater sludges is leached out rather quickly. Thus, the discussor thinks that care should be taken as to the amount and frequency of wastewater sludge application on agricultural land.

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