UNIVERSITAT DE BARCELONA

Leachates from Mediterranean forest soils amended with biosolids

Montse Toribio & Joan Romanyà

Dept. Natural Products, Plant Biology and Soil Sceince

Universitat de Barcelona

Context

In dry and semiarid Mediterranean conditions forest soils often show erosion signs that may be related, to some extend, to low organic matter levels at the soil surface.

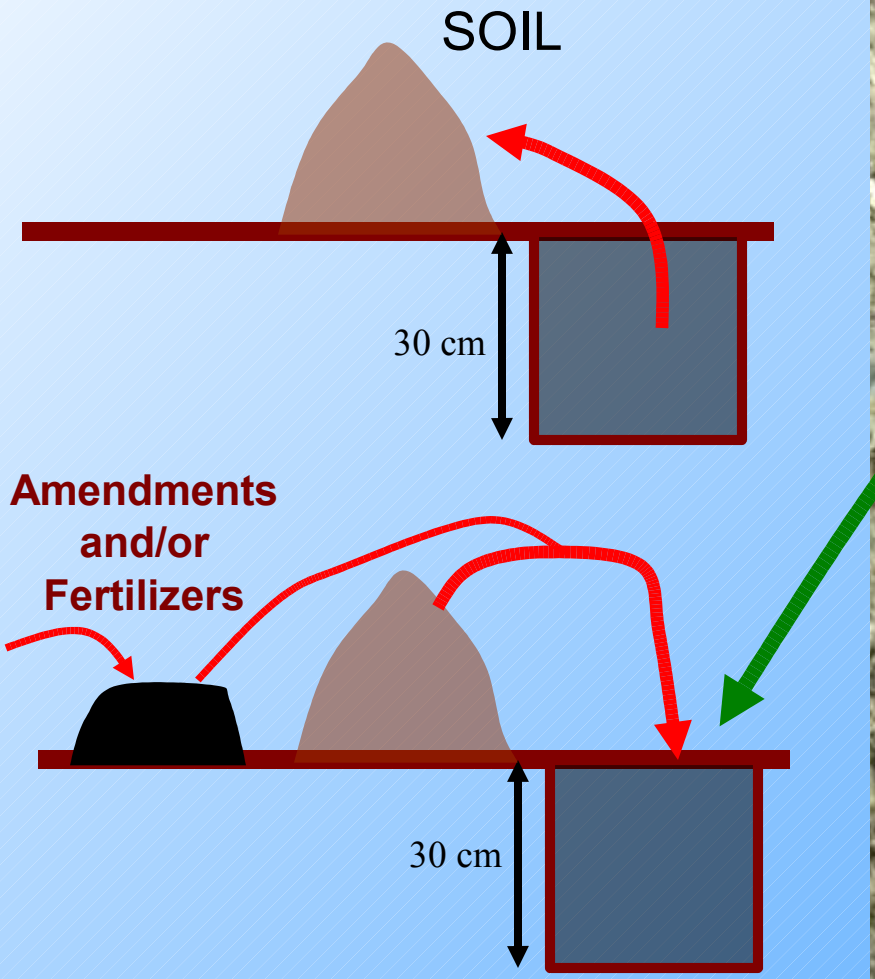
P:250-700 mm
PET: 800-1000 mm

The status of degradation of these soils often limit plant growth and regeneration, especially after perturbations such as fire.

FIRES IMPACTS ADD TO PAST LAND DEGRADATION

RESTORING MATURE VEGETATION USING NATIVE SPECIES

REFORESTATION METHODS: THE PLANTING OF SEEDLINGS



Justification and aims

• In degraded areas the use of high organic matter content residues may be considered as a means to enhance nutrient cycling and the general functioning of soils, and especially to help the establishment of new seedlings.

• In the Mediterranean area forest soils are mostly basic with its consequent low general heavy metal mobility and low P availability.

• However the application of biosolids always pose a risk to the environment that must be quantified in order to decide on the applicability of biosolids to forest soils.

In this work, by means of a laboratory incubation, we have focused on the study of the leachates after a biosolid application for reforestation purposes under dry and semiarid Mediterranean conditions.

Soil selection and characterisation

Limestone

Marl

Sandstone

	Limestone	Marl	Sandstone
Clay (%)	43.5	19.6	16.5
OC (%)	2.45	2.78	0.43
pH	8.4	8.4	5.9
$CaCO_3$ (%)	15.5	50.9	0.0
	Basic clay	*Basic loam*	*Acid loam*

Biosolid selection

	Biosolids	Metal enriched biosolids
pH	**7.37**	**7.37**
OC (%)	**20.3**	**20.3**
N (%)	**2**	**2**
P (mg/kg)	**6848.8**	**6092.8**
Cu (mg/kg)	**101.54**	**2098.10**
Ni (mg/kg)	**15.58**	**665.78**
Zn (mg/kg)	**395.07**	**5376.78**

Experimental design (lab incubation)

3 soils (basic clay, basic loam and acid loam),

x

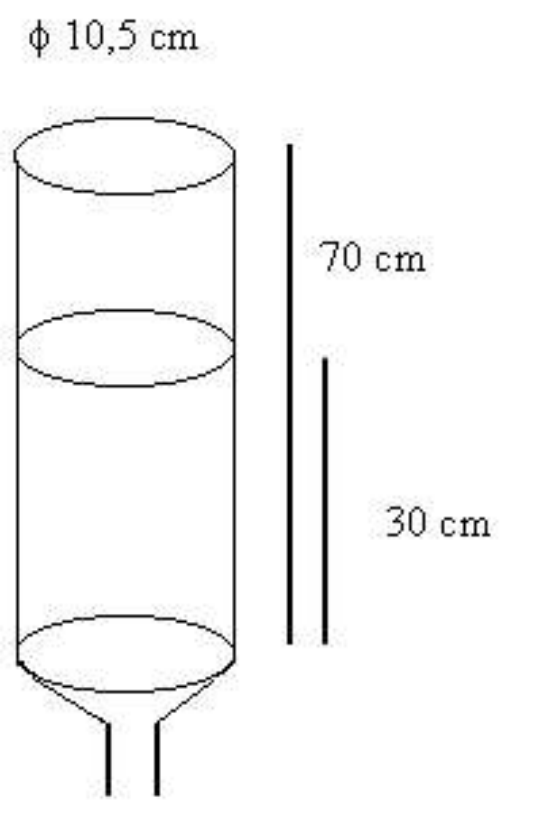
2 biosolids (bisolid and metal enriched biosolid)

Basic clay	Control	Biosolid	Biosolid enriched
Basic loam	Control	Biosolid	Biosolid enriched
Acid loam	Control	Biosolid	Biosolid enriched

5 replicates → 45 columns

Factor biosolid Factor metal (no interation)	Factor soil

Construction of columns



The rate of biosolids added amounted 60 Mg d.w. / ha for each soil.

The amount of soil or soil + biosolid mixture was calculated considering soil volume and bulk density

Soils were incubated for 16 weeks

Irrigation was maximised in order to maximise the leachates and amounted 1150 mm for the whole studied period.

We have measured in the leachates:

	Used method
Total Zn, Cu and Ni	(ICP)
OC	(Walkey Black)
Index of aromacity (Є 254)	
E_{465}/E_{665}	
NO_3^-	(Brucine method)
Total soluble P	(ICP)
pH	
E.C.	
Eh	

always above 400 mV

Soils characteristics at time zero

Basic clay

	pH (H_2O)	% CO	Cu	Ni	Zn
Control	8,36 a	2,36 a	15,01a	30,20 a	55,19 a
Biosolids	8,21 b	2,59 b	16,02 a	31,31 a	58,36 b
Enrich. Bio.	8,06 c	2,70 b	45,55 b	38,08 b	123,57 c

Acid loam

	pH (H_2O)	% CO	Cu	Ni	Zn
Control	5,94 a	0,43 a	2,42 a	16,32 a	7,99 a
Biosolids	6,48 b	0,60 b	12,95 a	17,47 a	15,30 b
Enrich. Bio.	5,95 a	0,57 b	26,69 b	19,19 b	61,59 c

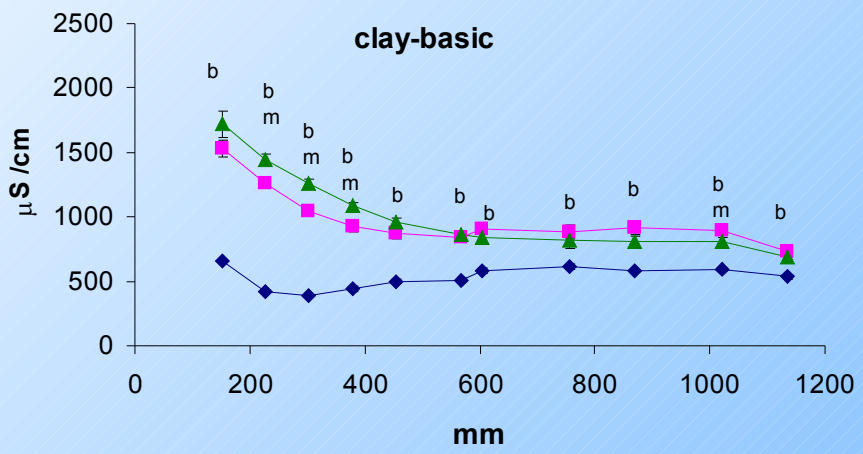
Basic loam

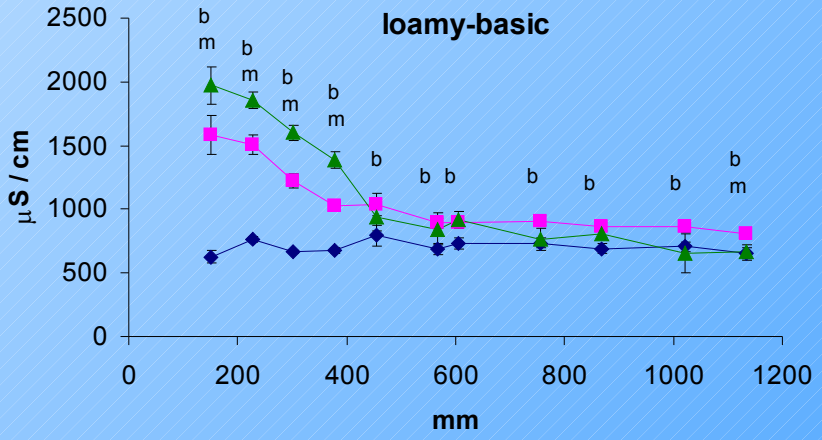
	pH (H_2O)	% CO	Cu	Ni	Zn
Control	8,41 a	2,78 a	1,64 a	7,13 a	14,12 a
Biosolids	8,18 b	3,20 b	3,25 a	6,48 a	17,68 a
Enrich. Bio.	8,17 b	3,00 b	24,15 b	12,39 b	66,11 b

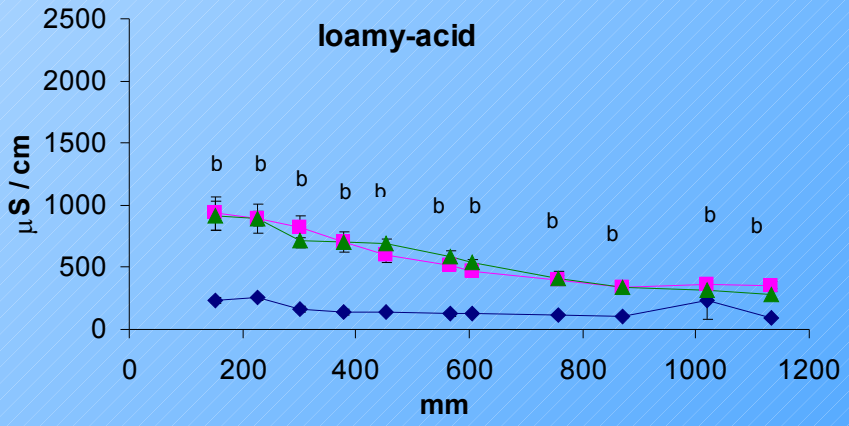
Biosolid

	pH (H_2O)	% CO	Cu	Ni	Zn
Biosolid	7,37	20,30 a	101,00 a	15,58 a	395,00 a
Enrich. bio.	—	20,26 a	2098,10 b	665,79 b	5376,78 b

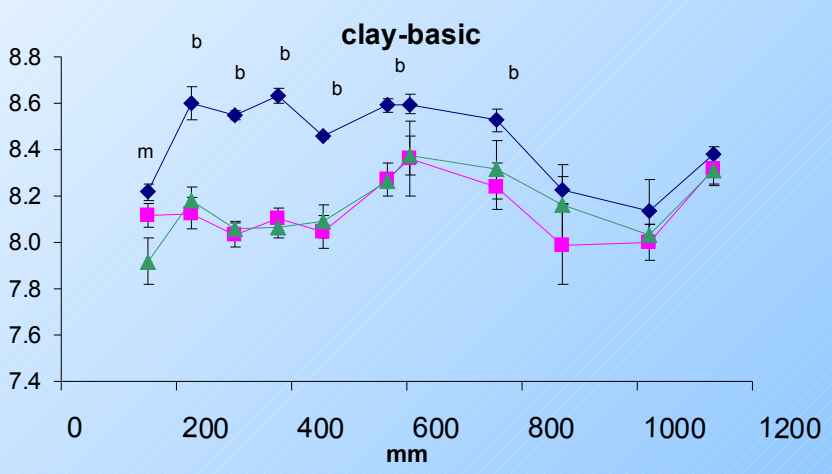
Electrical Conductivity

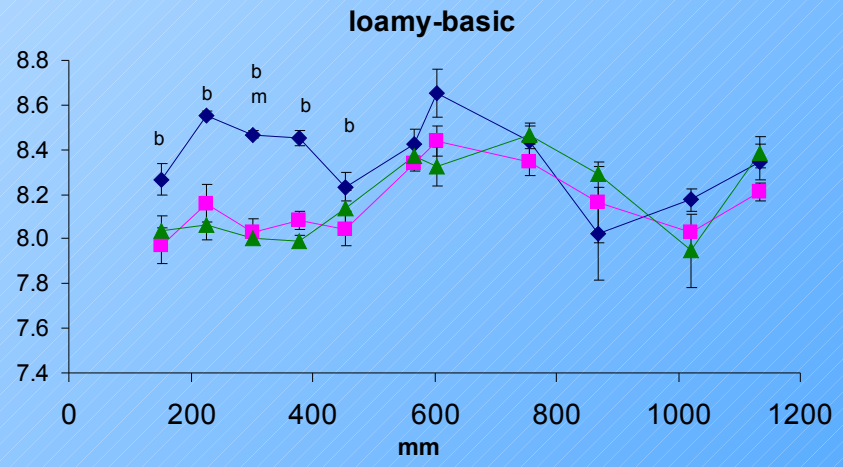


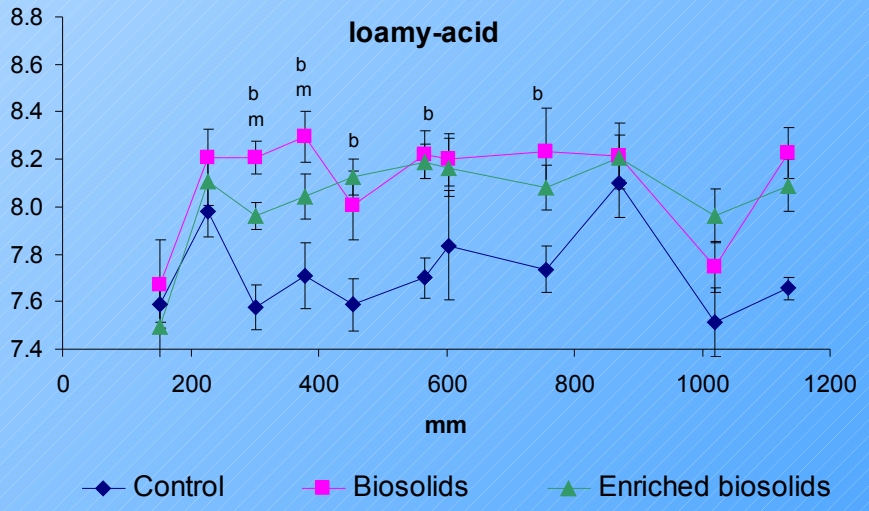




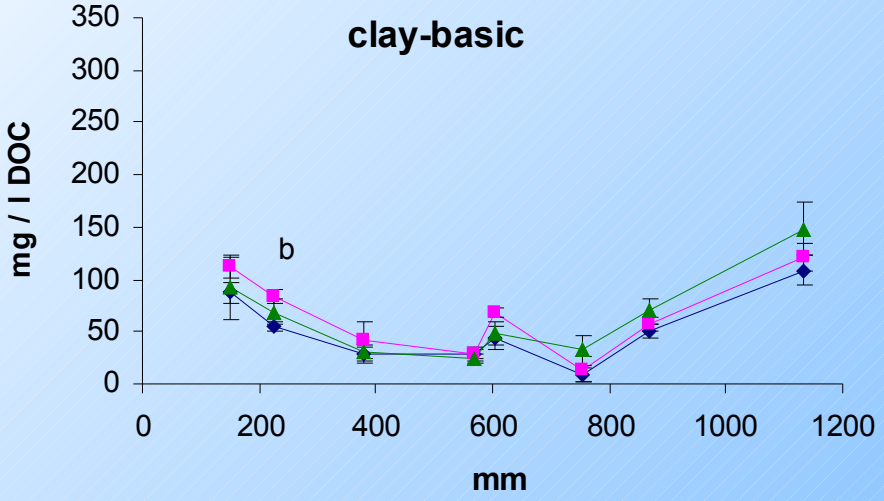
pH

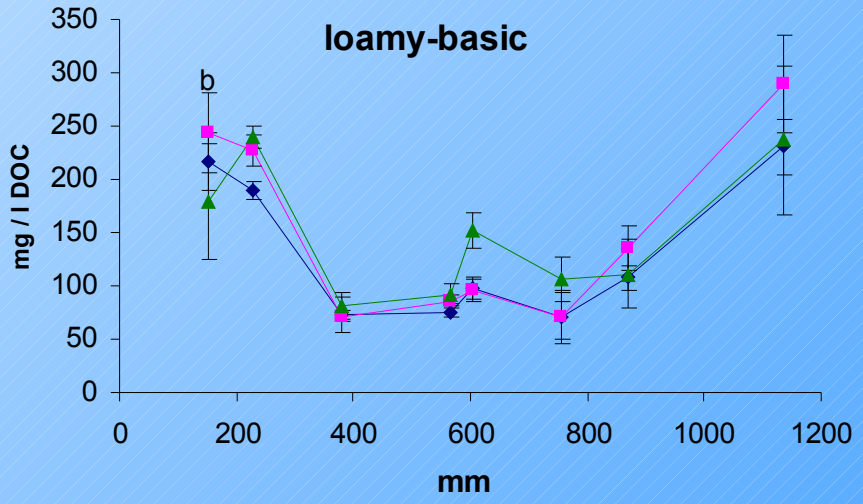

clay-basic
8.8
8.6
8.4
8.2
8.0
7.8
7.6
7.4
0
200
400
600
800
1000
1200
mm
m
b

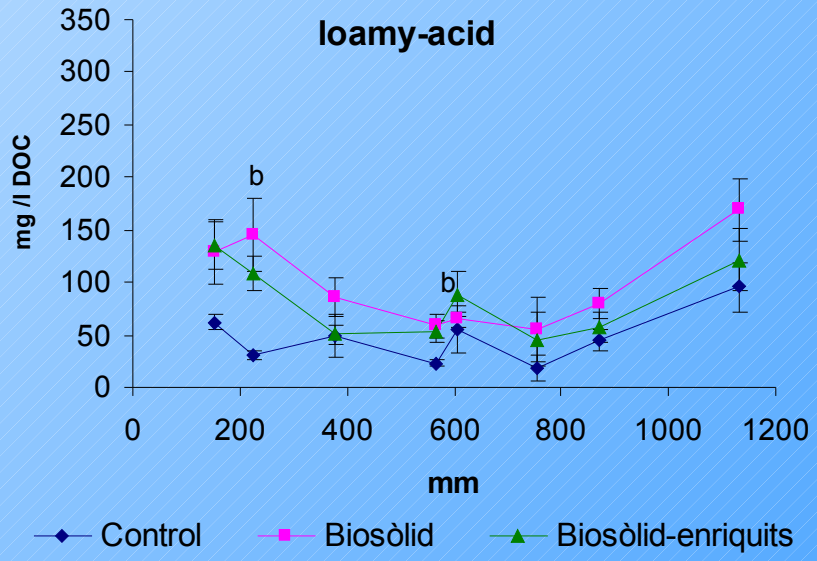

loamy-basic
8.8
8.6
8.4
8.2
8.0
7.8
7.6
7.4
0
200
400
600
800
1000
1200
mm
b
m


loamy-acid
8.8
8.6
8.4
8.2
8.0
7.8
7.6
7.4
0
200
400
600
800
1000
1200
mm
b
m
Control
Biosolids
Enriched biosolids

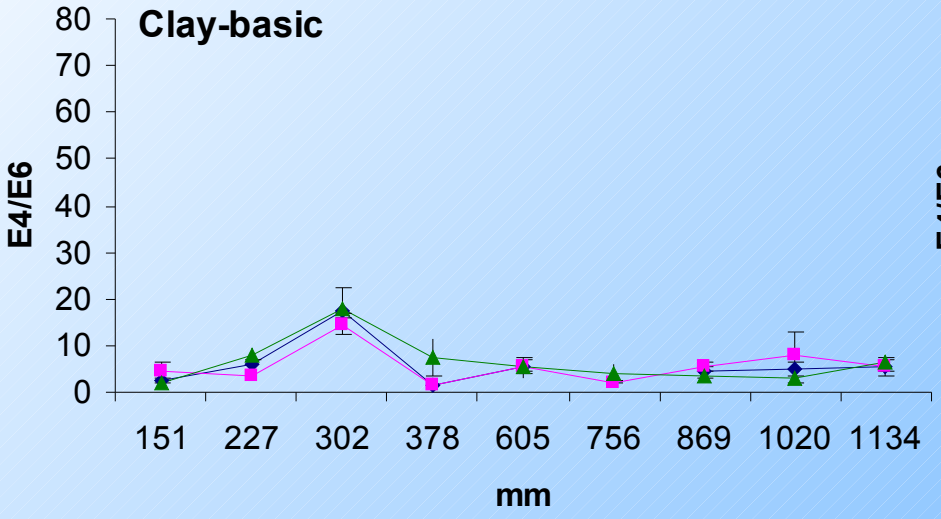
DOC

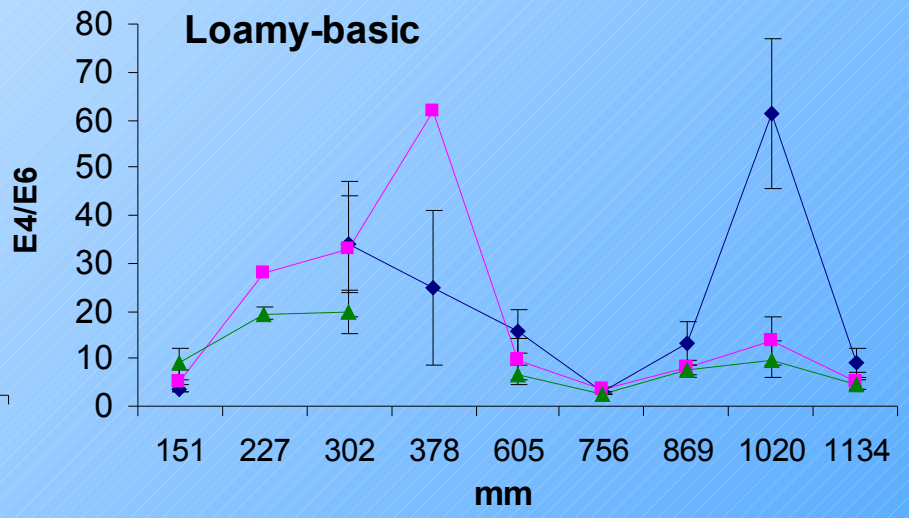

clay-basic
mg / l DOC
350
300
250
200
150
100
50
0
0
200
400
600
800
1000
1200
mm
b

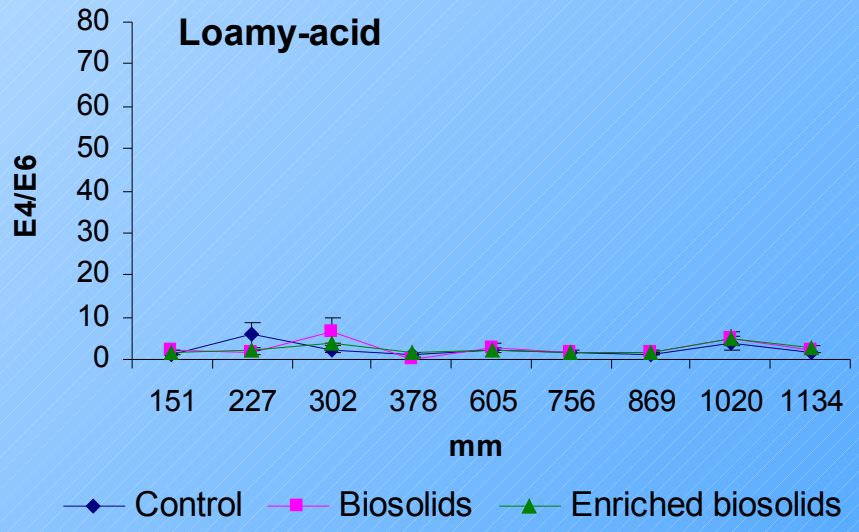

loamy-basic
mg / l DOC
350
300
250
200
150
100
50
0
0
200
400
600
800
1000
1200
mm
b


loamy-acid
mg /l DOC
350
300
250
200
150
100
50
0
0
200
400
600
800
1000
1200
mm
b
b
Control
Biosòlid
Biosòlid-enriquits

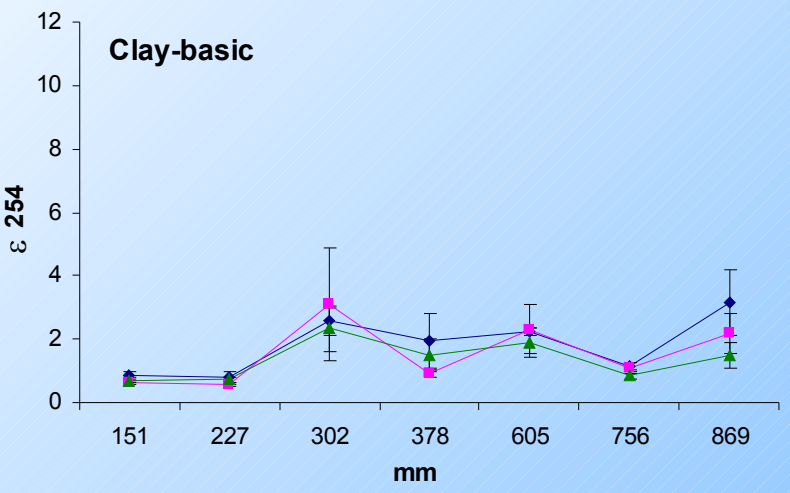
E465/E665

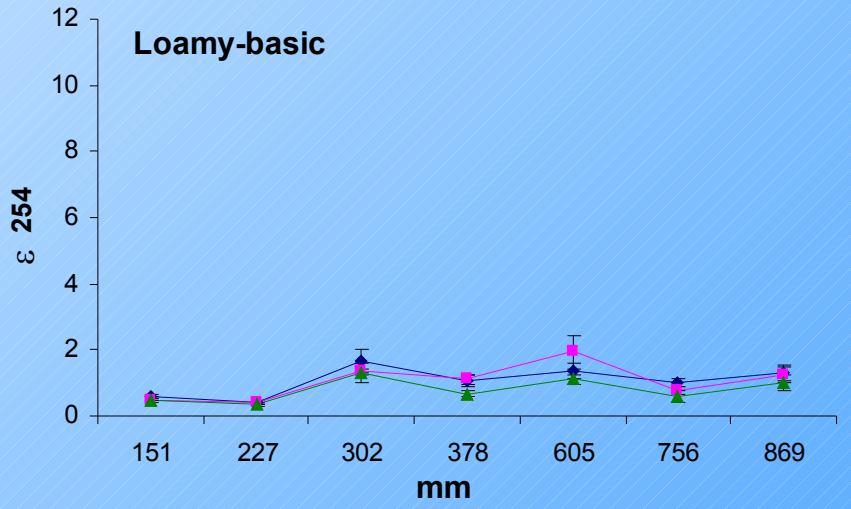

Clay-basic
E4/E6
80
70
60
50
40
30
20
10
0
151
227
302
378
605
756
869
1020
1134
mm

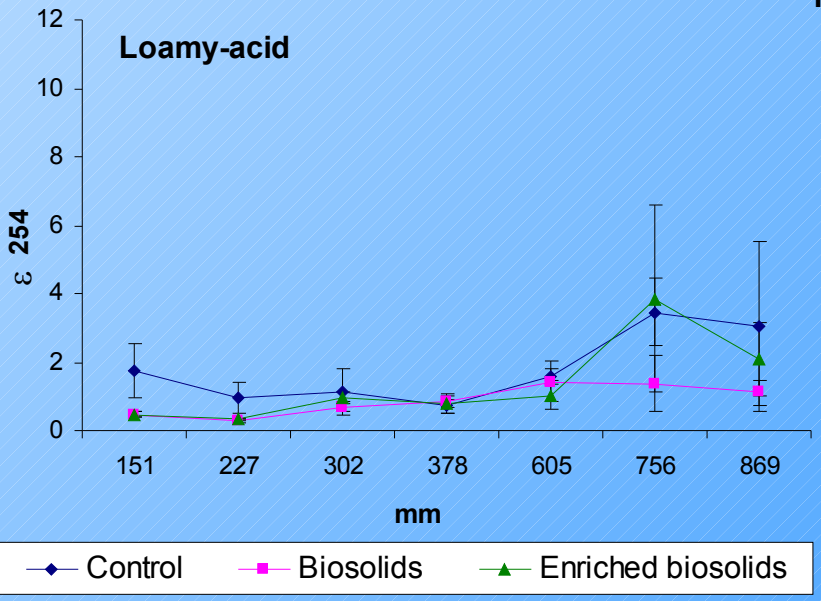

Loamy-basic
E4/E6
80
70
60
50
40
30
20
10
0
151
227
302
378
605
756
869
1020
1134
mm


Loamy-acid
E4/E6
80
70
60
50
40
30
20
10
0
151
227
302
378
605
756
869
1020
1134
mm
Control
Biosolids
Enriched biosolids

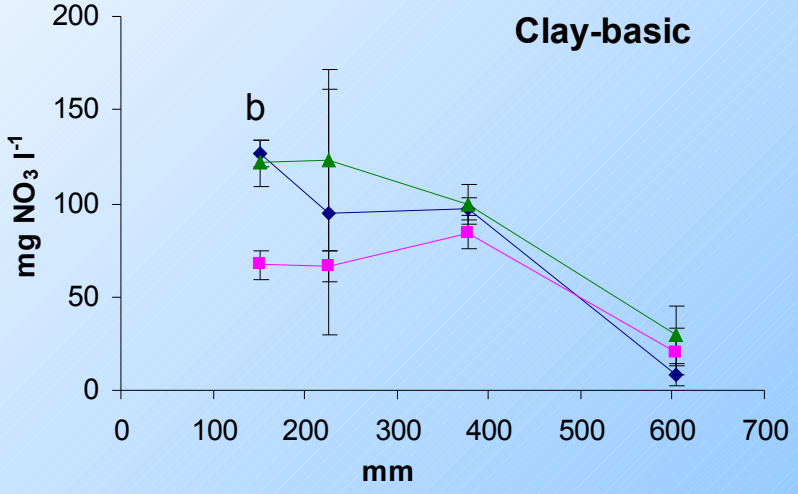
Index of aromacity (E254)

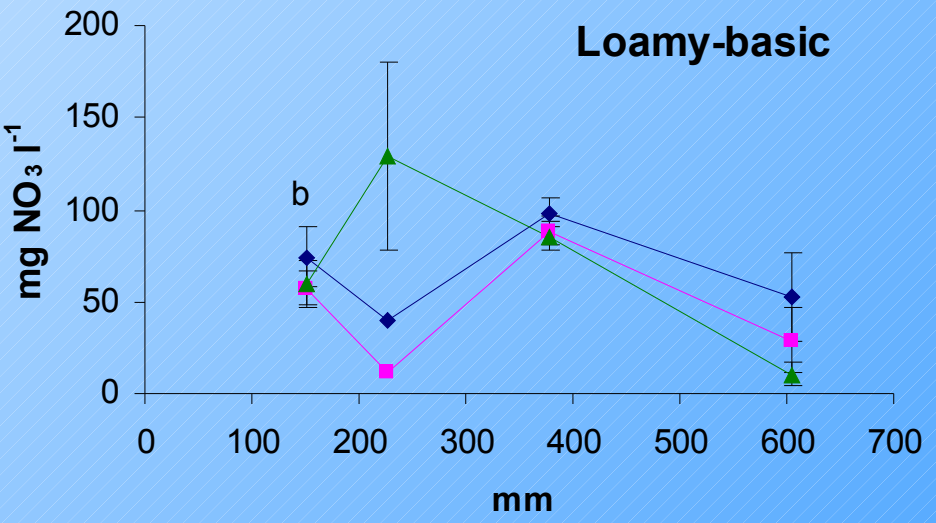


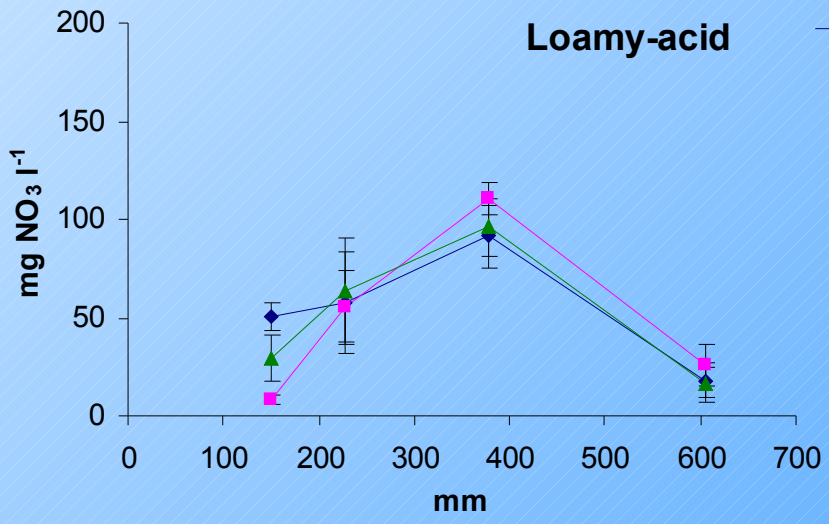




Nitrates

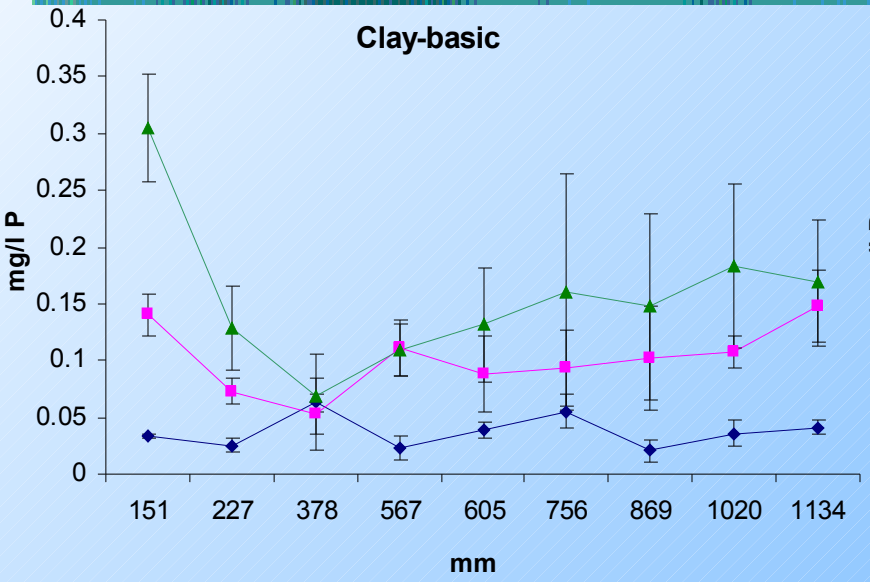


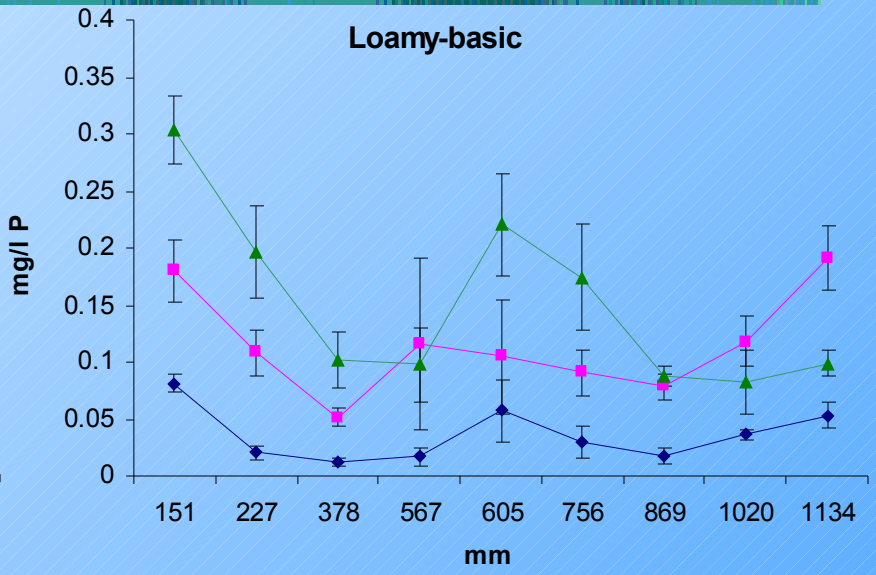


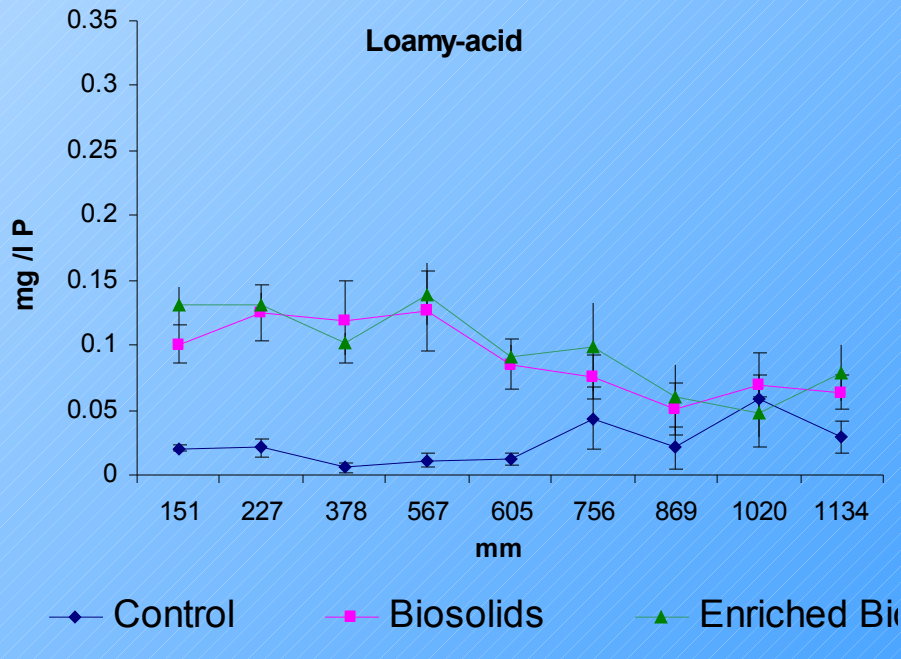


Control Biosolids Enriched biosolids

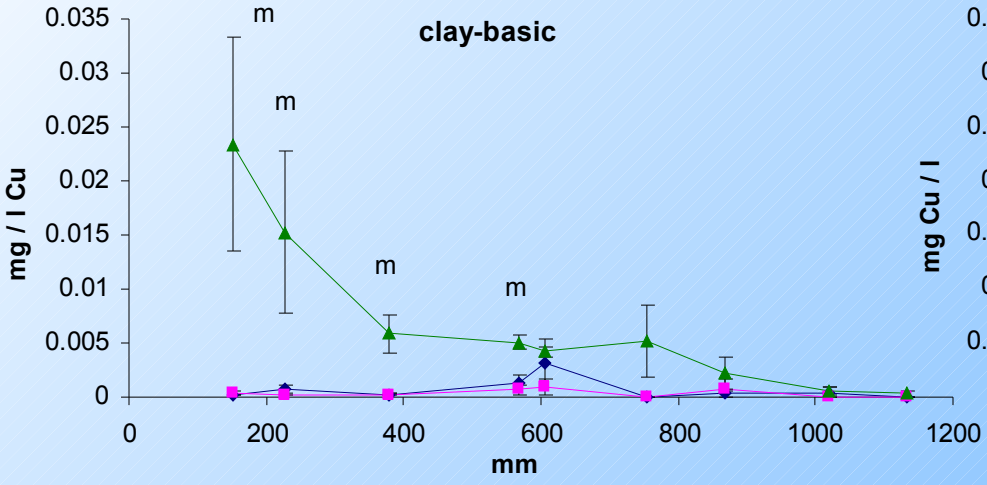
Total soluble P

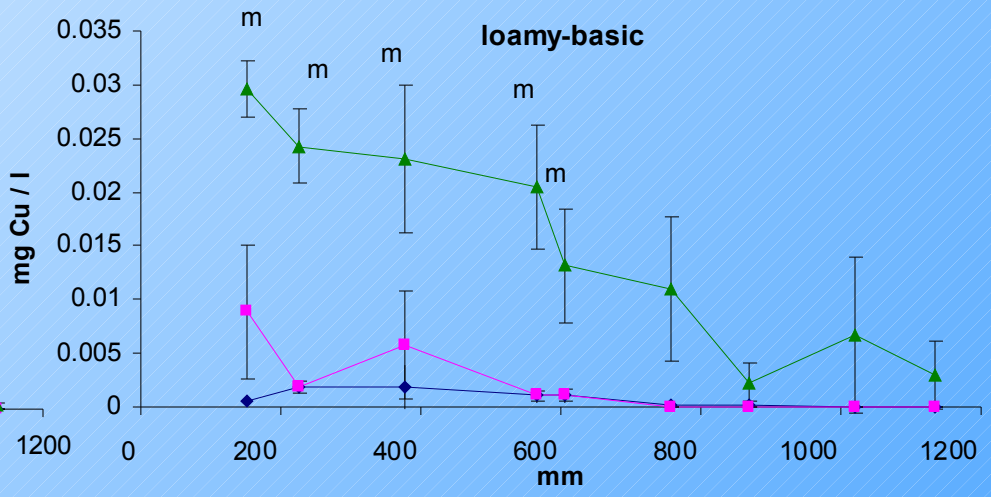


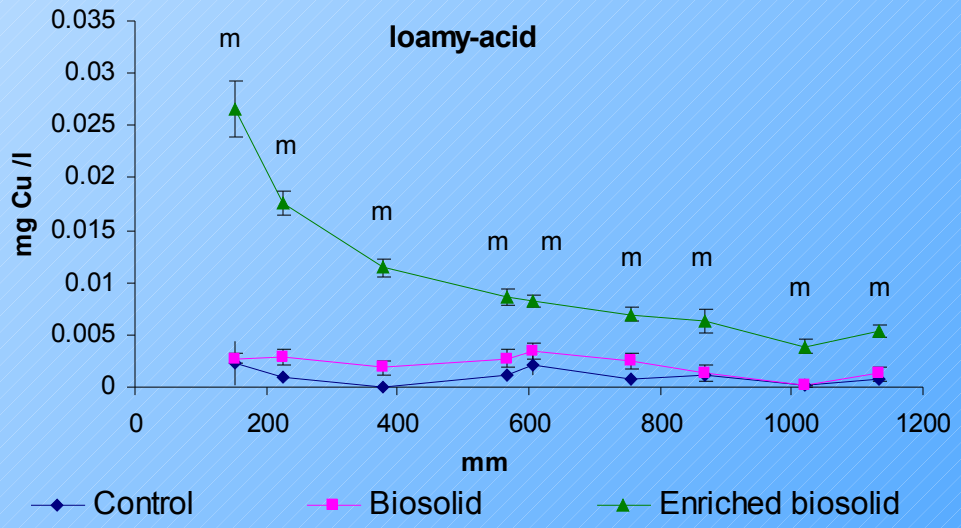




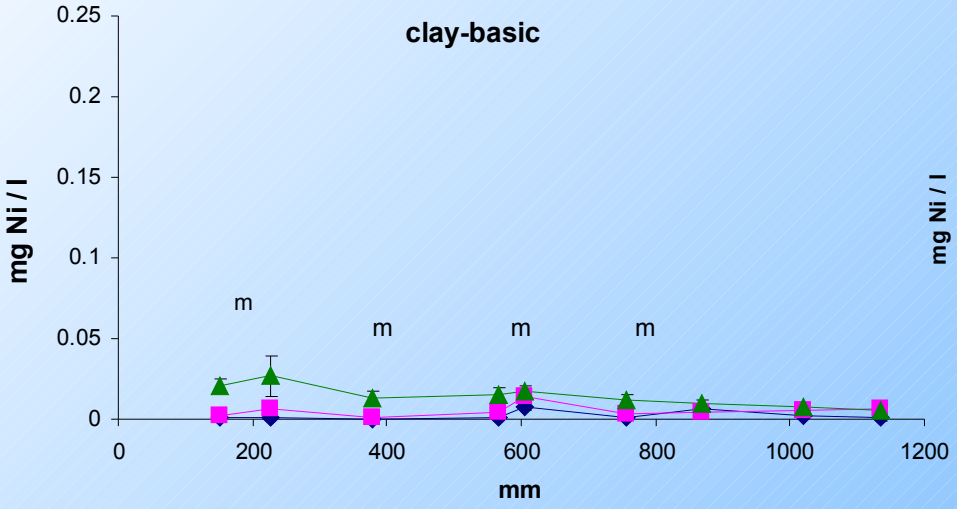
Cu

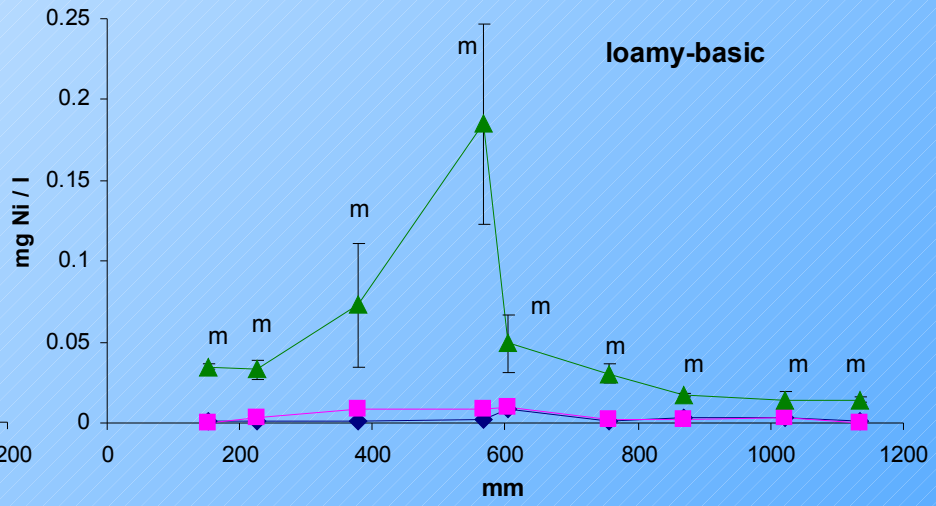

clay-basic
mg / l Cu
mm
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
200
400
600
800
1000
1200
m

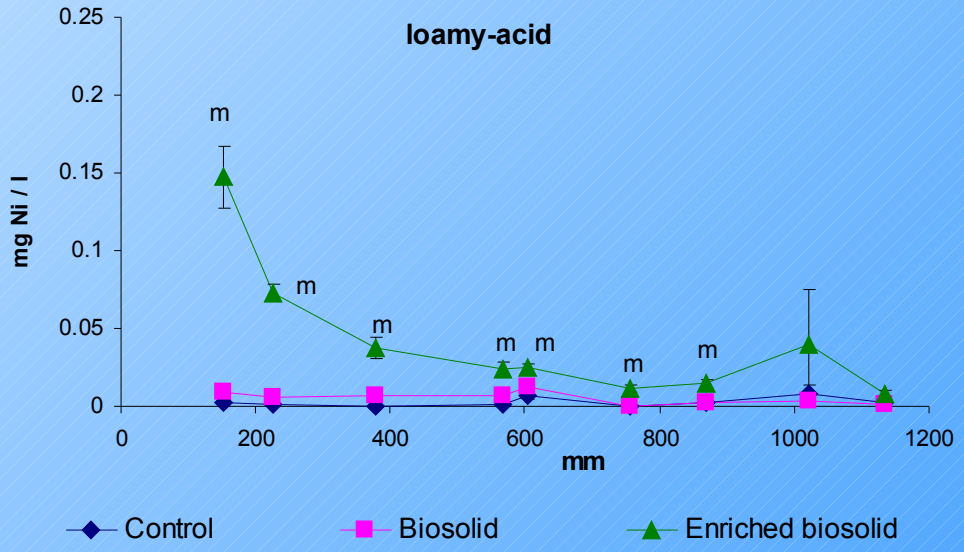

loamy-basic
mg Cu / l
mm
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
200
400
600
800
1000
1200
m


loamy-acid
mg Cu /l
mm
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0
200
400
600
800
1000
1200
m
Control
Biosolid
Enriched biosolid

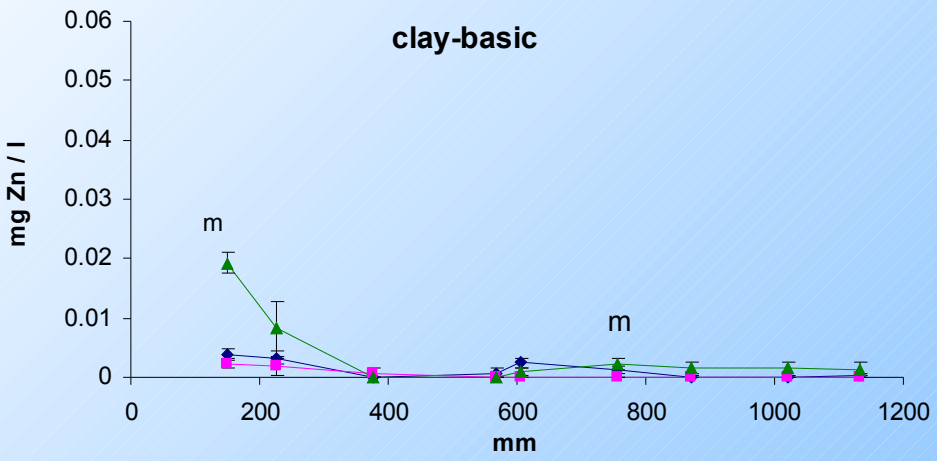
Ni

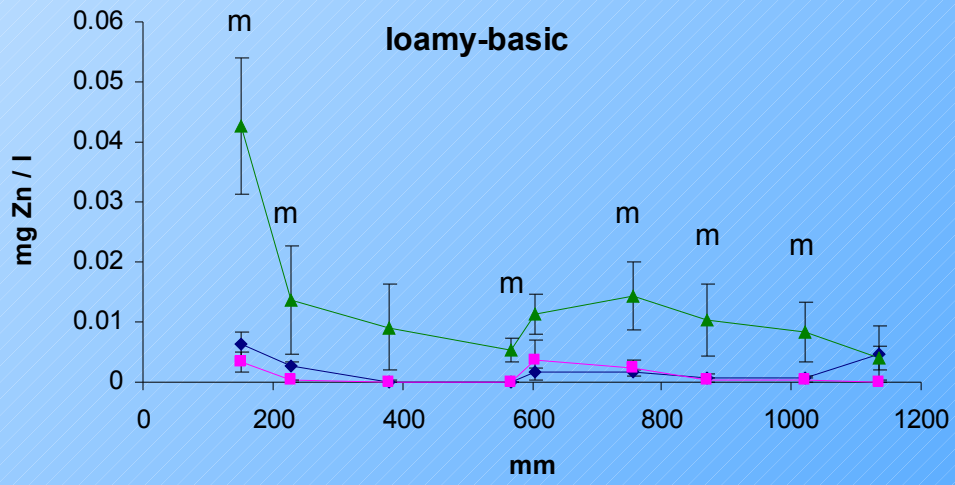

clay-basic
mg Ni / l
0.25
0.2
0.15
0.1
0.05
0
0
200
400
600
800
1000
1200
mm
m

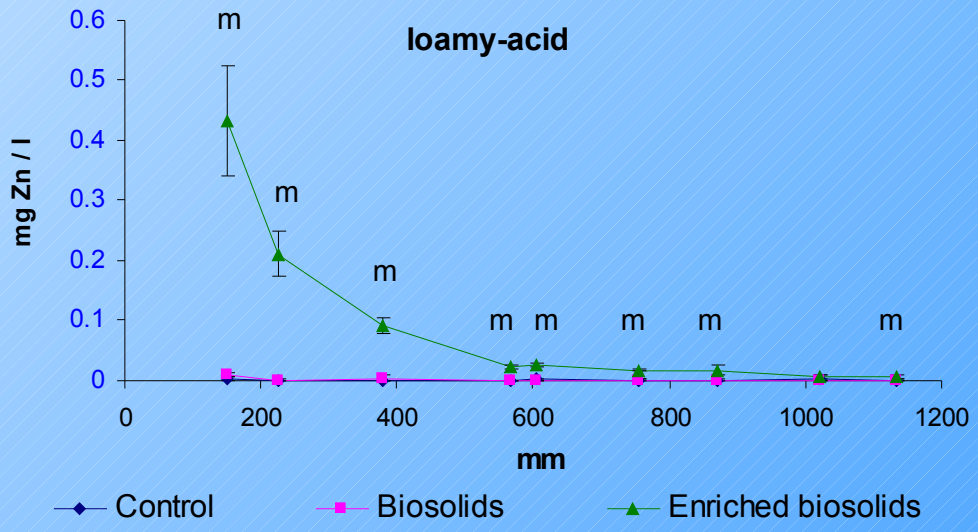

loamy-basic
mg Ni / l
0.25
0.2
0.15
0.1
0.05
0
0
200
400
600
800
1000
1200
mm
m


loamy-acid
mg Ni / l
0.25
0.2
0.15
0.1
0.05
0
0
200
400
600
800
1000
1200
mm
m
Control
Biosolid
Enriched biosolid

Zn


clay-basic
mg Zn / l
0.06
0.05
0.04
0.03
0.02
0.01
0
0
200
400
600
800
1000
1200
mm
m
m


loamy-basic
mg Zn / l
0.06
0.05
0.04
0.03
0.02
0.01
0
0
200
400
600
800
1000
1200
mm
m
m
m
m
m
m


loamy-acid
mg Zn / l
0.6
0.5
0.4
0.3
0.2
0.1
0
0
200
400
600
800
1000
1200
mm
m
m
m
m
m
m
m
m
Control
Biosolids
Enriched biosolids

Pearson correlation between DOC and pH and metals (n=55)

Basic clay

Control	DOC	Biosolid	DOC	Bios. Enri.	pH	DOC
Cu	n.s.	Cu	n.s.	Cu	n.s.	0.690**
Ni	n.s.	Ni	n.s.	Ni	n.s.	0.470**
Zn	0.380*	Zn	0.475**	Zn	-0.339**	0.520**

Basic loam

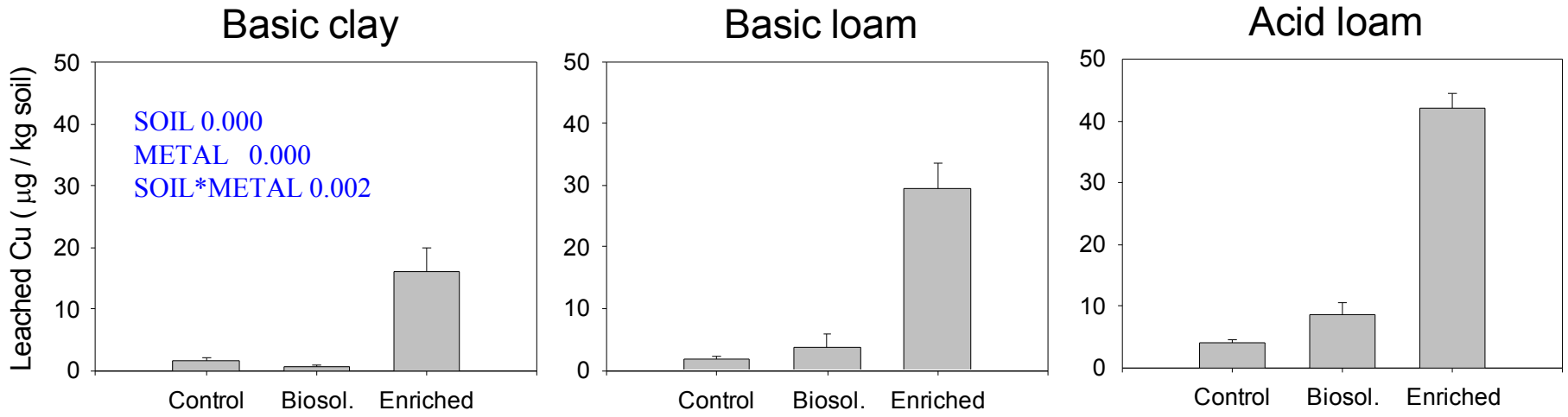
Control	DOC	Biosolid	DOC	Bios. enrich.	DOC
Cu	n.s.	Cu	0.421**	Cu	0.396*
Ni	n.s.	Ni	n.s.	Ni	n.s.
Zn	0.322*	Zn	n.s.	Zn	0.472**

Acid loam

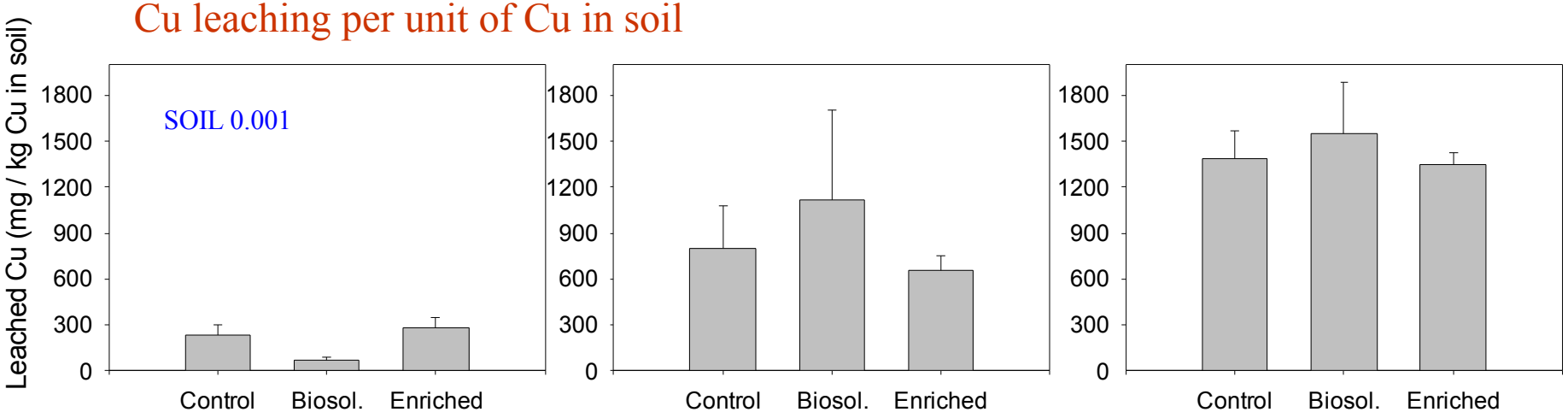
Control	DOC	Biosolid	DOC	Bios. Enrich.	pH	DOC
Cu	n.s.	Cu	n.s.	Cu	-0.482**	0.677**
Ni	0.504**	Ni	n.s.	Ni	-0.476**	0.620**
Zn	0.425**	Zn	n.s.	Zn	-0.542**	0.636**

Cummulative Cu leaching

Cu leaching per unit of soil

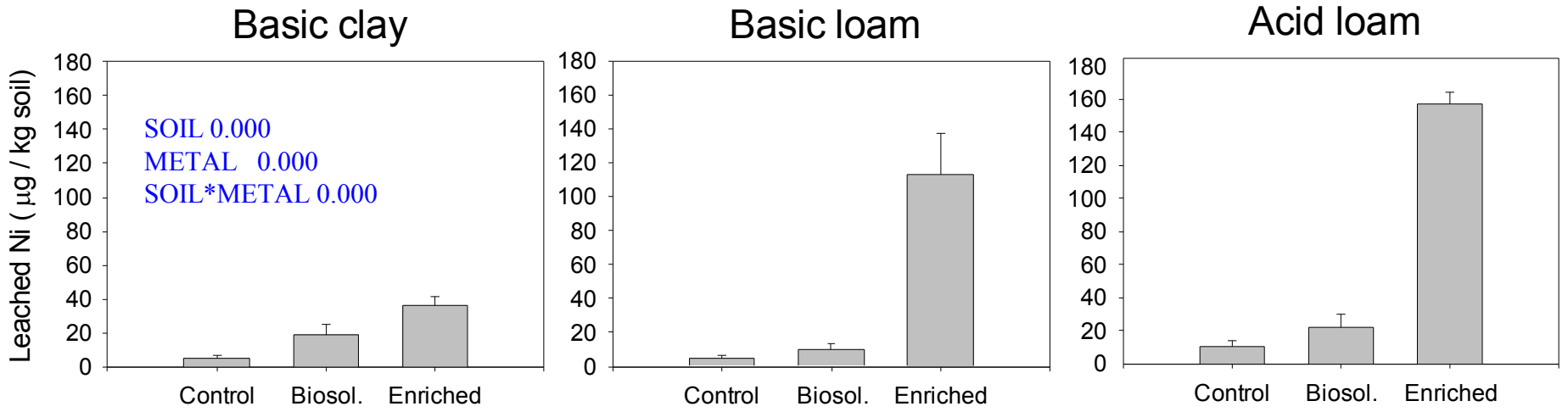


Cu leaching per unit of Cu in soil

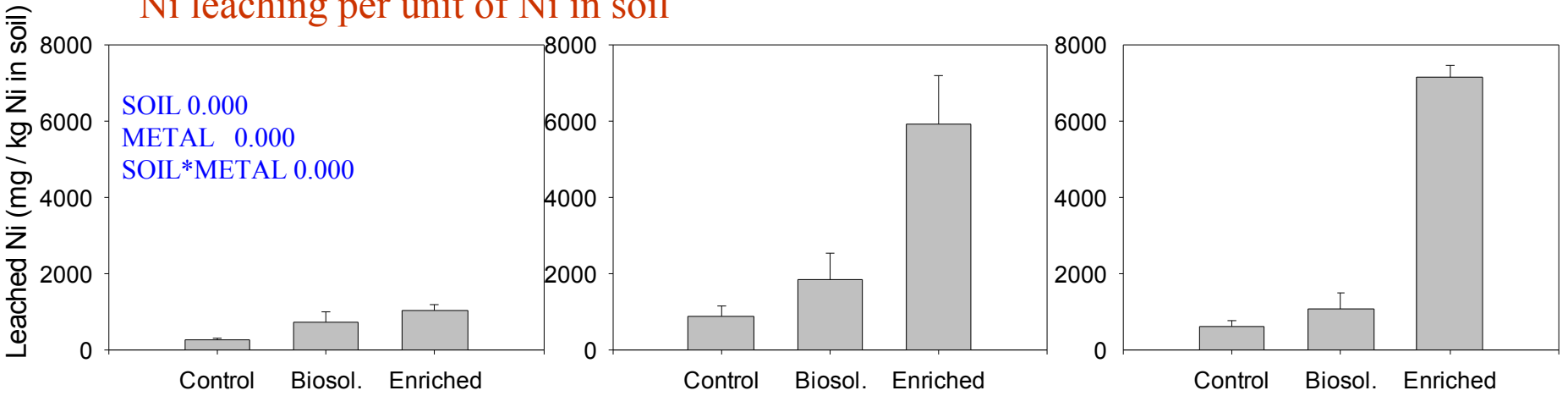


Cummulative Ni leaching

Ni leaching per unit of soil

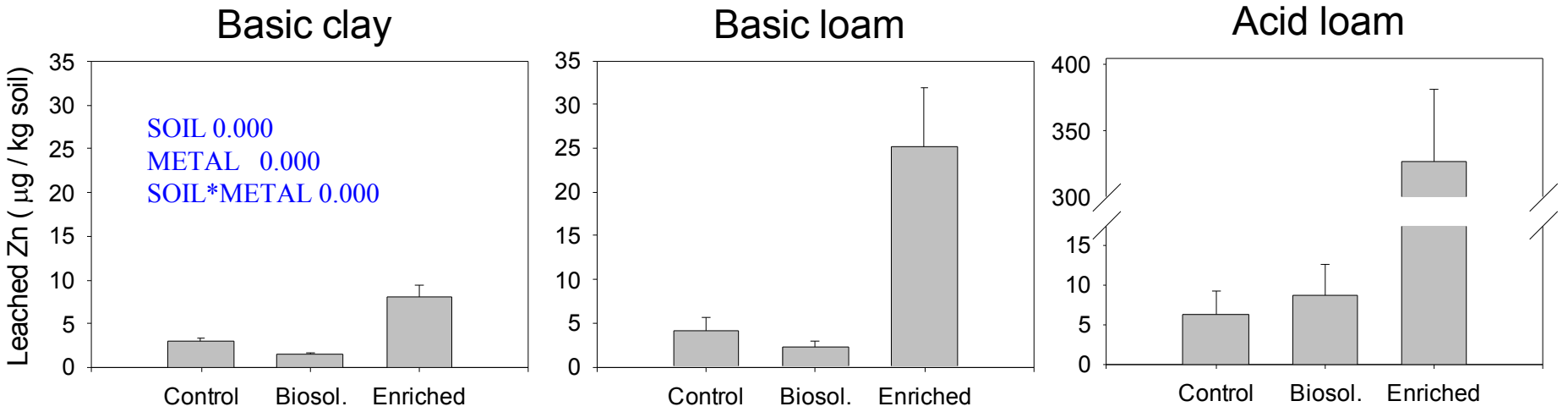


Ni leaching per unit of Ni in soil

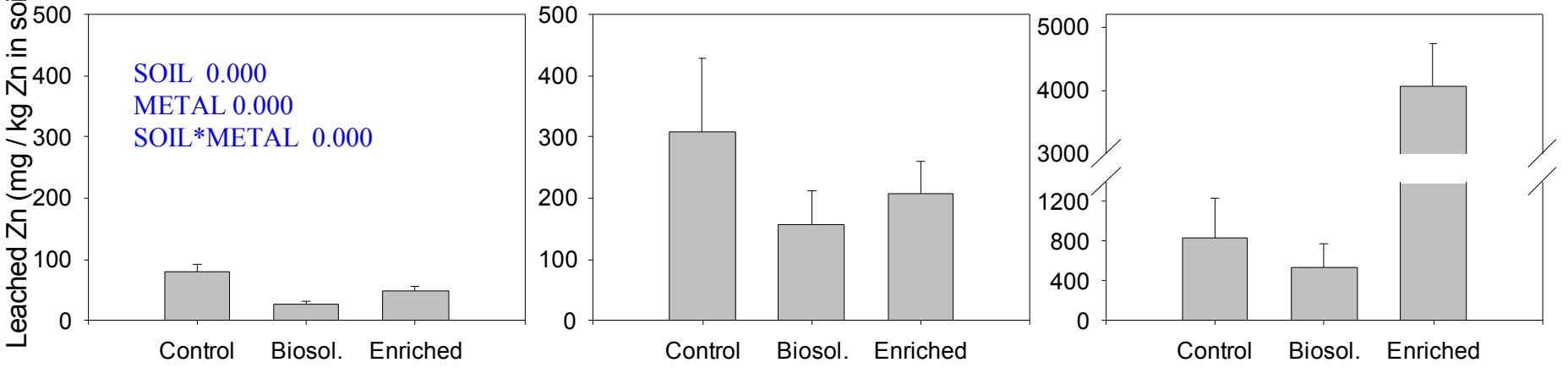


Cummulative Zn leaching

Zn leaching per unit of soil

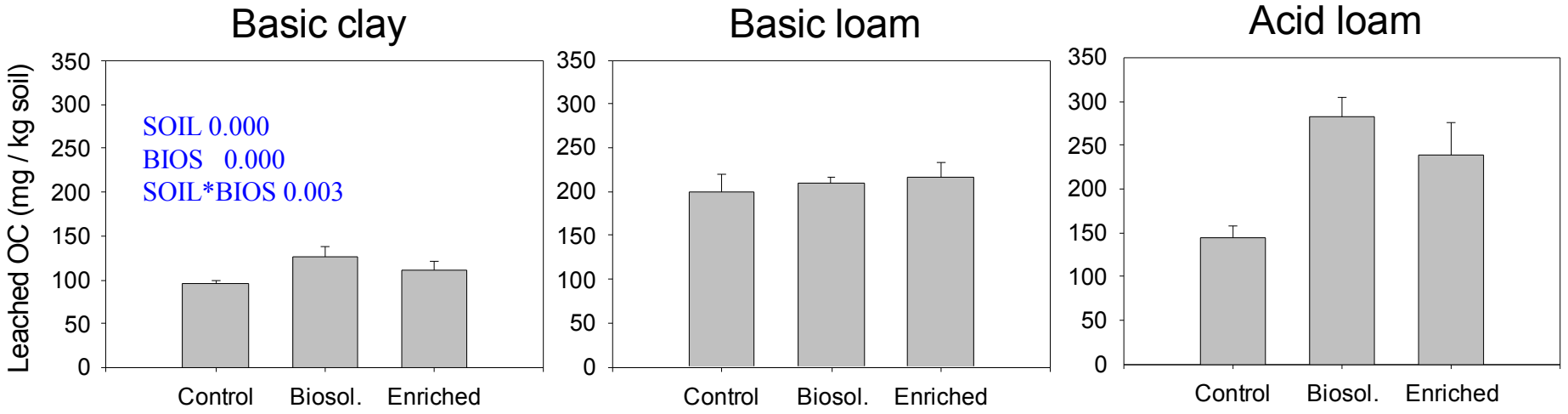


Zn leaching per unit of Zn in soil

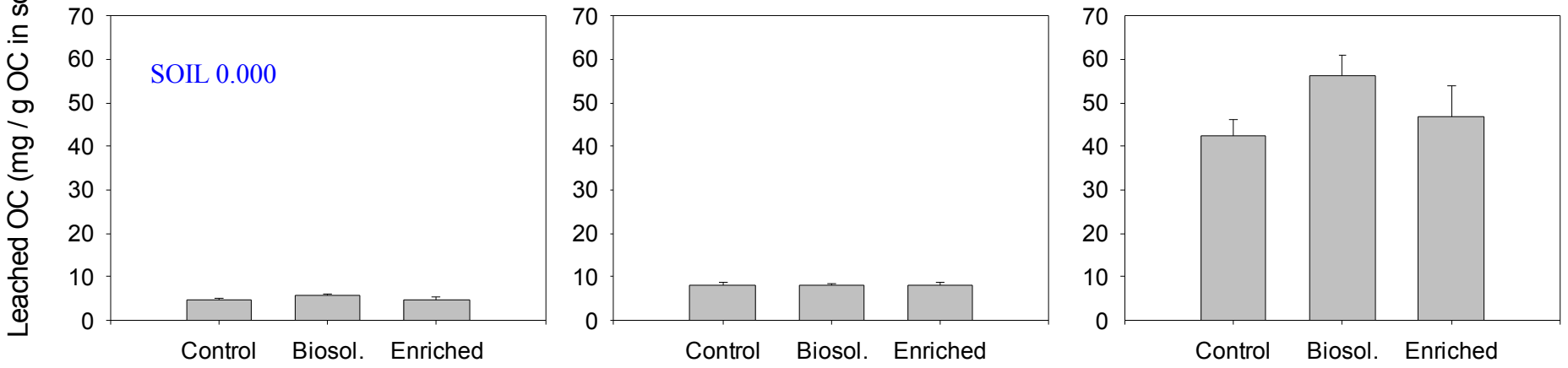


Cummulative OC leaching

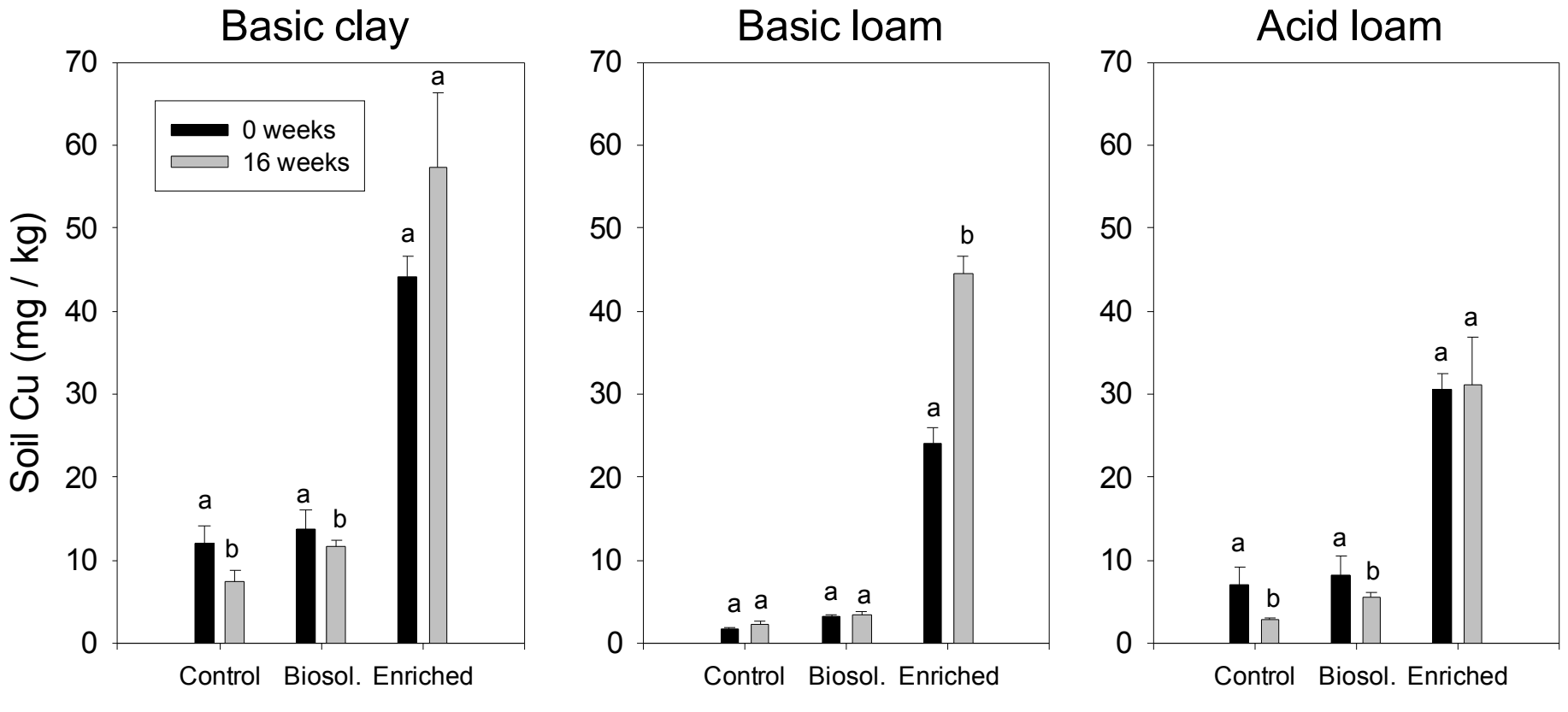
OC leaching per unit of soil



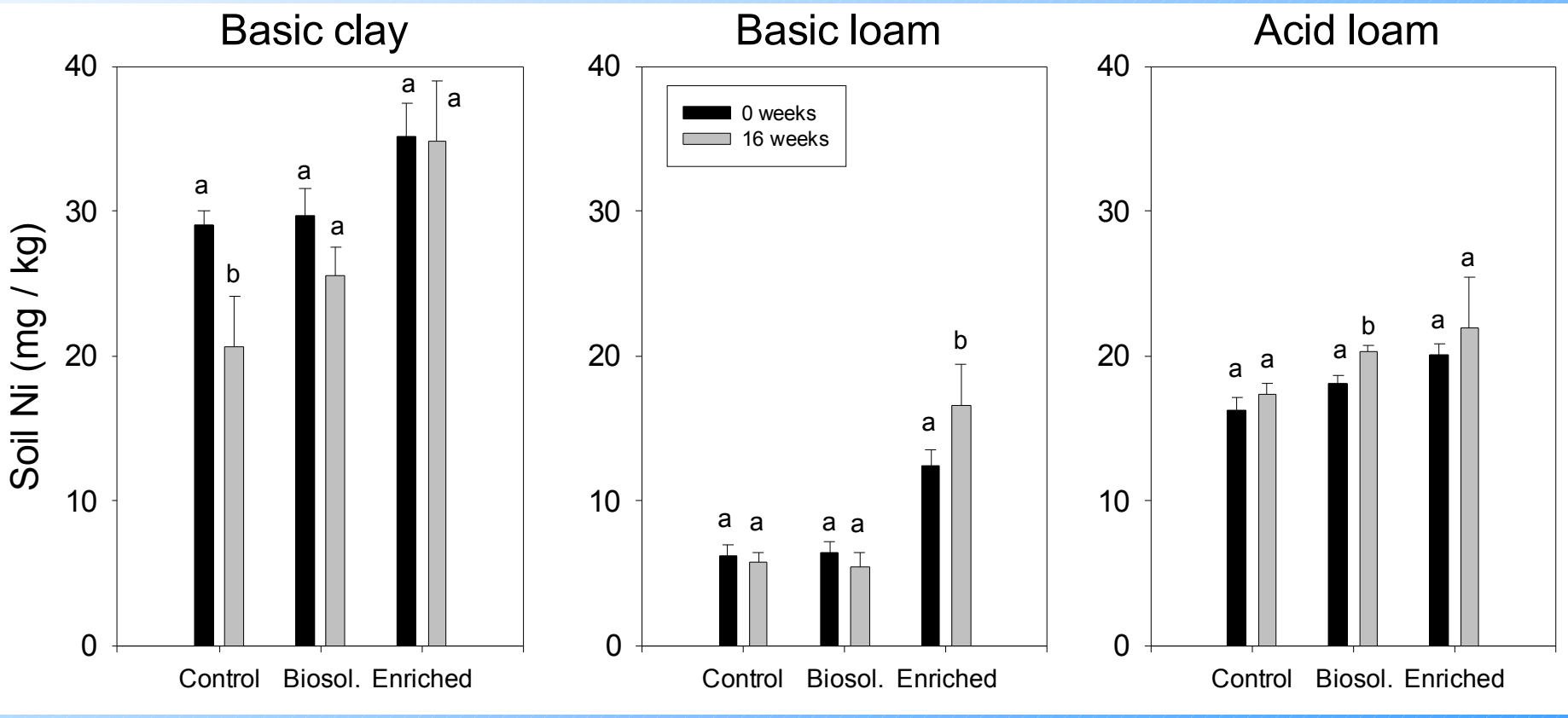
OC leaching per unit of OC in soil



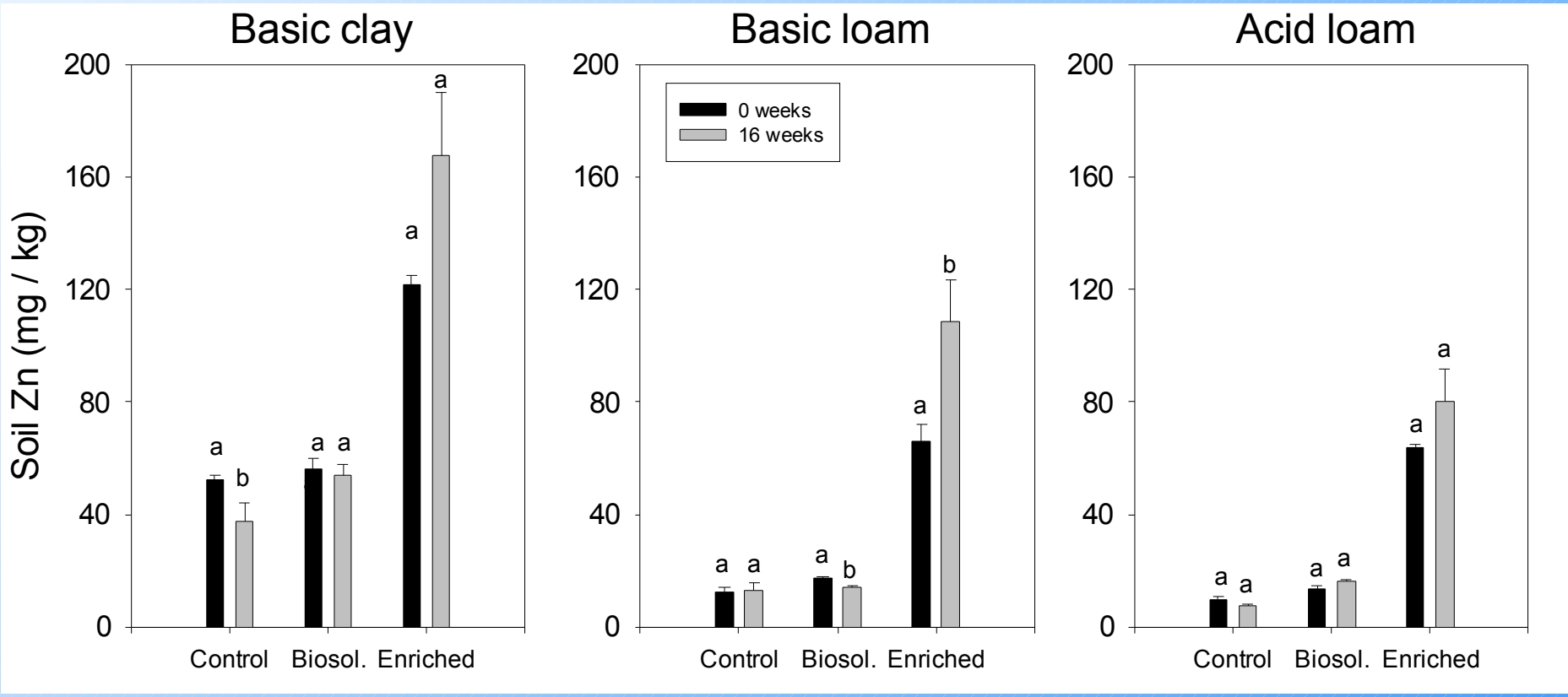
Pseudototal Cu before and after the incubation



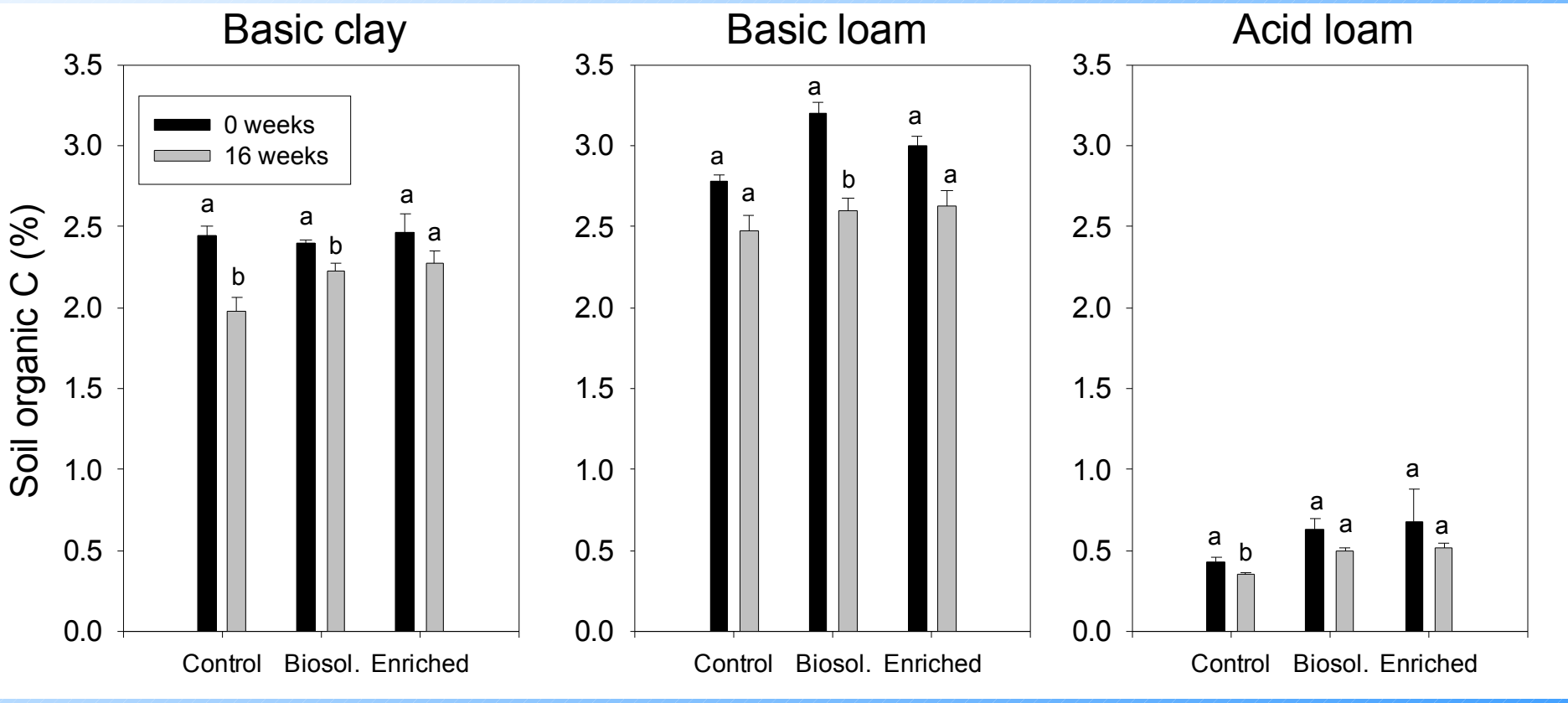
Pseudototal Ni before and after the incubation



Pseudototal Zn before and after the incubation



Total organic C before and after the incubation



Conclusions

- Both quality and quantity of the leachates from Mediterranean forest soils amended with biosolids depended on the soil characteristics.
- The increases in Cu, Ni, and Zn in the leachates of soils with enriched biosolids are particularly high at the beginning of the incubation while they tend to stay low towards the end of the incubation. However, in the basic loam soils, there are increases of pseudototal Cu, Ni and Zn after the incubation period that may enhance future leaching of these metals.
- The biosolid induced increases of organic matter in leachates does not show any clear pattern during the incubation period as it occurs for P leaching in basic soils. Acid soils show a clear decline of P increases in amended soils over time.

Conclusions

- Cu and Zn added with biosolids to the basic soils leached at a similar rates than Cu and Zn in control soils.
- After biosolid addition Ni in all studied soils and Cu and Zn in acid soils leached at faster rates than controls.
- The addition of biosolids increased the leaching of organic matter in all soils however this increase was large in the acid soil, medium in basic loam and very small in the clay loam. The leaching rate of the newly added organic matter was similar to the leaching rate in control soils.
- The addition of biosolids did not significantly increase NO_3^- leaching but it increased the leaching of PO_4^{3-} throughout the incubation even in soils rich in limestone and with high clay content.


Thank you