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Mobility and release of heavy metals after biogas digestate application to three different soils

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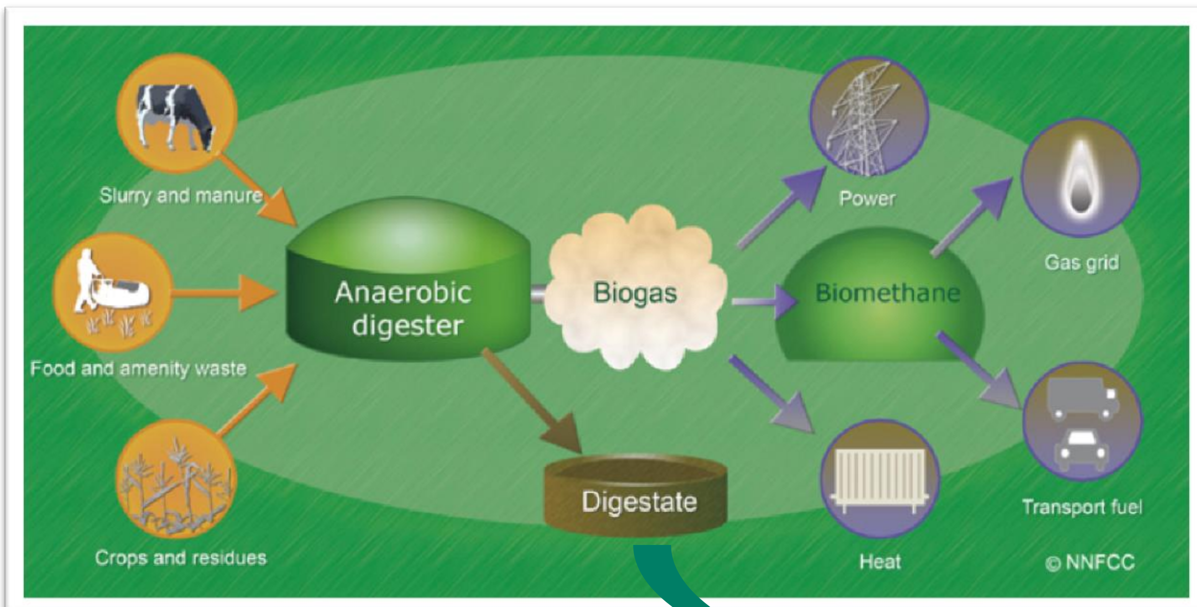
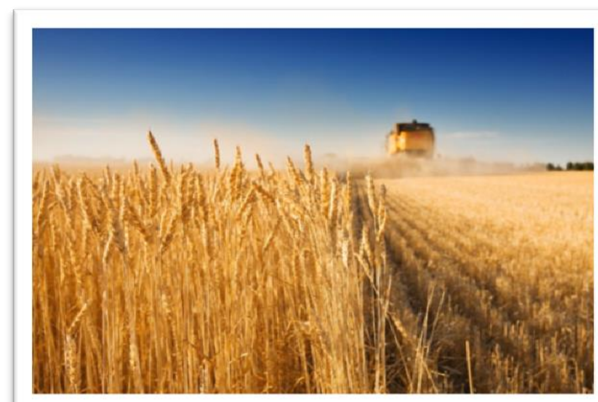
Presentation outline

1. Soils, biogas digestates and experimental set up

2. Hypothesis and research objectives

3. Research results and conclusions





1. Soils, biogas digestates and experimental set up

Loam Sand Silt

Table 1. Selected characteristics of soils used in the experiment.

Soil type	pH	Tot. C	DOC	Sand	Silt	Clay	Ni_{tot}	Cu_{tot}	Zn_{tot}
		%	mg L^{-1}		%		mg/kg	mg/kg	mg/kg
Loam	4.8	2.42	29.7	45	38	17	24.0 ± 0.1	10.3 ± 0.1	78.6 ± 2.1
Sand	5.1	0.37	15.5	94	3	3	12.9 ± 0.1	2.4 ± 0.1	54.5 ± 0.1
Silt	6.2	1.81	23.5	2	93	5	9.5 ± 0.1	7.9 ± 0.1	31.3 ± 0.1

Experimental digestate (EDIG) were produced by anaerobic digestion at the Biogas laboratory of the Norwegian University of Life Sciences and the Norwegian Institute of Bioeconomy Research.

- EDIG1 was a digestate produced using only animal manure as substrate,
- EDIG2 was produced from the mixed substrate manure and whey permeate in a ratio v/v 230:70,
- EDIG3 was also produced from mixed substrate manure:whey (v/v 120:280) with addition of fish ensilage.

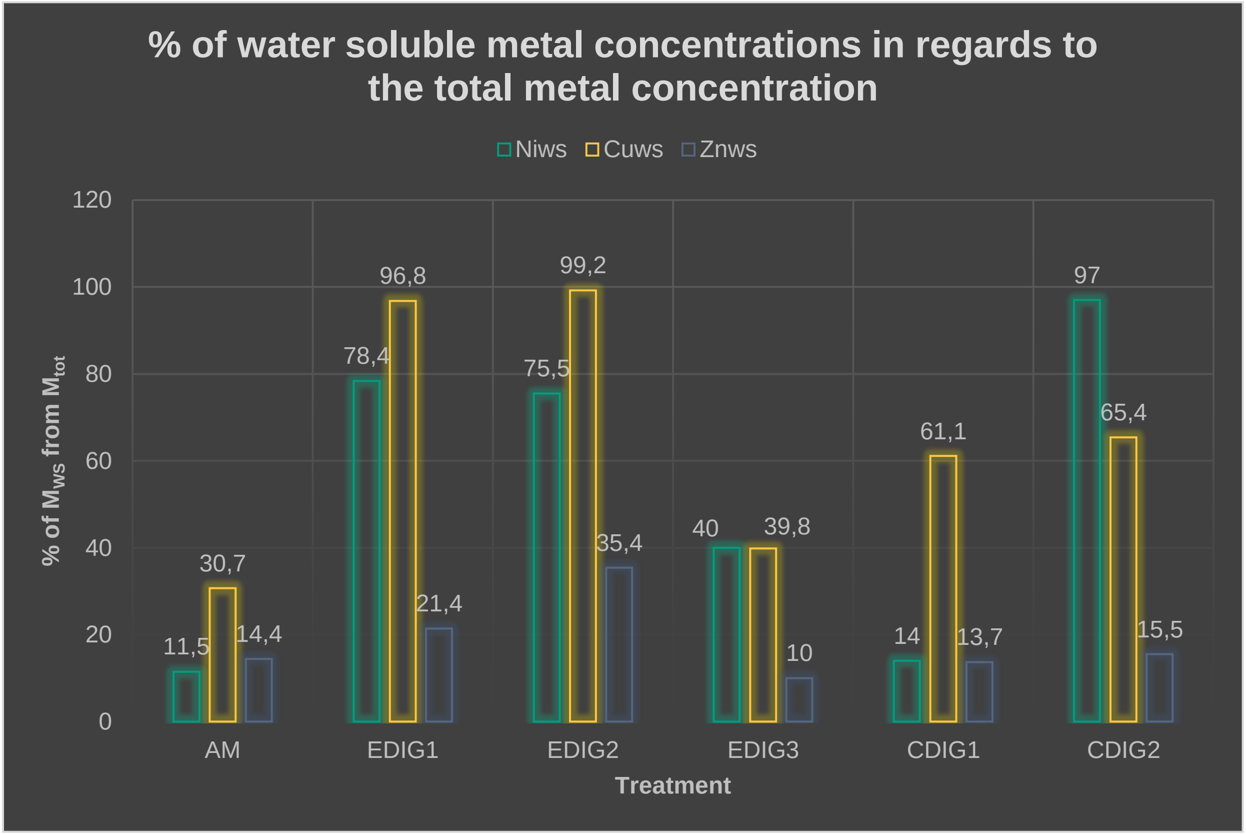
Commercial digestates (CDIG) were produced at two Norwegian biogas companies that are using different mixture of substrates.

- CDIG1 is produced based on pretreated (steam explosion) food waste as substrate,
- CDIG2 is produced using a combination of food waste and sewage sludge (ratio 50:50) as substrate.

1. Soils, biogas digestates and experimental set up

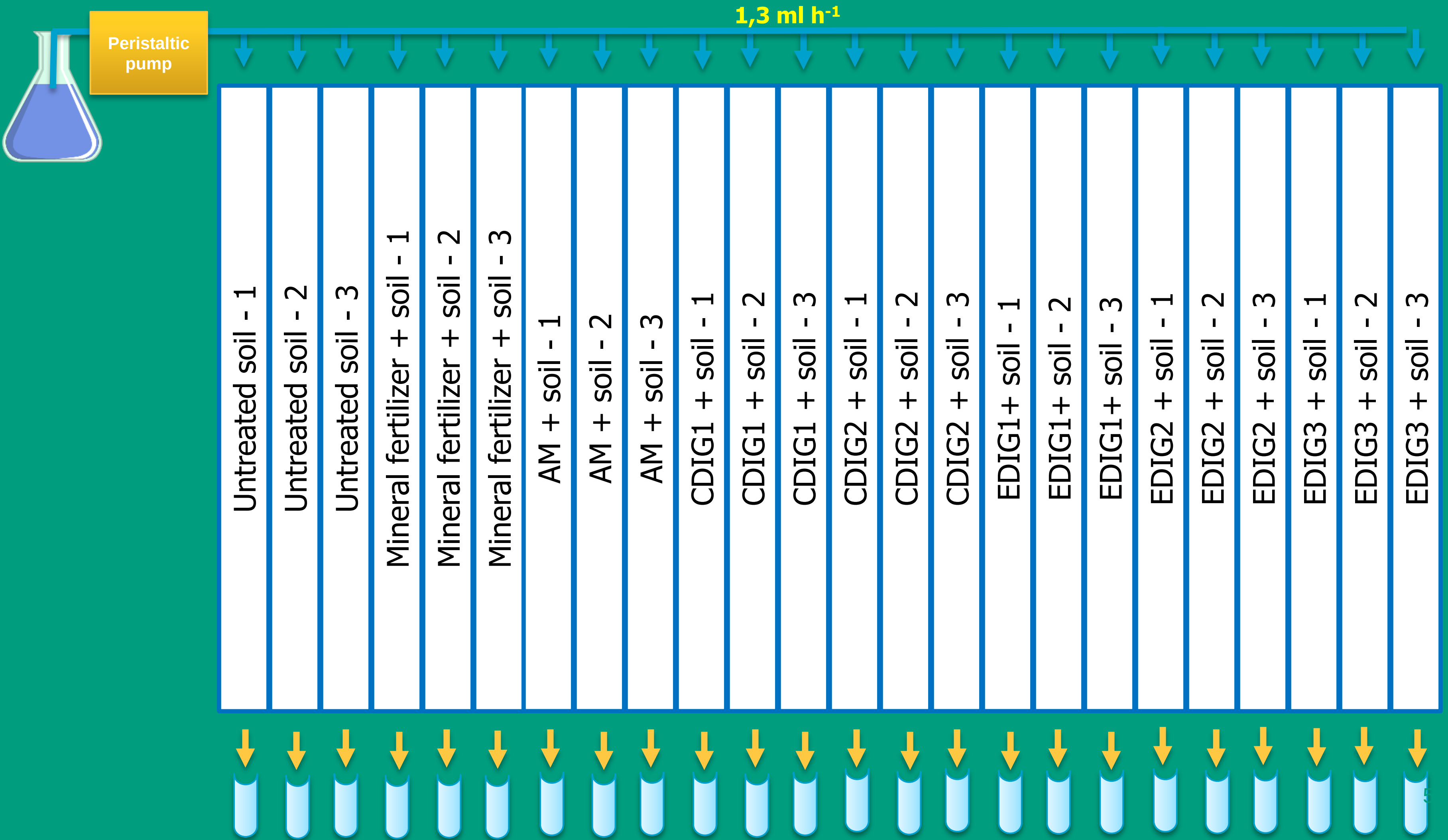
Table 2. Total content of Ni, Cu and Zn (mg kg^{-1} dry matter) in biogas digestates and animal manure.

Treat.	Ni_{tot}	Cu_{tot}	Zn_{tot}
	mg/kg	mg/kg	mg/kg
AM	36.6 ± 3.5	71.3 ± 5.7	163.3 ± 12.0
EDIG1	24.5 ± 0.1	63.5 ± 2.1	320.2 ± 15.0
EDIG2	26.5 ± 0.1	65.5 ± 0.1	305.1 ± 10.0
EDIG3	22.0 ± 1.7	43.5 ± 0.1	215.2 ± 10.0
CDIG1	109.0 ± 11.5	30.6 ± 0.1	146.3 ± 6.1
CDIG2	106.6 ± 5.8	92.3 ± 2.1	256.2 ± 6.0



1. Soils, biogas digestates and experimental set up

Number of columns: 24
Type of soil: sand, silt and loam
Flow rate: 1,3 ml h^{-1}
Sampling dynamics: Every 24 h
Physical-chemical parameters measured:
pH, DOC, Ni, Cu, Zn.

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2. Hypothesis and objectives

- Leaching of Cu, Ni and Zn under high precipitation conditions will increase in the order animal manure - experimental digestates – commercial digestates.

- Leached amounts of Cu, Ni and Zn will not exceed the maximum allowed concentrations given by the regulation for drinking water of the World Health Organization (WHO 2011).

- To investigate the effect of different types of biogas digestates on nickel, copper and zinc leaching under high precipitation conditions for three different soil types.

- To compare the effect of experimental and commercial digestate additions on metal leaching to more common fertilization mineral fertilizer, manure and untreated soils (control).

The amounts added in the different treatments were based on inorganic N content and were equivalent to a dose of 120 kg N/ha, a common amount for cereal production in Norway.

3. Research results - Ni

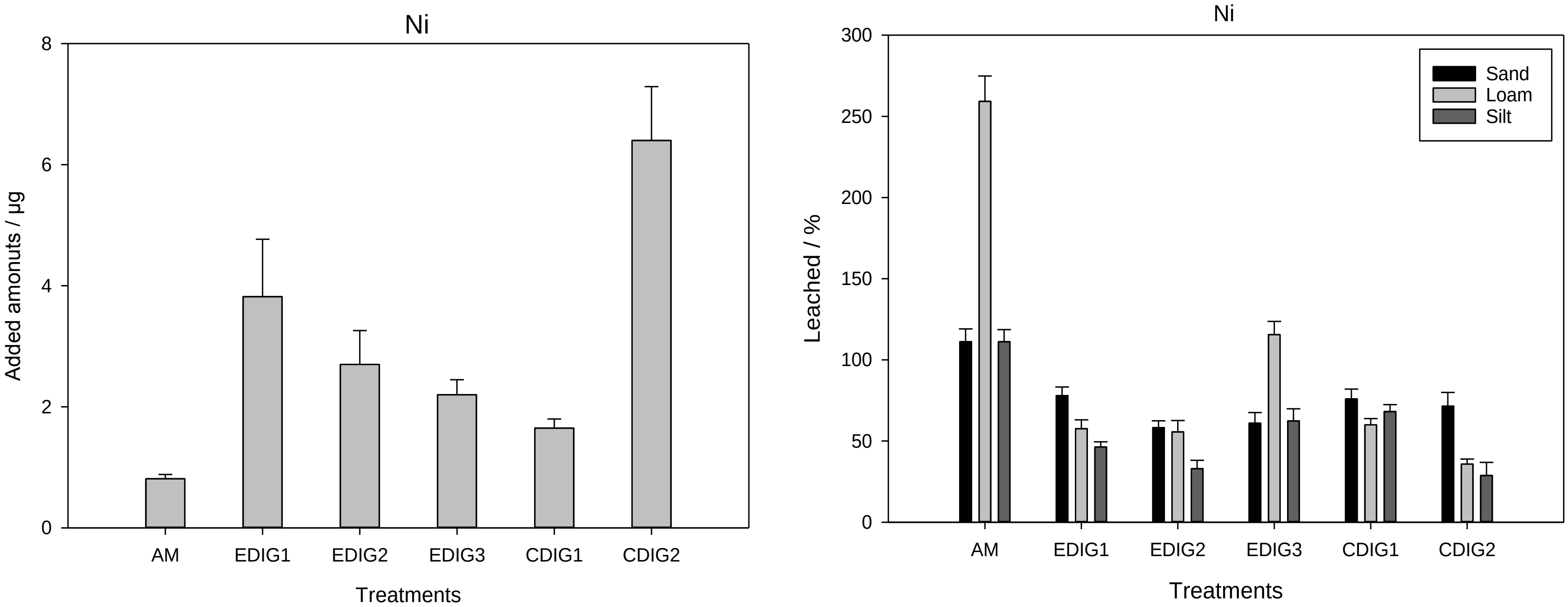


Figure 1. Added amounts of Ni based on water-soluble concentrations and added volumes, and percentage of Ni leached from the different treatments. The leaching values were corrected for the Ni concentrations leached from the control soils (NN).

3. Research results - Ni

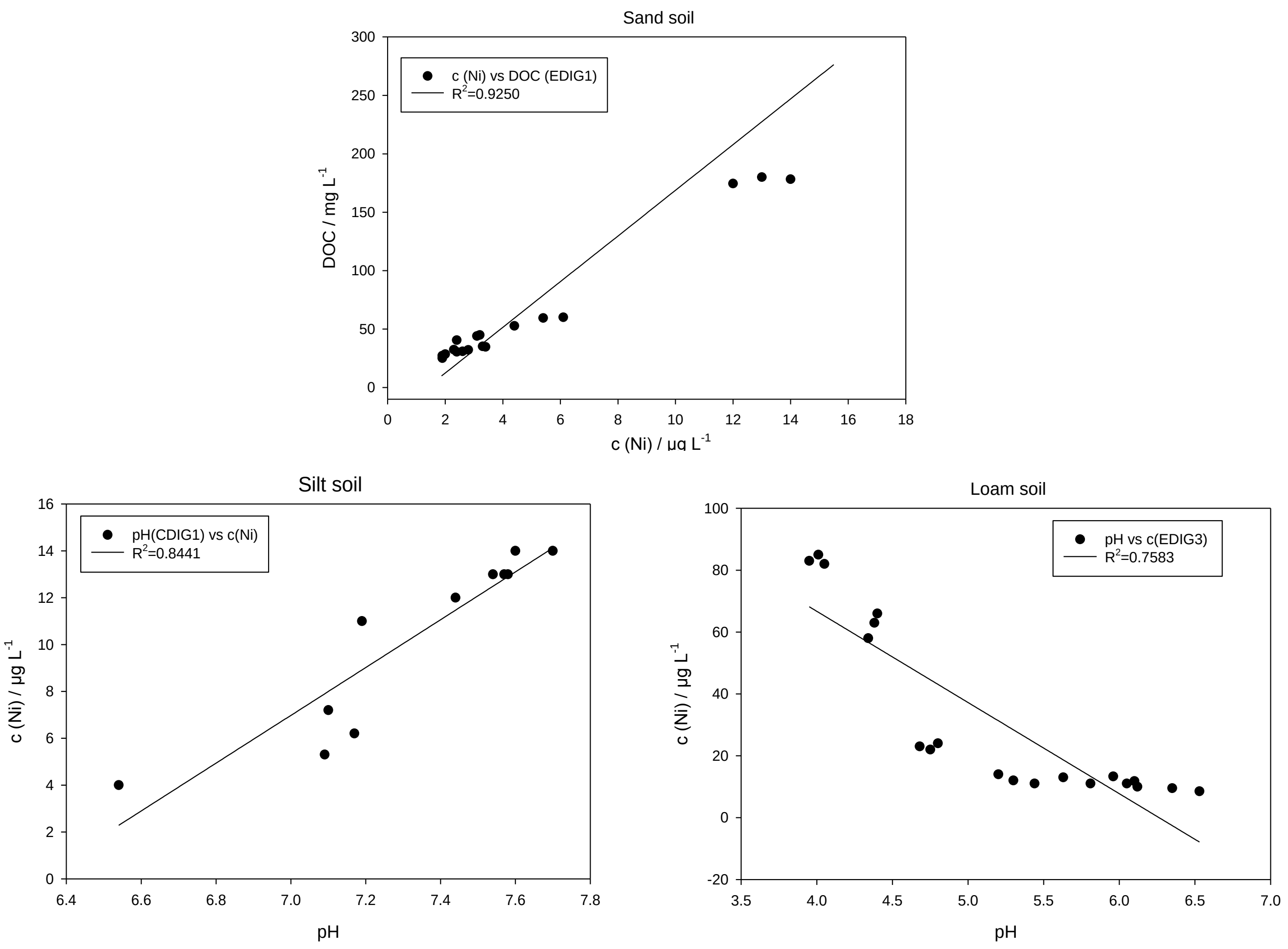
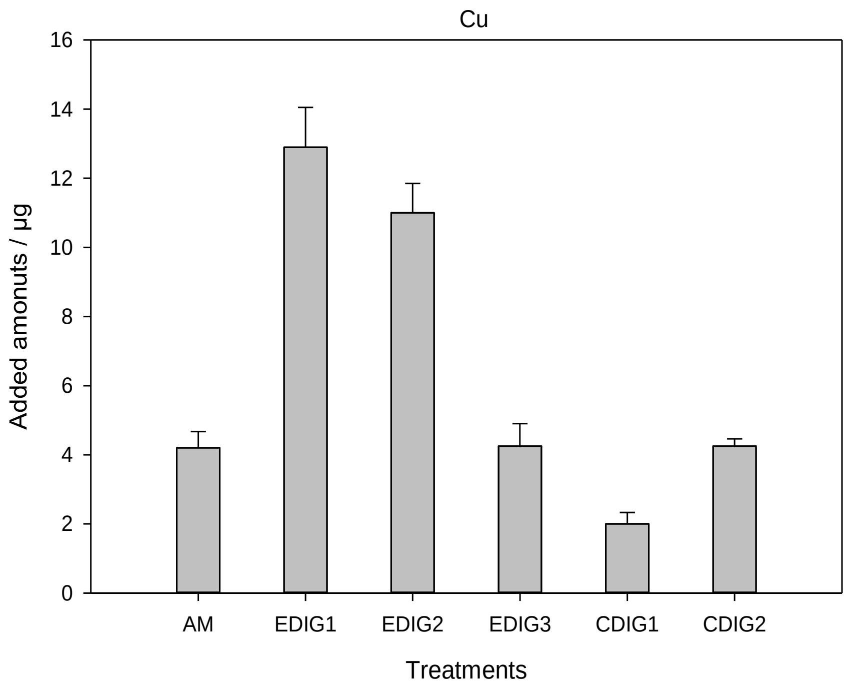


Figure 2. Linear correlations of Ni concentration with DOC (sand) and pH (loam and silt) during the leaching experiment for selected treatments.

3. Research results - Cu



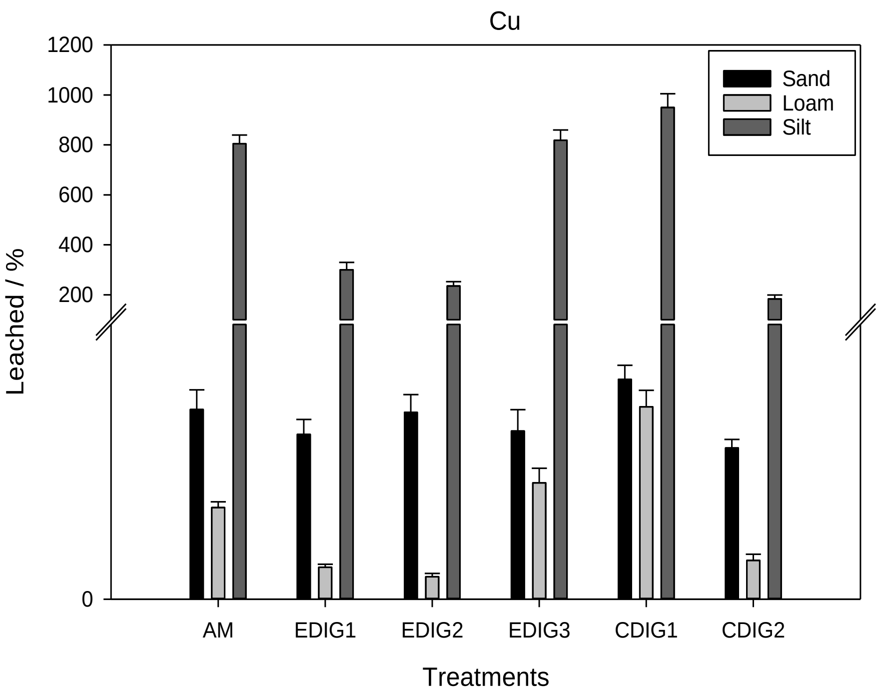


Figure 3. Added amounts of Cu and percentage of Cu leached from the soil columns (figure break set on 100%). The leaching values were corrected for the Cu concentrations leached from control soils (NN).

3. Research results - Cu

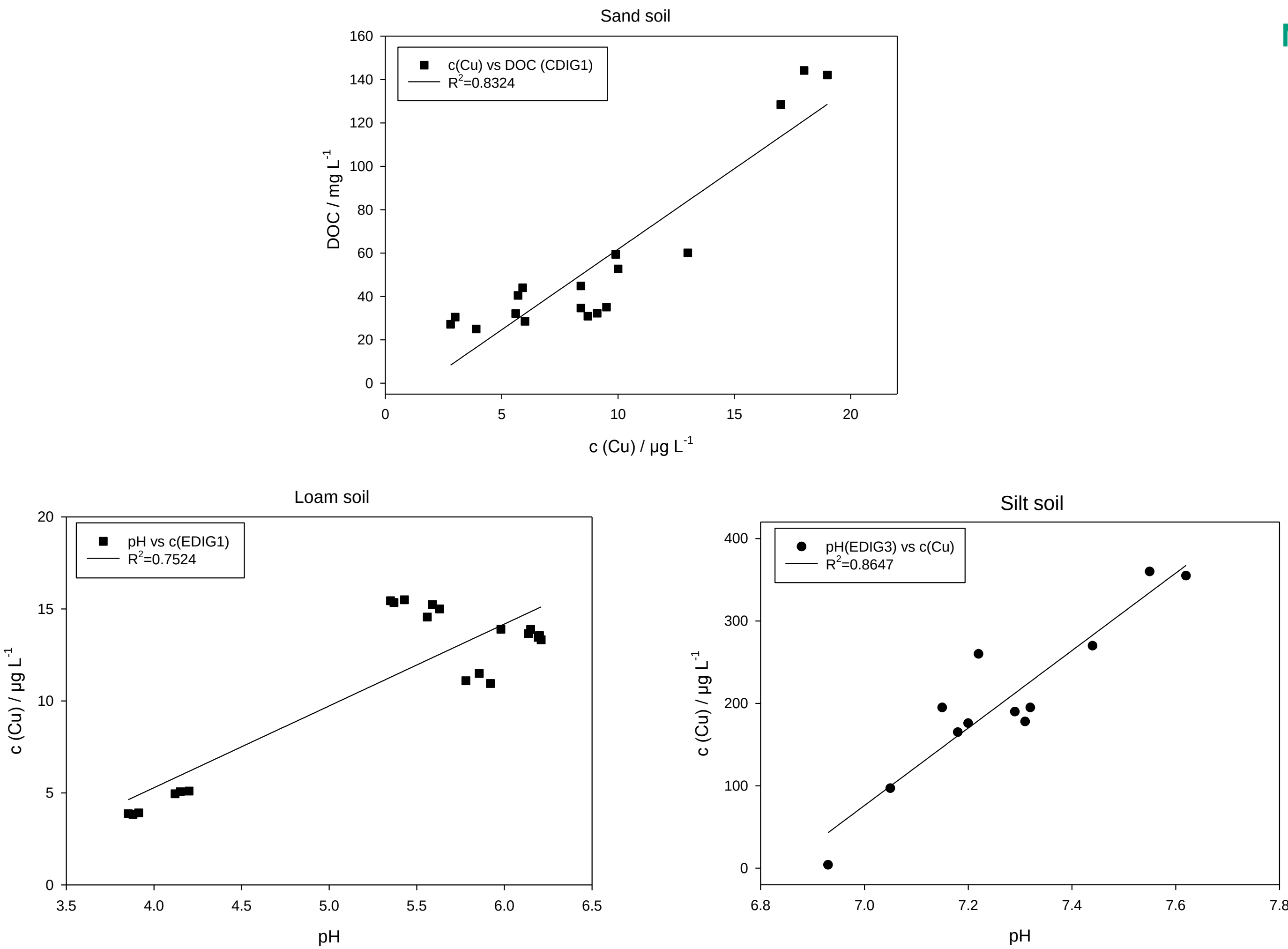


Figure 4. Linear correlations of Cu concentration with DOC (sand) and pH (loam and silt) during the leaching experiment for selected treatments.

3. Research results - Zn

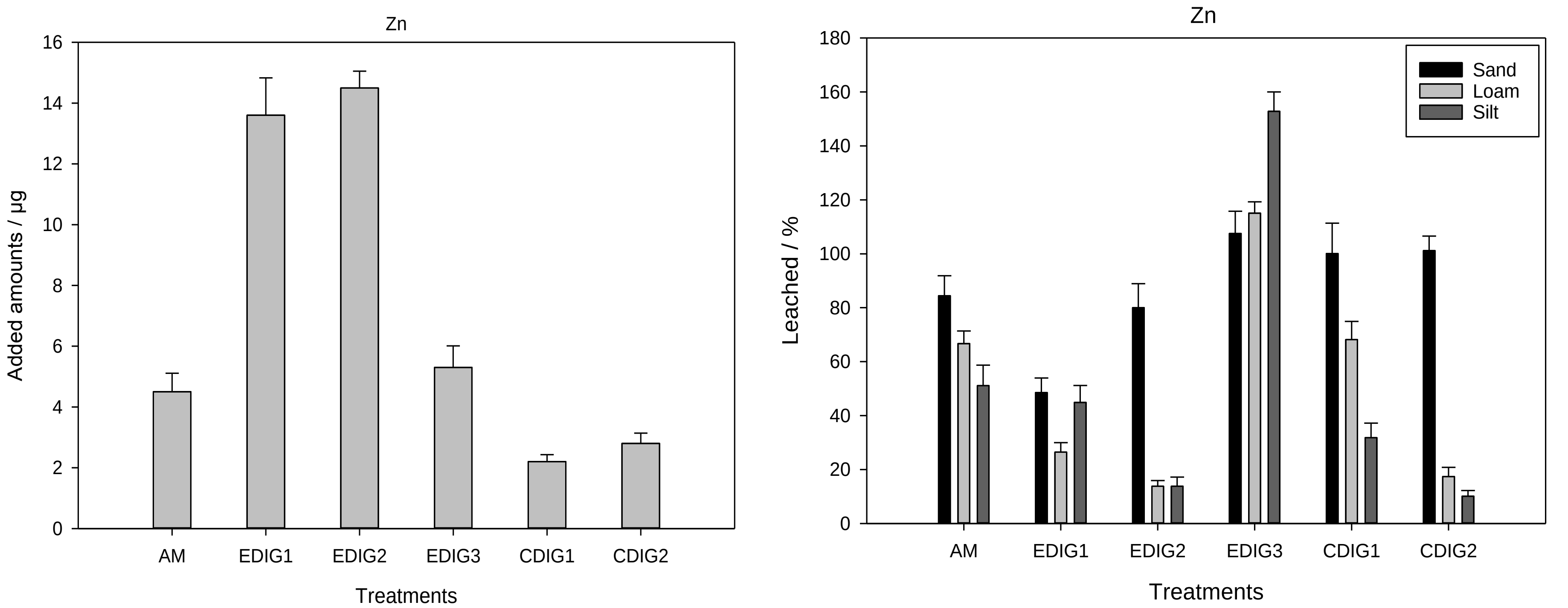


Figure 5. Added amounts of Zn based on water-soluble concentrations and applied volumes, and percentage of Zn leached from the soil columns in the different treatments. The leaching values were corrected for the Zn concentrations leached from control soils (NN).

3. Research results - Zn

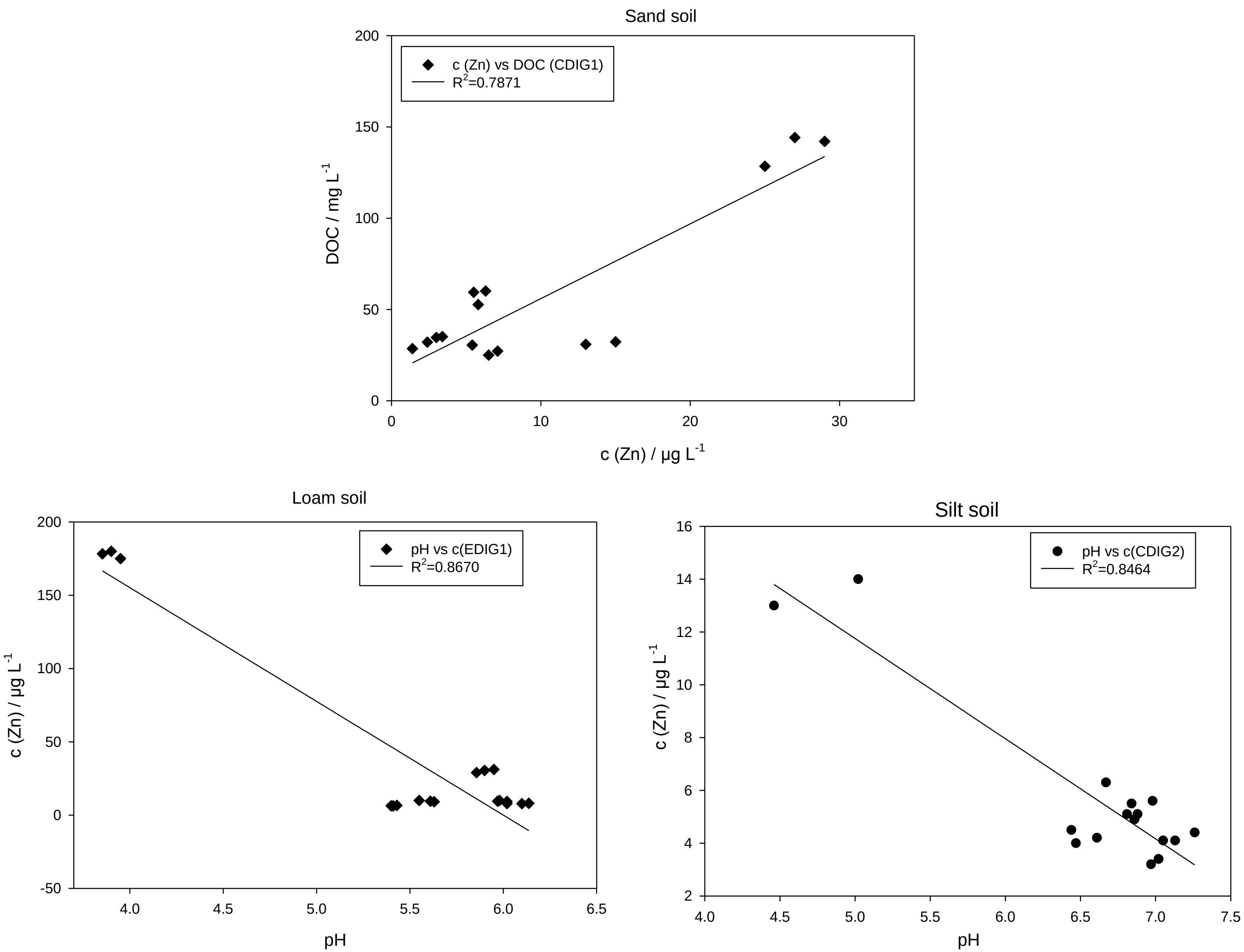


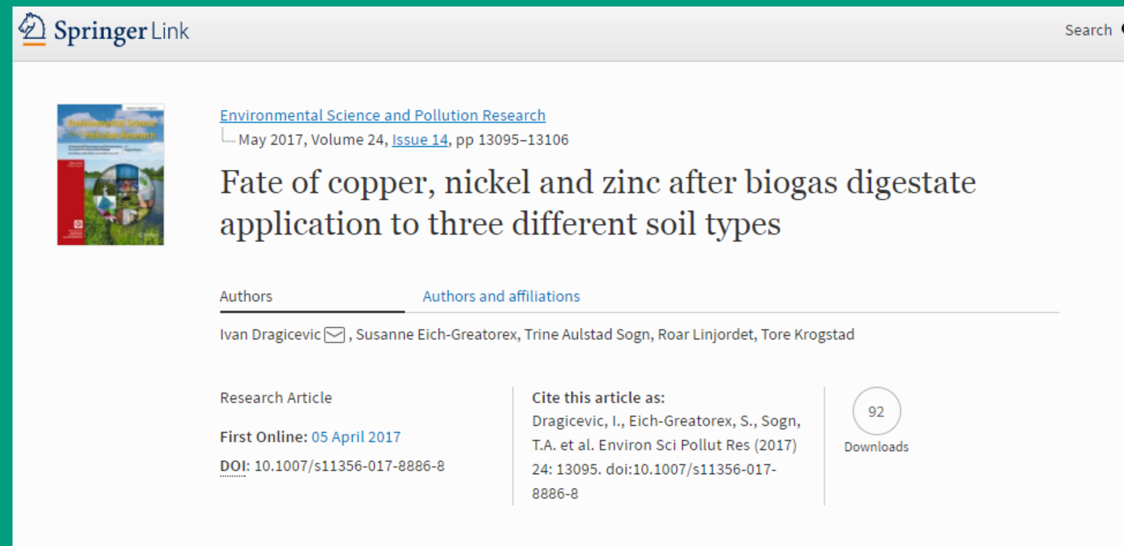
Figure 6. Linear correlations of Zn concentration with DOC (sand) and pH (loam and silt) during the leaching experiment for selected treatments.

3. Conclusions

- High concentration of DOC in soils amended with digestates and its potential to increase Cu, Ni and Zn leaching has not been fully confirmed.
- Animal manure has showed increase in leached Ni when relative to added amounts.
- Both digestate and animal manure derived Cu was readily leached from sand, but not form loam. Still, in silt soil the leaching of Cu was over the added amounts, increasing the mobility of naturally present Cu in soil.
- The Zn leaching was lowest for commercial digestates and highest for experimental digestates, generally showing a high retention rate especially in loam and silt soils.
- The concentration of Cu, Ni and Zn from soils amended with digestates did not exceed values given by Regulation for drinking water of the WHO (WHO 2011).

Thank you for your attention!

Your comments are welcome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Environmental Science and Pollution Research
May 2017, Volume 24, Issue 14, pp 13095–13106

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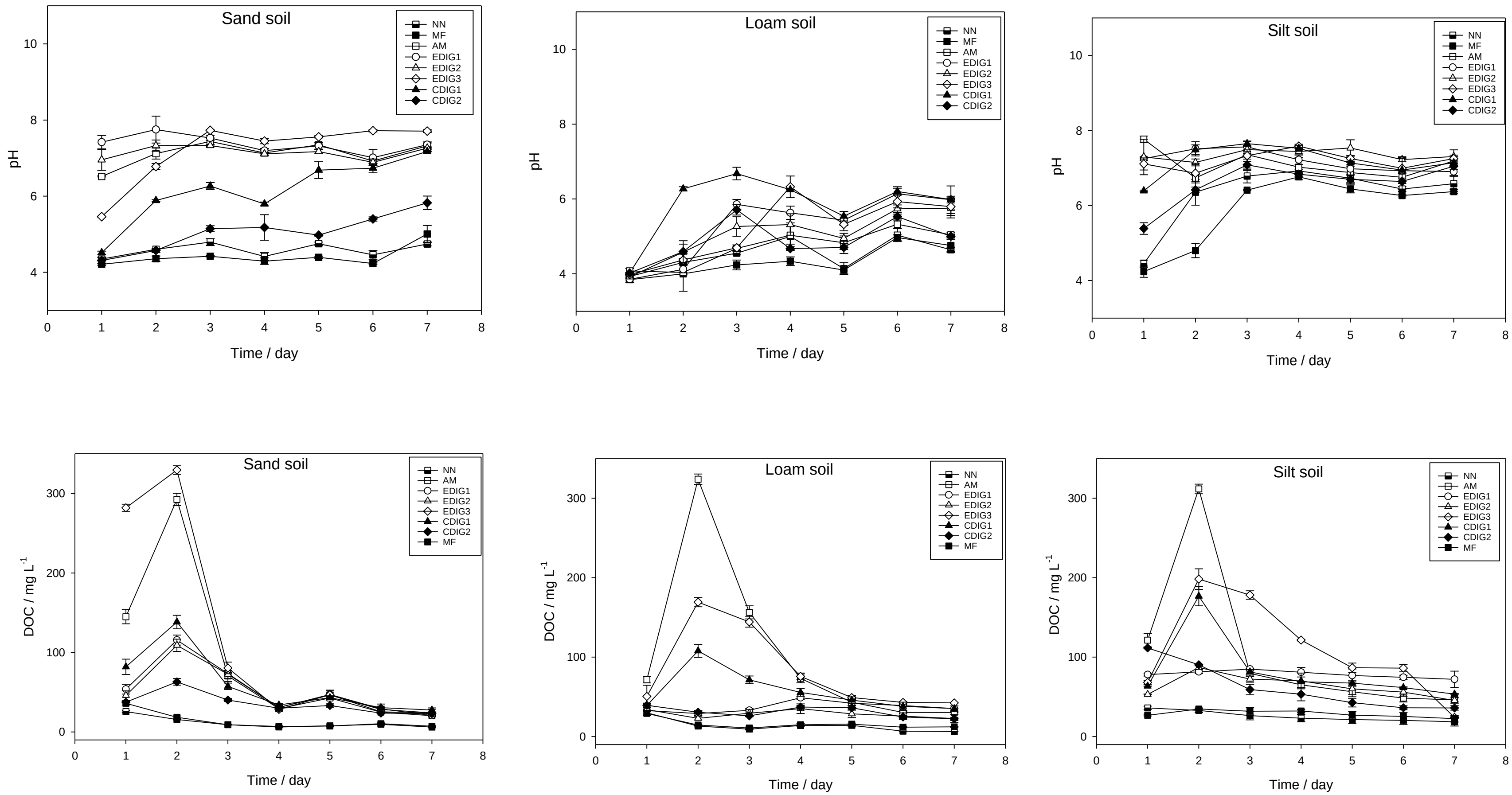
Research Article

First Online: 05 April 2017
DOI: 10.1007/s11356-017-8886-8

Cite this article as:
Dragicevic, I., Eich-Greatorex, S., Sogn, T.A. et al. Environ Sci Pollut Res (2017) 24: 13095. doi:10.1007/s11356-017-8886-8


Sand soil
Loam soil
Silt soil
pH
DOC / mg L^{-1}
Time / day
NN
MF
AM
EDIG1
EDIG2
EDIG3
CDIG1
CDIG2