

WATER EXTRACTABLE ORGANIC MATTER (WEOM) CONCENTRATION OF FOUR DIFFERENT SOILS AS AFFECTED BY COMMUNAL SEWAGE SLUDGE LOADS

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Introduction

Agricultural use of sewage sludge could constitute a valid alternative to incineration or landfill, both for the environment and agriculture, therefore, the attention on this practice has increased in the last twenty years (Simon, 2001).

The decomposition of the organic matter added into the soil through sewage sludge applications may cause significant changes in the chemical forms of metals. These possible transformations in the forms of metals may subsequently lead to changes in their bioavailability. So, we know the effect of sewage sludge loads on the water extractable organic matter (WEOM) content of soils. This fraction of the soil organic matter might occur in the forms of metals (Filep, 1988).

The amount of communal sewage sludge is 700 thousand t/yr (25-30% D.M.) in Hungary, and 23% of this amount has been used on field. Dissolution of toxic and other elements, as well as WEOM depend on the soil properties (Kádár, 2005; Filep *et al.*, 2002).

Objectives of our study were (i) to investigate which soil parameters determine the soil WEOM content to the greatest degree, and (ii) to study the communal sewage sludge loads effects on WEOM concentration of soils investigated.

Methods

A pot experiment was set up in 1999 to examine the effect of communal sewage sludge loads on soil parameters. Imre Kádár and Balázs Morvai designed the experiment using four different soils (Table 1).

Applied sewage sludge loads investigated in this article were the followings: 0, 5, 20 g sludge D.M./kg air-dry soil with 3 replications.

Air-dry soil (< 5-mm particle size) and homogenized fresh sludge was mixed and dispensed into 10-l pots. After 1-month incubation, spring barley was sown in April. After its harvest (July) peas were sown. Soil samples were taken after pea harvest in October. Pots were irrigated with deionized water to 75 % water capacity during the experiment, according to the evapotranspiration.

The water extractable organic matter (WEOM) contents were measured from the soil samples: 5 g of soil samples was shaken with 50 cm³ 0.01 M CaCl₂ for 2 hours. The liquid phase was separated by filtration (Filtrak 292). Then the filtrate was through pass a 0.45 µm membrane (Millipore). The carbon content of these solutions was measured by a TOC analyser (Teledyne Tekmar Apollo 9000).

Table 1 Properties of soils used

	Nagyhőrcsök Calcareous chernozem	Órbottyán Calcareous sandy	Gyöngyös Brown forest	Nyírlugos Acid sandy
<i>pH</i> (H_2O)	8.1	8.3	6.8	5.4
<i>pH</i> (KCl)	7.6	7.3	5.8	3.9
<i>Plasticity</i> ¹	40	22	44	25
<i>CaCO₃</i> (%)	10	15	0	0
<i>Clay+silt</i> (%)	36	6	57	5
<i>OM</i> (%)	2.5	0.7	3.0	0.7

1: Upper limit of plasticity

Treatment effects were estimated by one-way ANOVA with Duncan range test at $p < 0.05$. The correlation analysis was performed by Pearson's correlation test.

Results and discussion

The effect of soil parameters on WEOM concentrations

It is clear from data of Table 2 that there are substantial differences between the average WEOM content of soils.

Table 2 the water extractable organic matter concentrations of soils in average of treatments

	WEOM (mg/kg)
Nagyhőrcsök	246 b
Órbottyán	180 a
Gyöngyös	292 c
Nyírlugos	174 a

a-c denote significant differences at 0.05 according to the Duncan-test

Considering the average of treatments, we measured the lowest extractable organic carbon concentration on Nyírlugos soil (174 mg/kg; acid sandy soil), however, the value of calcareous sandy soil (Órbottyán) is very close to that value (180 mg/kg). For calcareous chernozem soil significant higher value was found (246 mg/kg), while in case of Gyöngyös soil (brown forest soil) the WEOM concentration was almost twofold (292 mg/kg) comparing to that measured on sandy soils. In light of this, we may conclude that the higher the soil organic matter contents of soil the higher the WEOM concentration of that.

To get better understanding about the reason of differences of the WEOM values among soils investigated correlation analysis was evaluated between soil parameters and soil water extractable organic matter content (Table 3).

Table 3 Correlation matrix of soil parameters and WEOM

	pH (H ₂ O)	pH (KCl)	Plasticity	Clay+silt	OM	WEOM
pH (H ₂ O)	1					
pH (KCl)	0.990**	1				
Plasticity	0.095	0.211	1			
Clay+silt	0.122	0.218	0.973*	1		
OM	0.187	0.296	0.993**	0.984*	1	
WEOM	0.150	0.244	0.970*	1.000**	0.985*	1

* Correlation is significant at 0.05; ** Correlation is significant at 0.01

The WEOM content of soils was the closest correlation with clay+silt fraction of the soil, but there also were strong relationships between WEOM and soil organic matter content, as well as soil plasticity index. It is not so wonder because these soil parameters (clay+silt, organic matter, and plasticity) were correlated with each other. Due to these cross-correlation it is very hard to know exactly which parameter determine the WEOM content of soil to the greatest extent.

The effect of sewage sludge treatments on WEOM concentration

Increasing the communal sewage sludge loads caused no a significant increase in WEOC concentration of soils in case of Órbottyán and Nagyhörcsök, while for Gyöngyös and Nyírlugos there were significant effects (Table 4).

Table 4 the effect of communal sewage sludge on the water extractable organic matter concentrations of soils

	Órbottyán	Nagyhörcsök	Gyöngyös	Nyírlugos
Load (g sludge D.M. / kg soil)	WEOM (mg/kg)			
0	168 <i>a</i>	245 <i>a</i>	273 <i>a</i>	158 <i>a</i>
5	185 <i>a</i>	244 <i>a</i>	290 <i>ab</i>	162 <i>a</i>
20	186 <i>a</i>	250 <i>a</i>	311 <i>b</i>	202 <i>b</i>

a-c significant differences in columns at 0.05 according to Duncan-test

Sewage sludge loads had the greatest effect on Nyírlugos soil, the WEOM increment was 127 %. For Gyöngyös, Nagyhörcsök, and Órbottyán, this increment value was 114, 102, and 111 %, respectively.

In other words, only on the acid soils was significant treatments effect, indicating that dissolution of constituents being in sewage sludge is limited on calcareous soils. On the other hand, as Zmora-Nahum and co-workers (2005) reported the WEOM concentration of composts investigated decreased rapidly within the first month, it is possible that the treatments had effects on WEOM content only in the beginning of the experiment.

Conclusions

Substantial differences were found between the average WEOM content of soils. The WEOM content of soils was the closest correlation with clay+silt fraction of the soil, but there were strong relationships between WEOM and soil organic matter content, as well as soil plasticity index.

Increasing the communal sewage sludge loads caused no a significant increase in WEOM concentration of soils in case of Órbottyán and Nagyhörcsök, while for Gyöngyös and Nyírlugos there were significant effects In other words, only the acid soils were significant

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