



4th International Congress **EUROSOIL 2012**

Soil Science for the Benefit of Mankind and Environment
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WHEN BUSINESS MEETS THE ENVIRONMENT



DECONTAMINATION AND FUNCTIONAL RECLAMATION OF DREDGED BRACKISH SEDIMENTS

SERENA DONI*, CRISTINA MACCI,
ELEONORA PERUZZI, BRUNELLO CECCANTI,
GRAZIA MASCIANDARO

*e-mail: serena.doni@ise.cnr.it





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AGRIPORT

 executive agency
eaci
for competitiveness & innovation

Agricultural Reuse of Polluted dredged Sediments

No. ECO/08/239065/S12.532262

Project objective



Project aimed at **reclaiming slightly contaminated sites through phytoremediation** as an innovative technology to recover dredging sediments using plants.





TREATED SEDIMENT

Brackish sediments

Navicelli Canal (Pisa-Italy) a navigable canal which connects Pisa to Livorno and flows into the sea

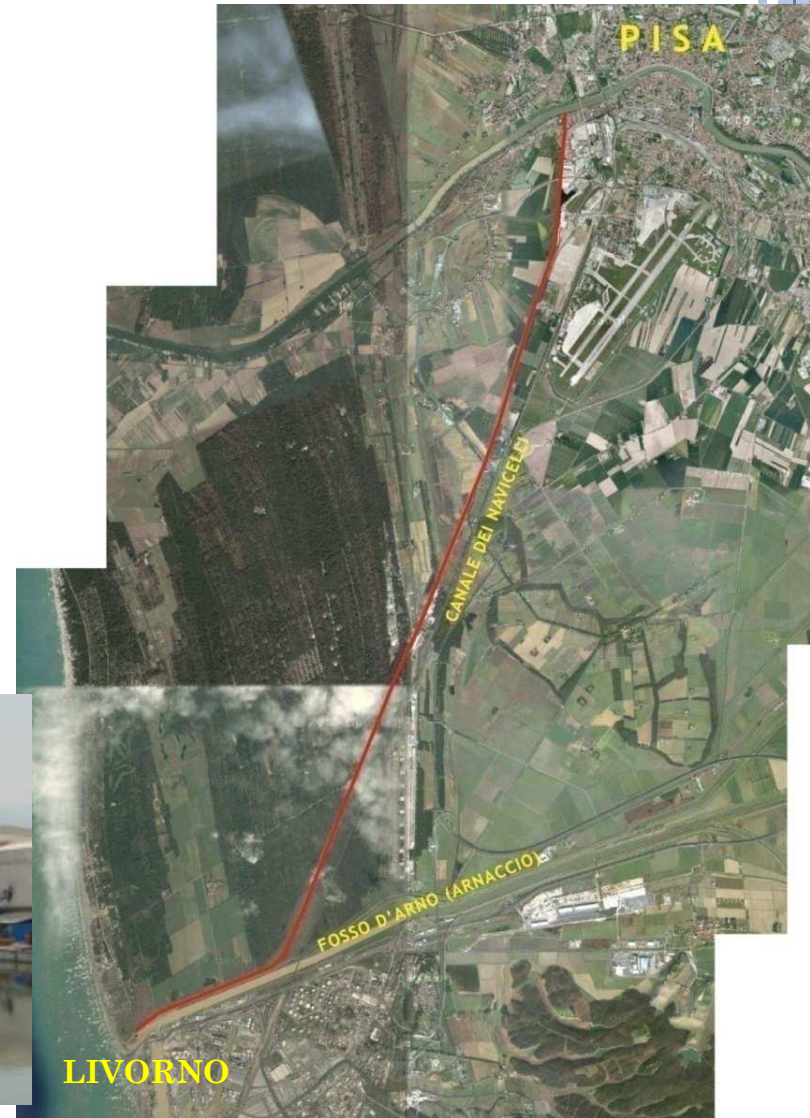
Length: 16 km

Width: 32 m

Depth: 3 m



VIEW OF THE NAVICELLI CANAL





STORAGE BASIN OF NAVICELLI CANAL

30,000 m³ sediments
currently dredged





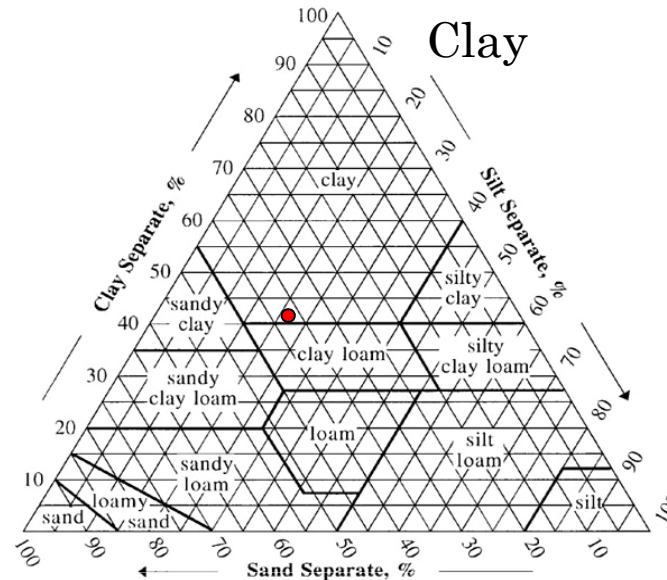
SEDIMENT CHARACTERISTICS IN THE STORAGE BASIN OF NAVICELLI



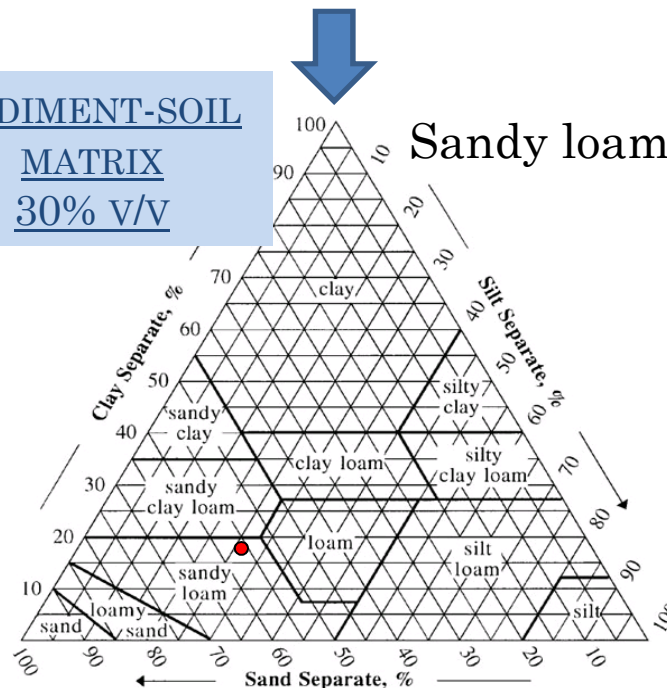
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Sand (%)	
Silt (%)	
Clay (%)	
Texture (USDA classification)	
pH	
Electrical Conductivity (dS m ⁻¹)	
Total Organic C (%)	
Total N (%)	
C/N	
NH ₄ ⁺ (mg kg ⁻¹)	
Total P (mg kg ⁻¹)	
Ni (mg kg ⁻¹)	
Pb (mg kg ⁻¹)	
Cu (mg kg ⁻¹)	
Cr (mg kg ⁻¹)	
Cd (mg kg ⁻¹)	
Zn (mg kg ⁻¹)	
Total Petroleum Hydrocarbon (mg kg ⁻¹)	



**SEDIMENT-SOIL
MATRIX
30% v/v**



High fraction of fine particles

Unbalanced nutrient content

Slight contamination of heavy metals and a more significant contamination of pollutant organic compounds.



EXPERIMENTAL SETUP

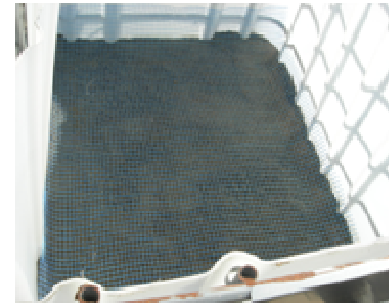
CONTAINERS OF ABOUT 1 m³ FILLED WITH THE
CONTAMINATED SEDIMENTS DREDGED FROM NAVICELLI CANAL



- a) GRAVEL-SAND DRAINAGE,
- b) PLASTIC NETWORK,
- c) MIXTURE SEDIMENT-SOIL



a)



b)



c)

CONTAINERS ARE
EQUIPPED FOR
GRAVITATIONAL
LEACHATE COLLECTION



A HIGH QUALITY
COMPOST WAS MIXED
WITH THE SEDIMENT-
SOIL MATRIX AT
SURFACE LEVEL
(40T/ha)



PLANTATION

TREATMENTS:

1. *Nerium oleander l.* + *Paspalum v.*
2. *Tamarix gallica* + *Paspalum v.*
3. *Spartium junceum* + *Paspalum v.*
4. *Phragmites australis*
5. *Paspalum v.*
6. Control

PLANT SELECTION

High adaptability to
water stress and
survival in presence
of pollutants



Paspalum vaginatum



Tamarix Gallica



Spartium Junceum



Nerium oleander



Phragmites australis

Monitoring

The monitoring of the pilot system consisted of samplings carried out twice a year. The results **after planting** (Ti, October 2010) and **one year and a half** (Tf, May 2012) from the experiment set up are reported.



Each sediment sample consists of three subsamples collected at 0-20, 20-40 and 40-60 cm, mixed, homogenised, sieved (2 mm) and stored dried at room temperature until chemical analysis, and stored at 4°C until biological analysis.





Specific Objectives



- 1) **AGRONOMICAL RECOVERY** (improvement of the chemical-nutritional characteristics)
- 2) **ECOLOGICAL-FUNCTIONAL RECOVERY** (improvement of the biochemical fertility)
- 3) **DECONTAMINATION** (contaminant reduction)





• MONITORING



Sediment analysis

AGRONOMICAL RECOVERY

- pH and Electrical Conductivity (E.C.)
- Total Organic Carbon (TOC)
- Total Nitrogen (TN)
- Total Phosphorus (TP)
- Nitrate

DECONTAMINATION

- Heavy metals : Zn, Pb, Ni, Cu, Cr, Cd
- Total Petroleum Hydrocarbon (TPH)

ECOLOGICAL-FUNCTIONAL RECOVERY

- Total cultivable microbial population
- Dehydrogenase activity

The growth and development of the selected vegetal species was periodically monitored on site

Samples of the leachate were collected and analysed in order to evaluate the need for further treatment before discharging



OCTOBER 2010 (PLANTATION)



Nerium oleander



Phragmites australis



Paspalum vaginatum



Spartium junceum



Tamarix gallica

APRIL 2011 (AFTER SIX MONTHS)



Nerium oleander



Phragmites australis



Spartium junceum



Paspalum vaginatum



Tamarix gallica





OCTOBER 2011 (AFTER ONE YEAR)



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Nerium oleander



Phragmites australis



Spartium junceum



Paspalum vaginatum



Tamarix gallica





MAY 2012 (AFTER ONE YEAR AND A HALF)



Nerium oleander



Phragmites australis



Spartium Junceum



Paspalum vaginatum



Tamarix gallica



PLANT GROWTH

	O	Ph	S	T
	Height (cm)			
October 2010	25	20	20	25
May 2012	104±2.1	110±9	134±30	145±10
Growth (%)	410	551	670	581

O= *Oleander +Paspalum*

Ph= *Phragmites*

S= *Spartium+Paspalum*

T= *Tamarix+Paspalum*

P= *Paspalum*

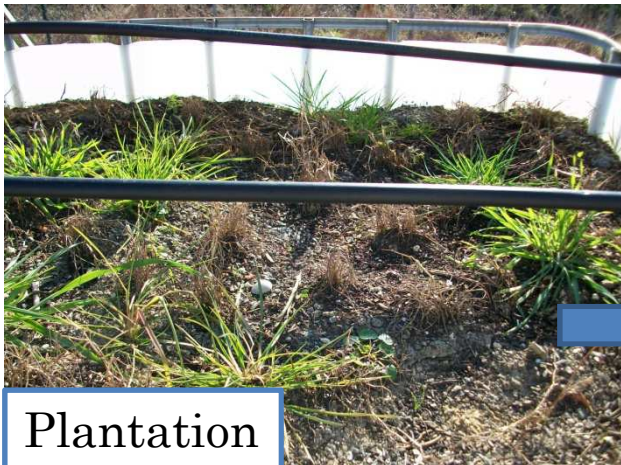
PLANT GROWTH

Phragmites australis



Phragmites reached 60% of plant cover

Paspalum vaginatum

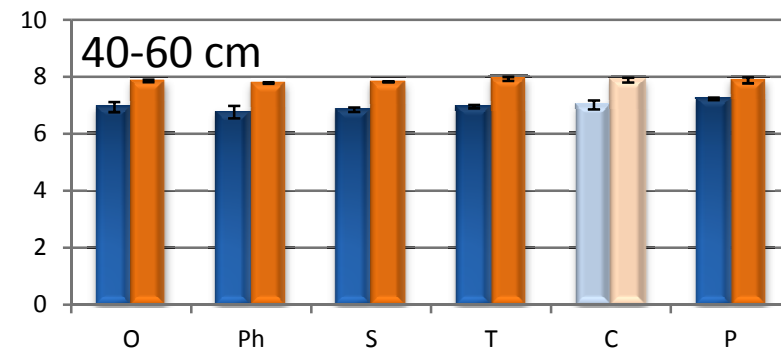
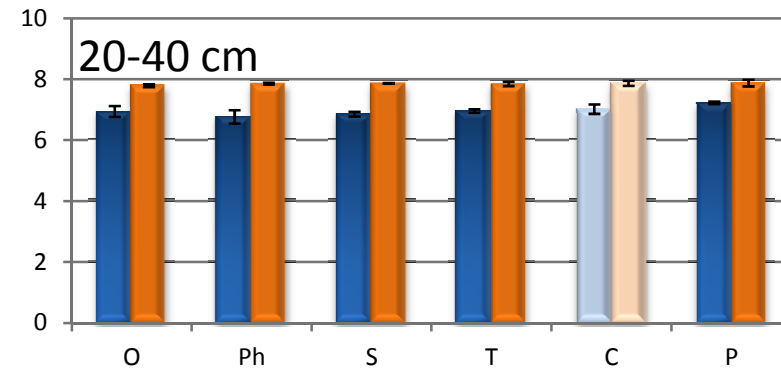
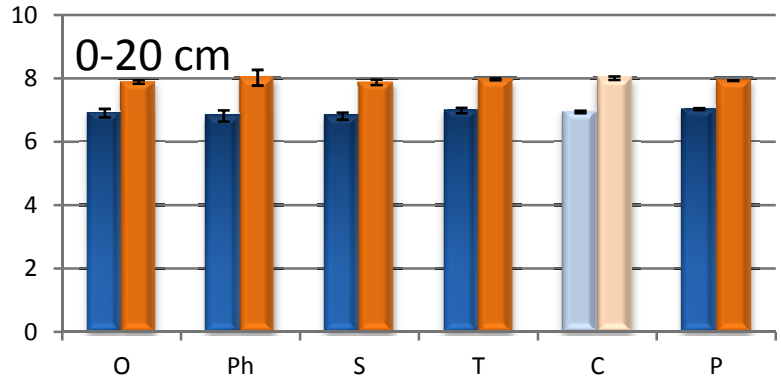


Paspalum reached 100% of plant cover in all the treatments

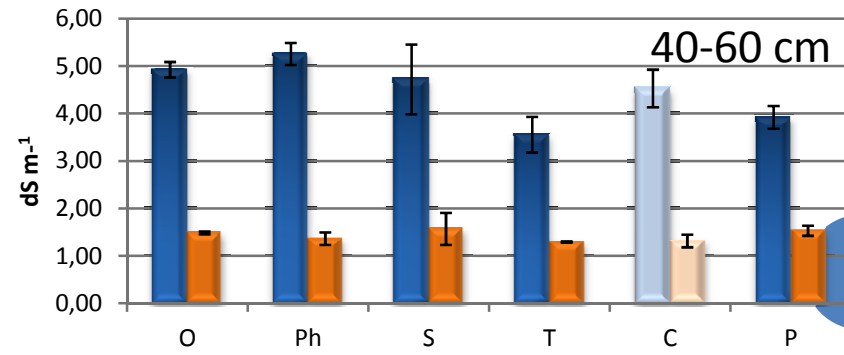
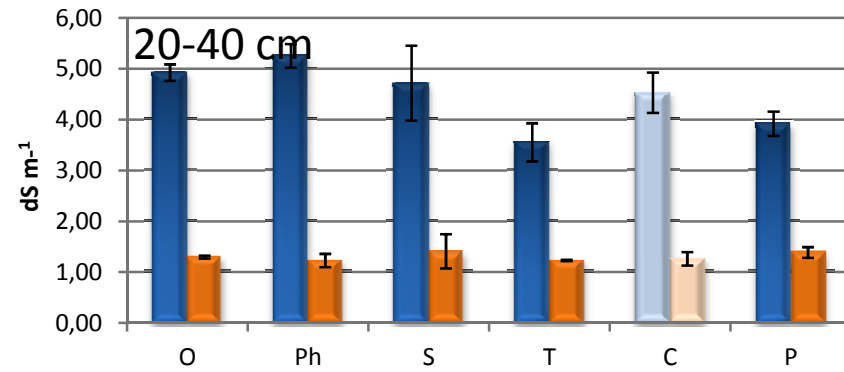
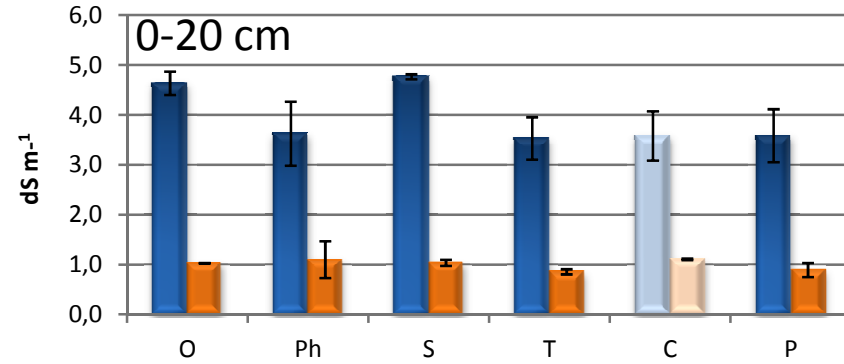
AGRONOMICAL RECOVERY

pH

■ Ti ■ Tf



Electrical Conductivity



O= Oleander +Paspalum; Ph= Phragmites; S= Spartium+Paspalum; T= Tamarix+Paspalum; C=Control; P= Paspalum

AGRONOMICAL RECOVERY

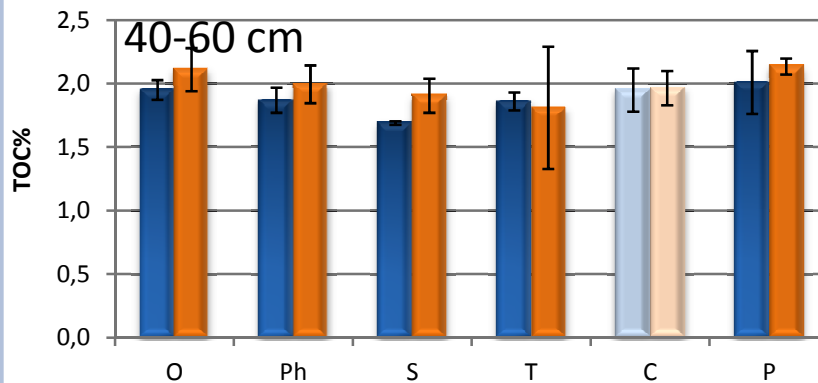
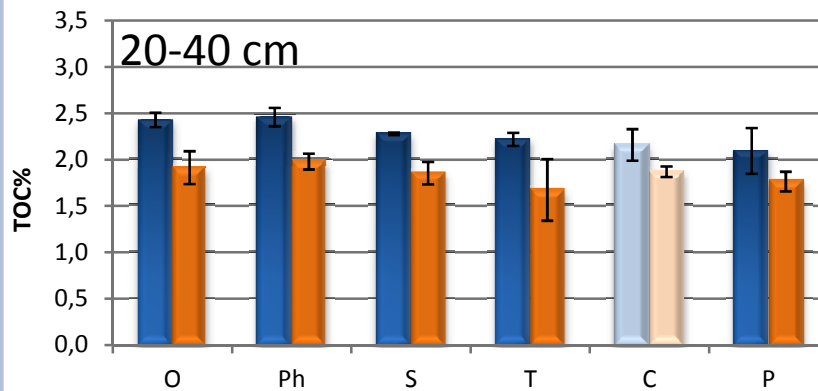
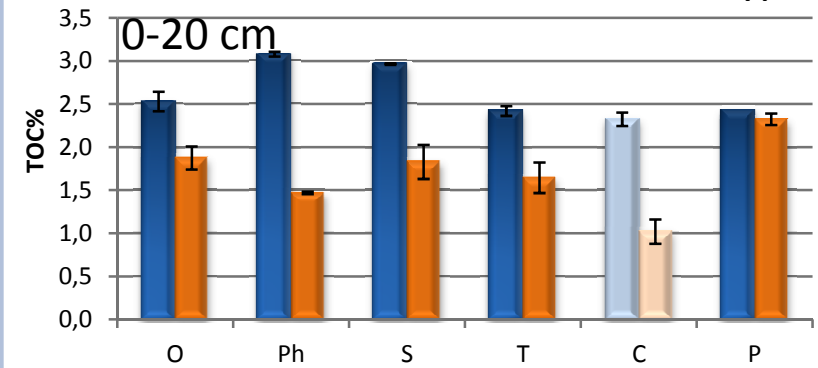


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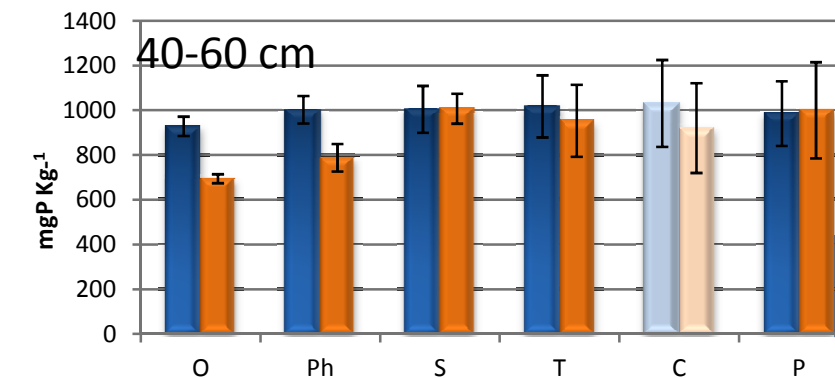
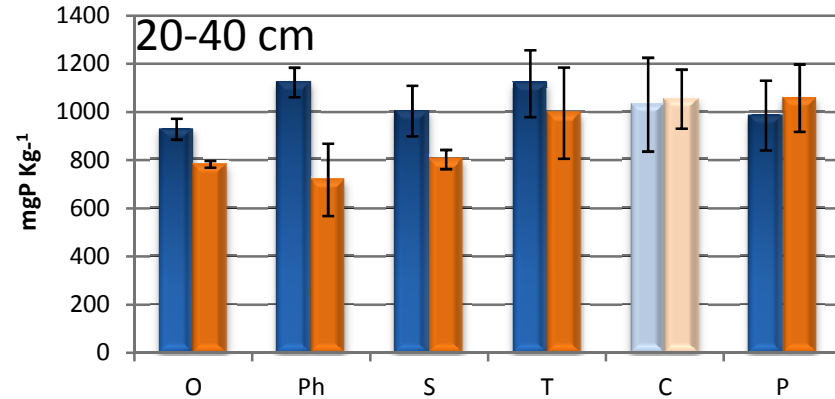
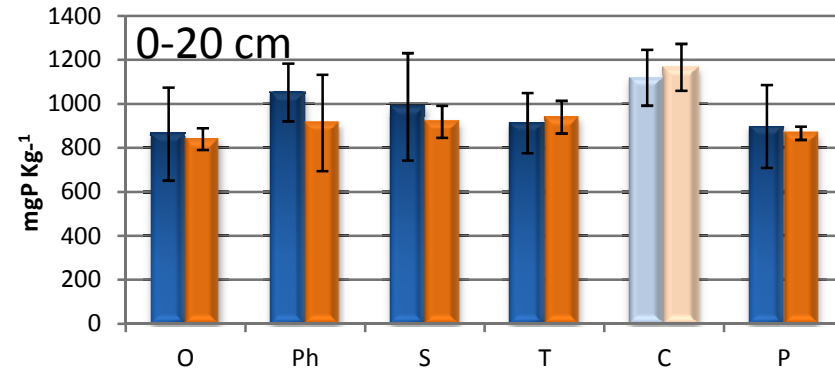


Total Organic Carbon

■ Ti ■ Tf



Total Phosphorus



O= *Oleander + Paspalum*; Ph= *Phragmites*; S= *Spartium + Paspalum*; T= *Tamarix + Paspalum*; C=Control; P= *Paspalum*

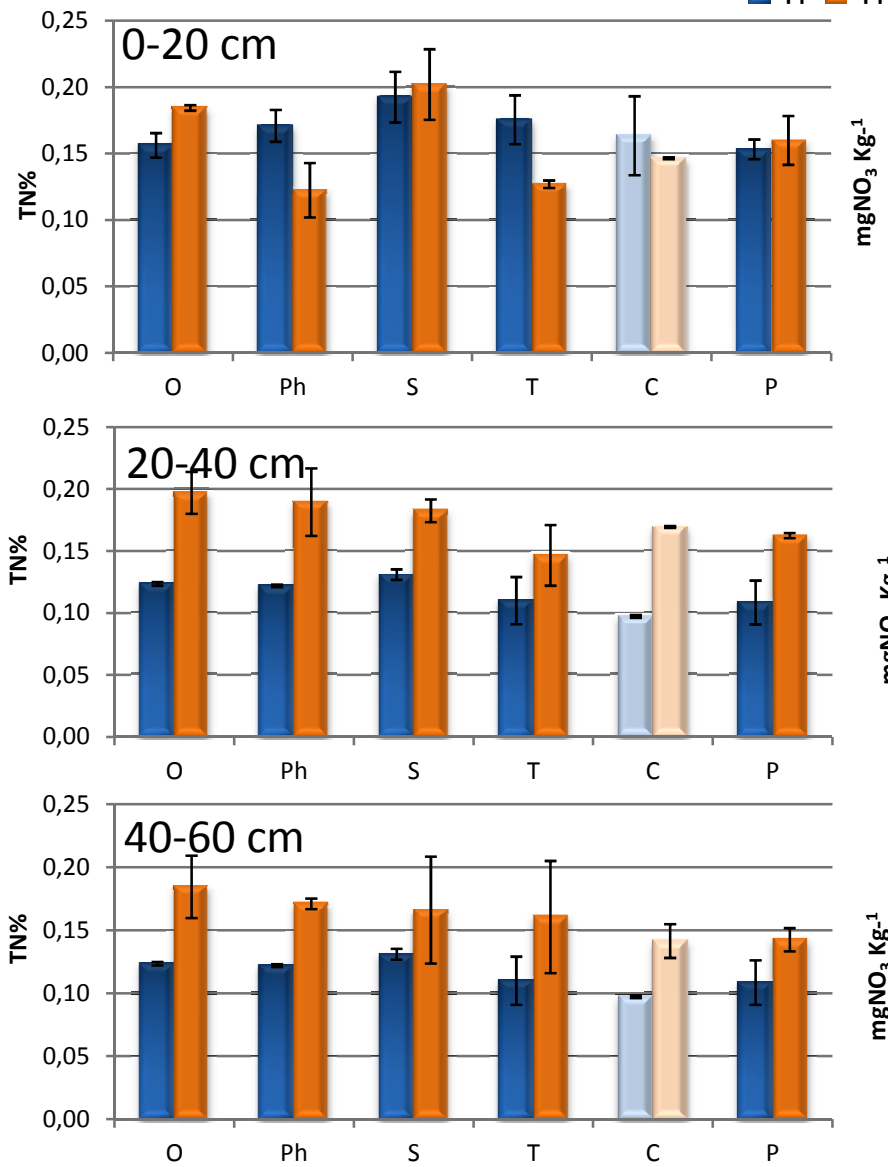
AGRONOMICAL RECOVERY



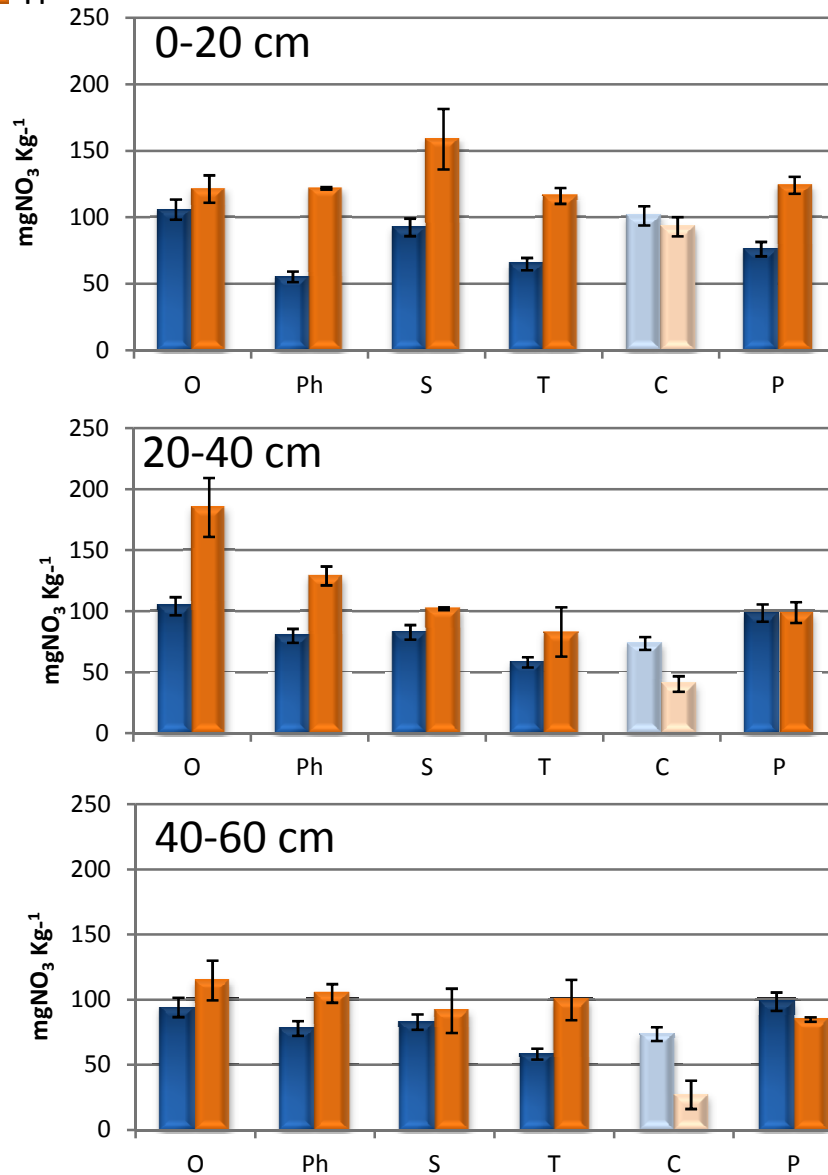
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Total Nitrogen



Nitrate



O= *Oleander* +*Paspalum*; Ph= *Phragmites*; S= *Spartium*+*Paspalum*; T= *Tamarix*+*Paspalum*; C=Control; P= *Paspalum*

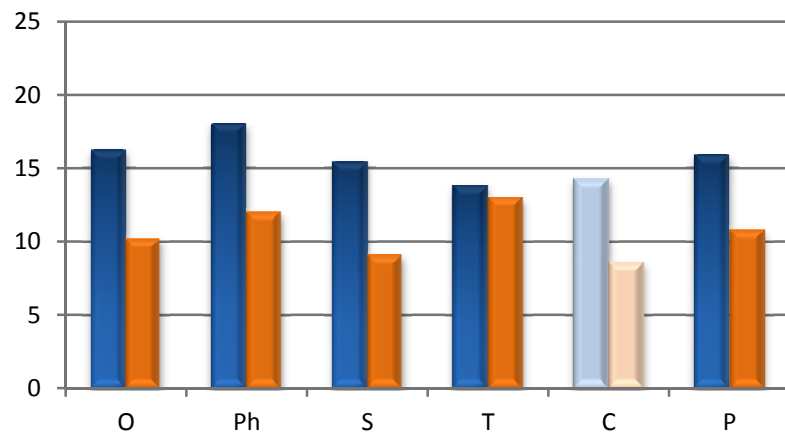
AGRONOMICAL RECOVERY



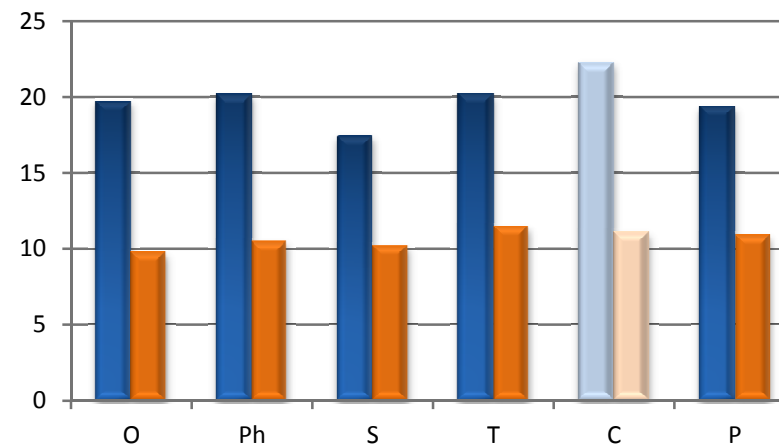
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C/N (0-20 cm)

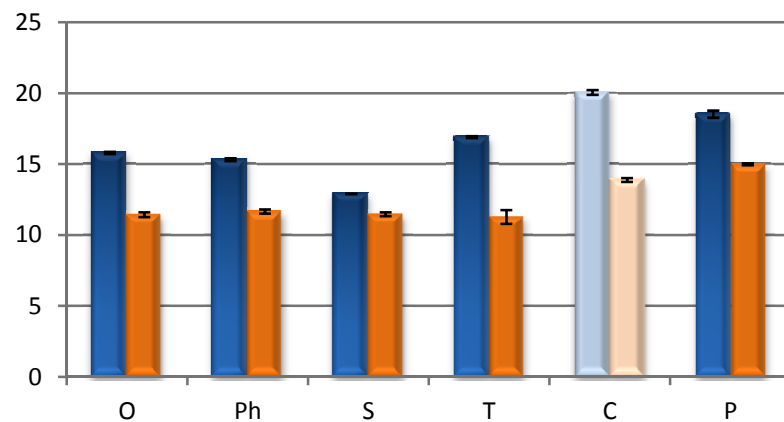
■ Ti ■ Tf



C/N (20-40)

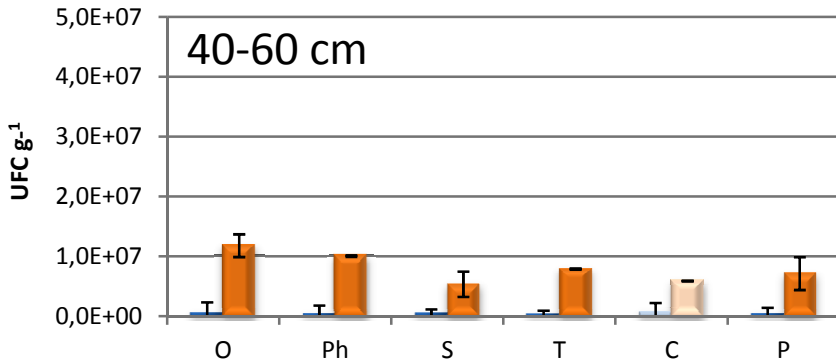
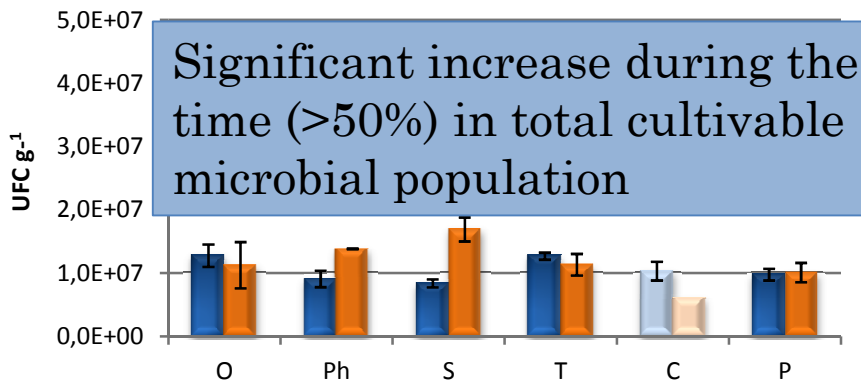
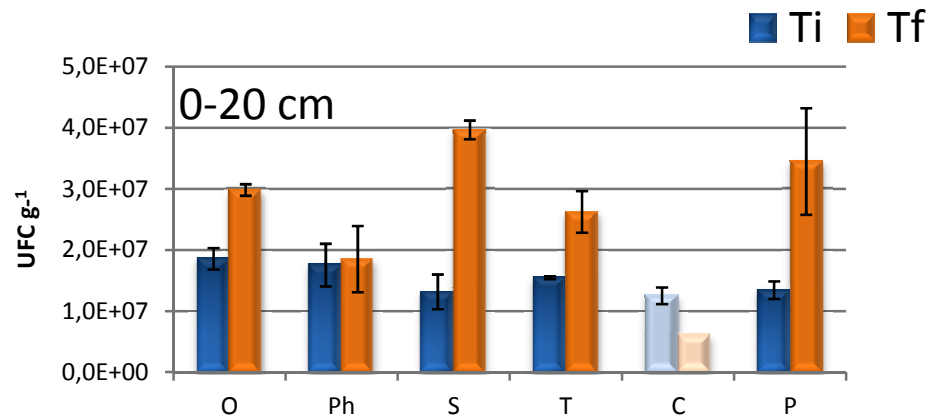


C/N (40-60)



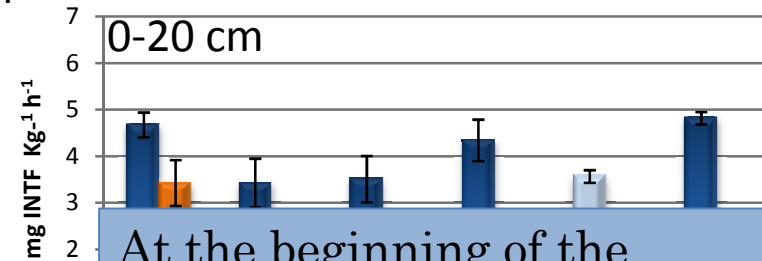
FUNCTIONAL RECOVERY

Total cultivable microbial population



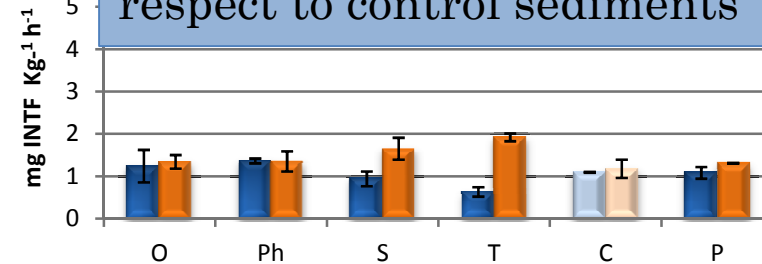
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Dehydrogenase activity



At the beginning of the experimentation the dehydrogenase activity was very high due to the initial compost application

At the end of the experimentation the plant treatments showed an average increase in dehydrogenase activity of about 40% with respect to control sediments



O= Oleander +Paspalum; Ph= Phragmites; S= Spartium+Paspalum; T= Tamarix+Paspalum; C=Control; P= Paspalum

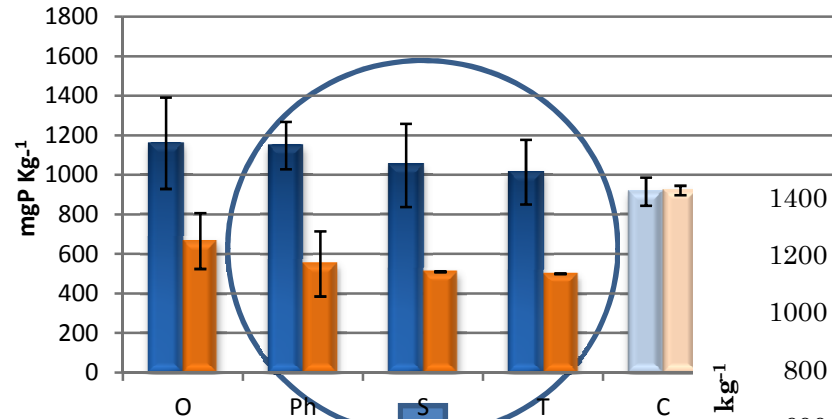
DECONTAMINATION

Total Petroleum Hydrocarbons



0-20 cm

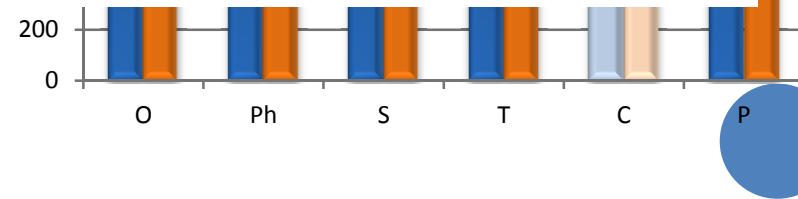
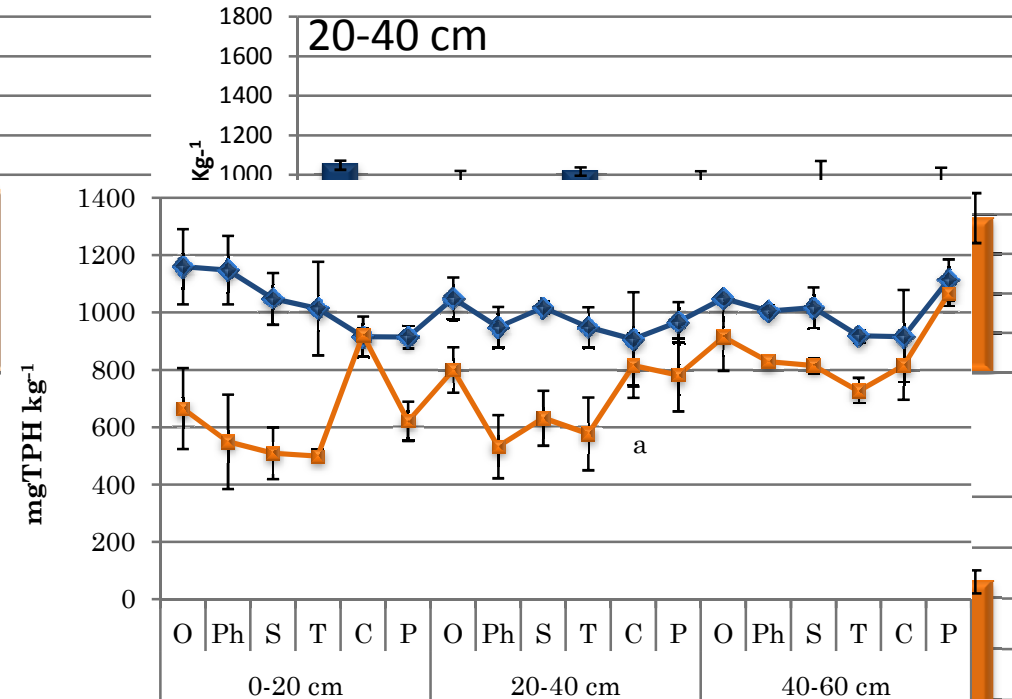
■ Ti ■ Tf



Average decrease higher than 50%

Average decrease in TPH of 35-40% in the 0-20 and 20-40 cm layers

20-40 cm

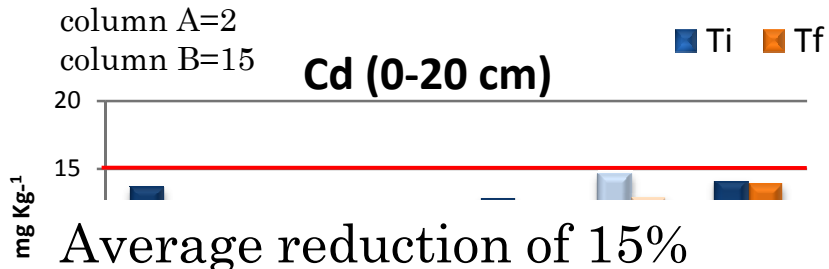


O= *Oleander +Paspalum*; Ph= *Phragmites*; S= *Spartium+Paspalum*; T= *Tamarix+Paspalum*; C=Control; P= *Paspalum*

DECONTAMINATION

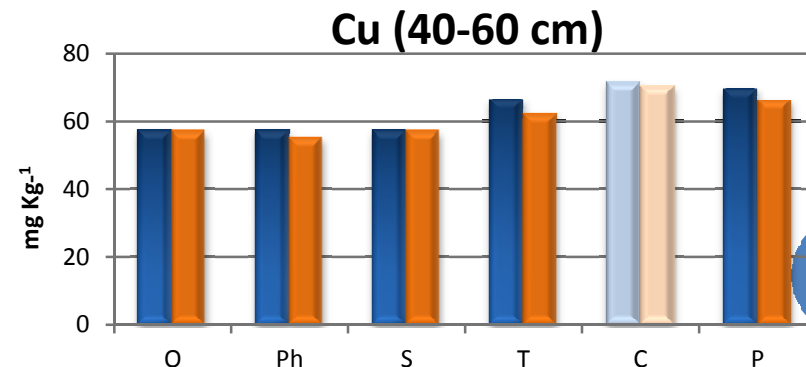
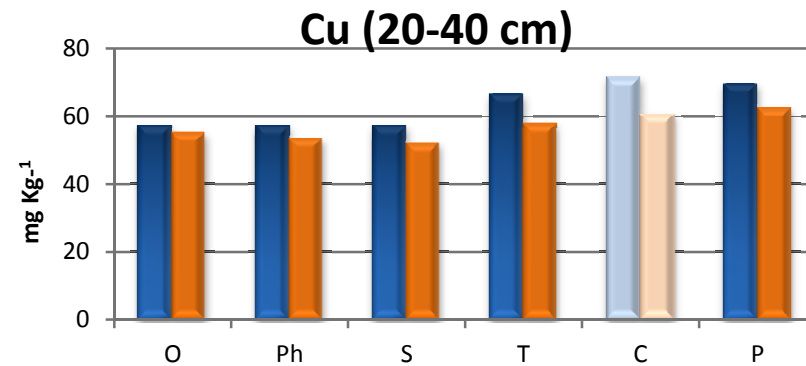
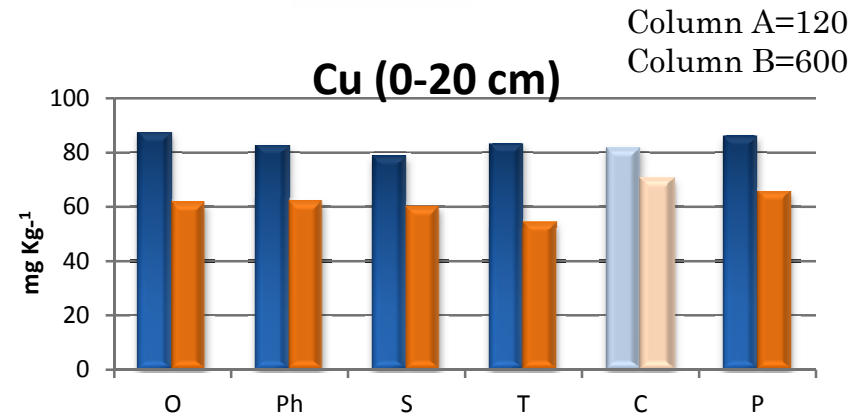
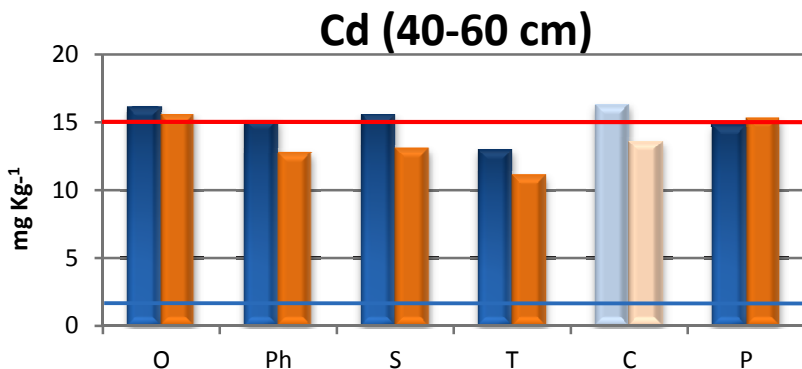


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O and T treatments at surface layers decreased in Cd >20%

At the end of experimentation Cd values were lower than the legal limit for industrial use (column B, D. Lgs. 152/06)



O= *Oleander + Paspalum*; Ph= *Phragmites*; S= *Spartium + Paspalum*; T= *Tamarix + Paspalum*; C=Control; P= *Paspalum*



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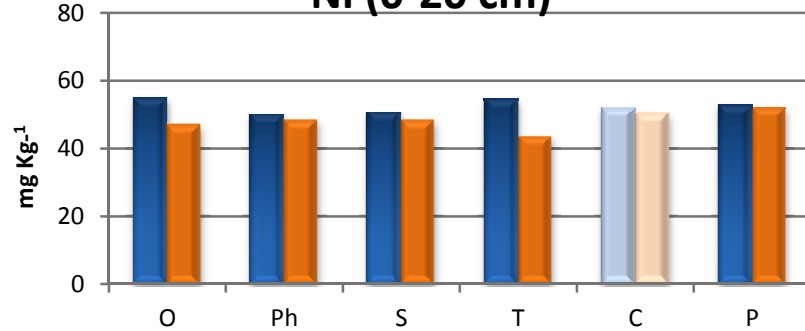
DECONTAMINATION

Column A=120

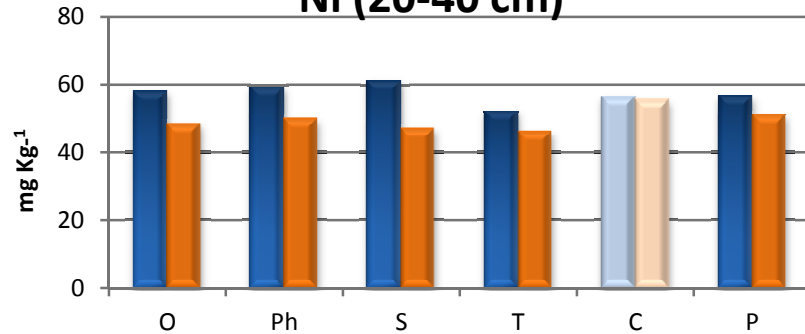
Column B=500

Ni (0-20 cm)

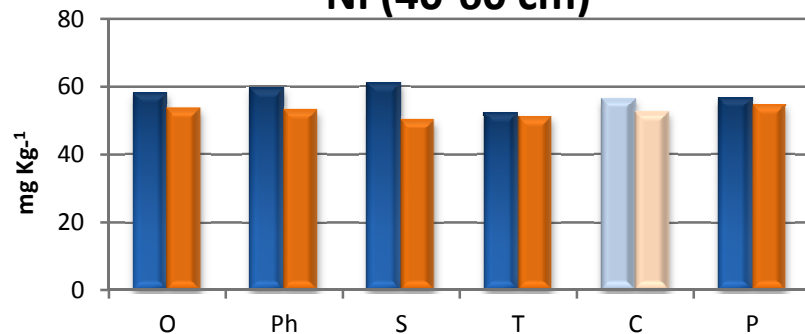
■ Ti ■ Tf



Ni (20-40 cm)



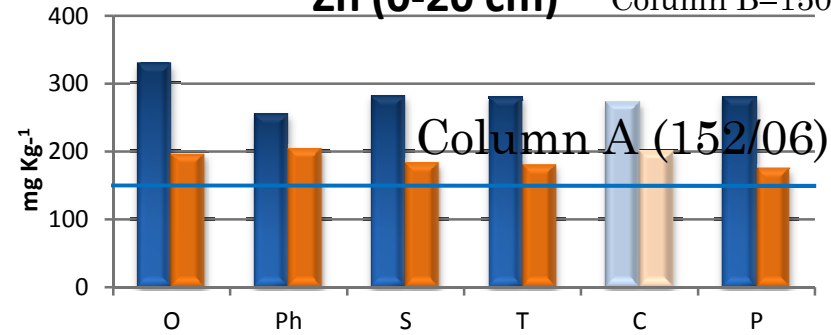
Ni (40-60 cm)



Comun A=150

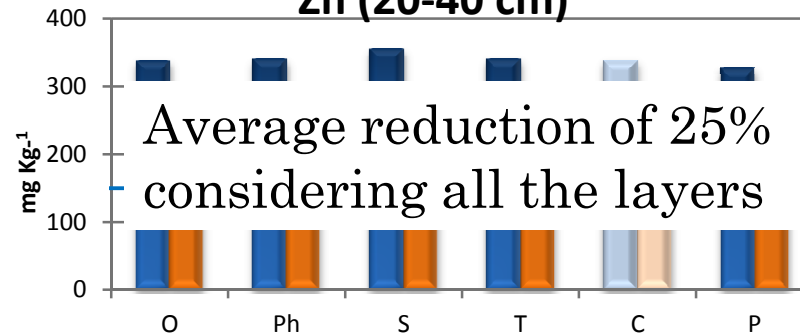
Column B=1500

Zn (0-20 cm)



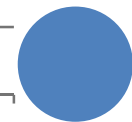
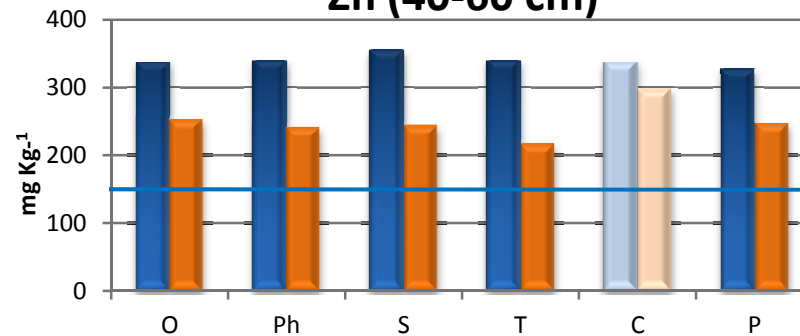
Column A (152/06)

Zn (20-40 cm)



Average reduction of 25%
considering all the layers

Zn (40-60 cm)



O= Oleander +Paspalum; Ph= Phragmites; S= Spartium+Paspalum; T= Tamarix+Paspalum; C=Control; P= Paspalum

DECONTAMINATION

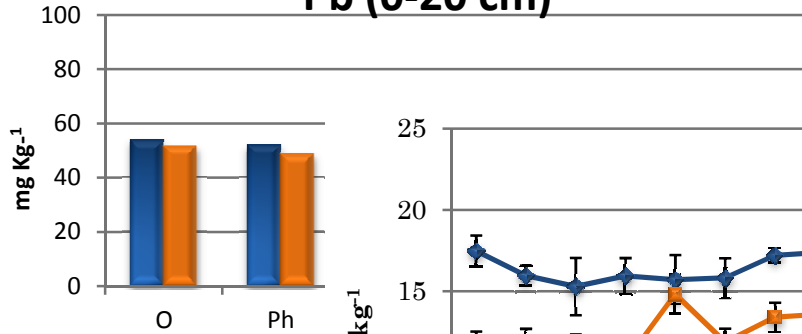


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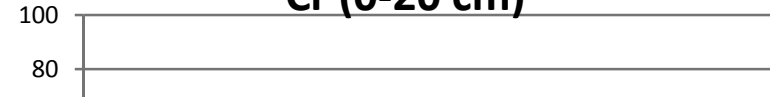
Column A=100
Column B=1000

Column A=150
Column B=800

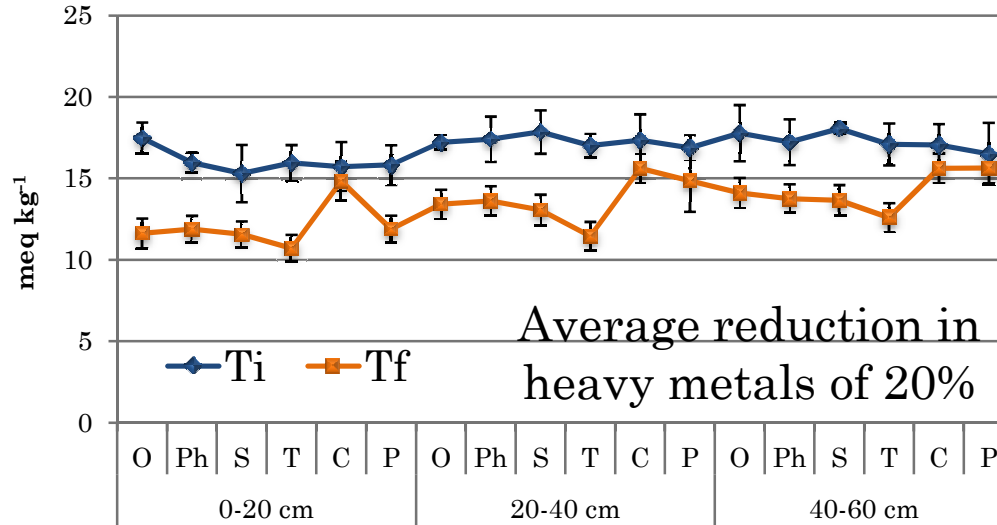
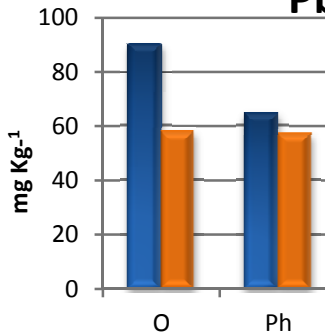
Pb (0-20 cm) ■ Ti ■ Tf



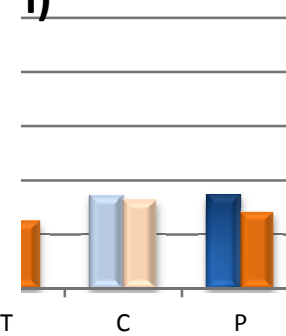
Cr (0-20 cm)



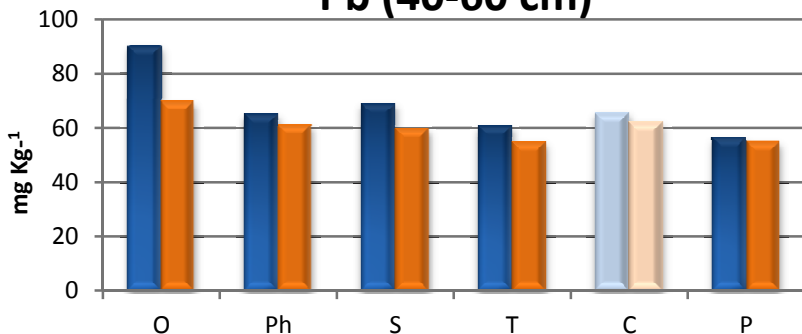
Pb



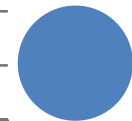
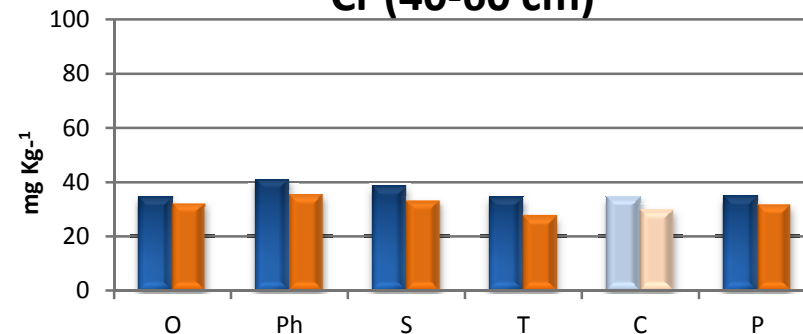
1)



Pb (40-60 cm)



Cr (40-60 cm)



O= Oleander +Paspalum; Ph= Phragmites; S= Spartium+Paspalum; T= Tamarix+Paspalum; C=Control; P= Paspalum

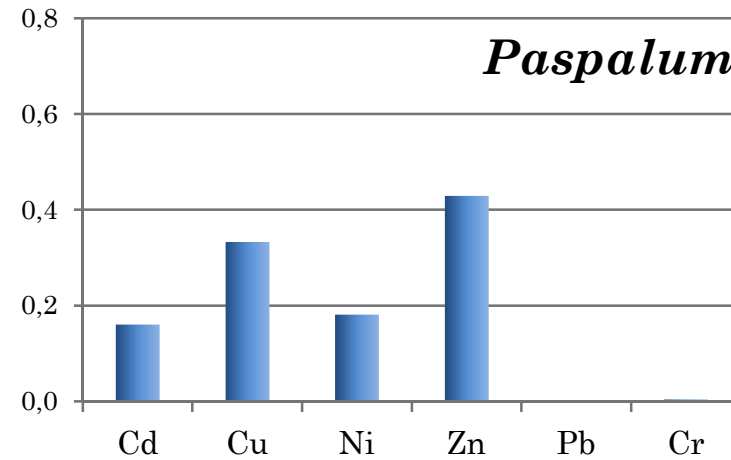
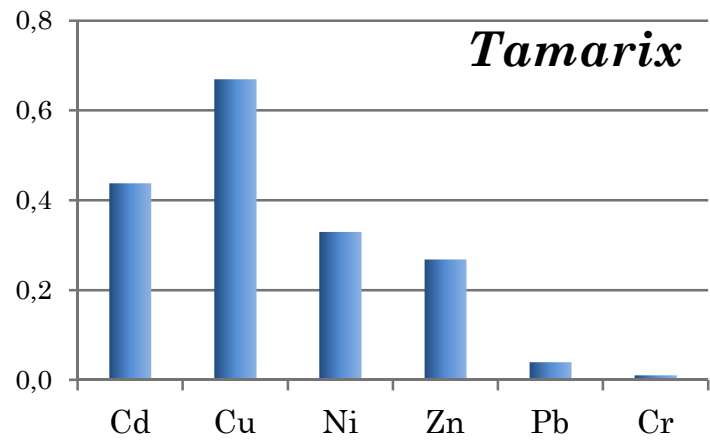
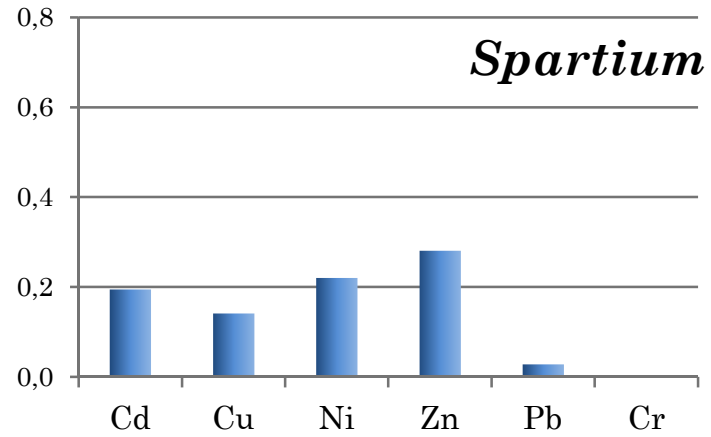
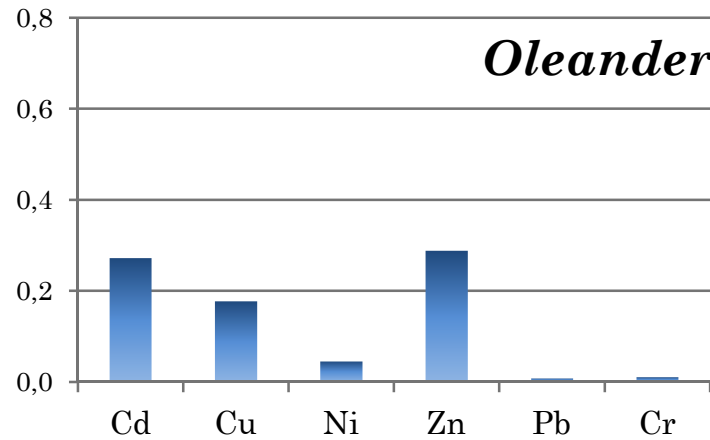


LEACHATE CHARACTERIZATION (SAMPLING MAY 2012)

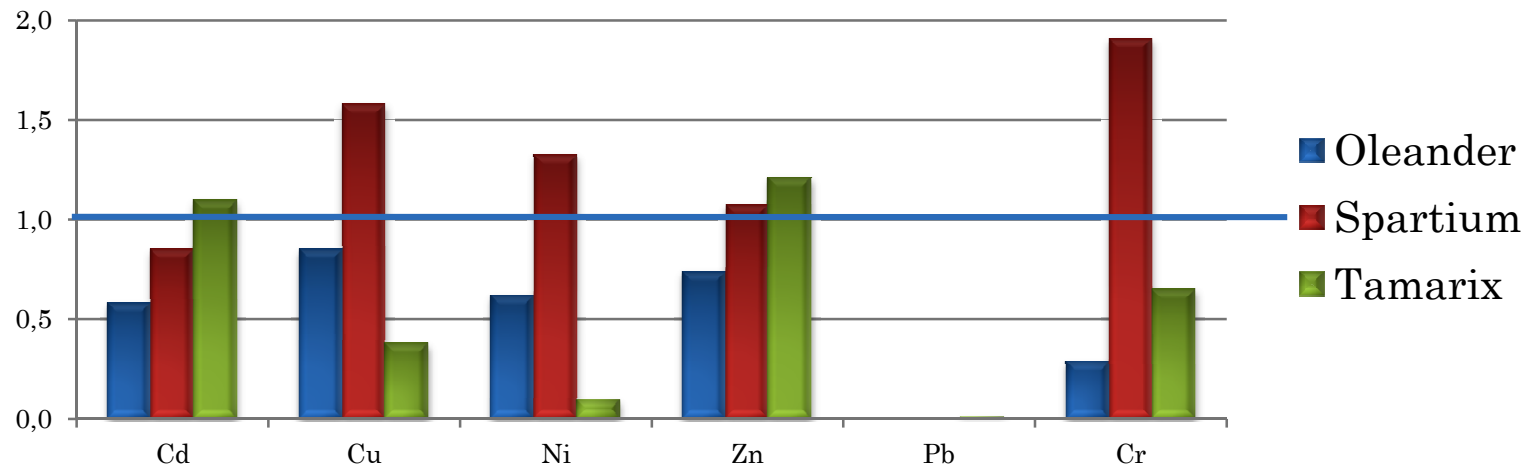
	1	2	3	4
	mg/l			
pH	8.2	8.3	8.2	8.3
TPH	0.026	0.10	0.044	0.075
Cd	<0.0003	<0.0003	<0.0003	<0.0003
Cr	<0.001	<0.001	<0.001	<0.001
Ni	0.032	0.027	0.038	0.035
Pb	<0.005	<0.005	<0.005	<0.005
Cu	0.008	0.016	0.006	0.012
Zn	0.003	0.004	<0.002	0.010

Dlg.152/2006	Cd	Cu	Ni	Zn	Pb	Cr
discharge in surface water	0.02	0.1	2.00	0.5	0.20	2.0
discharge in soil	-	0.1	0.20	0.5	0.1	1

BIOACCUMULATION FACTOR:
Concentration roots/sediments



TRANSLOCATION FACTOR: epigeic part/roots



Higher TF shown by *Spartium* for Cu, Ni and Cr

and by *Tamarix* for Cd and Zn





CONCLUSIONS

- ✓ After one year and a half from the experiment set up all the plant species were well adapted and in a healthy condition (plant growth 400-700%)
- ✓ An increase in the **dehydrogenase activity**, which is an enzyme related to the soil microbial functionality, was obtained at 20-40 and 40-60 cm in the shrub-grass treatments. This suggested an improvement of the chemical-physical conditions for microorganisms and plants
- ✓ The microbial metabolism stimulation in the plant treatments determined the higher efficiency of Ph, S and T plant species in **TPH (>50%)** removal with respect to the other treatments
- ✓ A general decrease in **heavy metal (20%)** content were obtained in the planted sediments with respect to the control sediments
- ✓ Very low concentrations of contaminants was measured in the leachate, if comparing the data with the Italian Legal limits (D.lgs. 152/2006)

Thanks for your attention

