ISTITUTO DI SCIENZE DELLA VITA

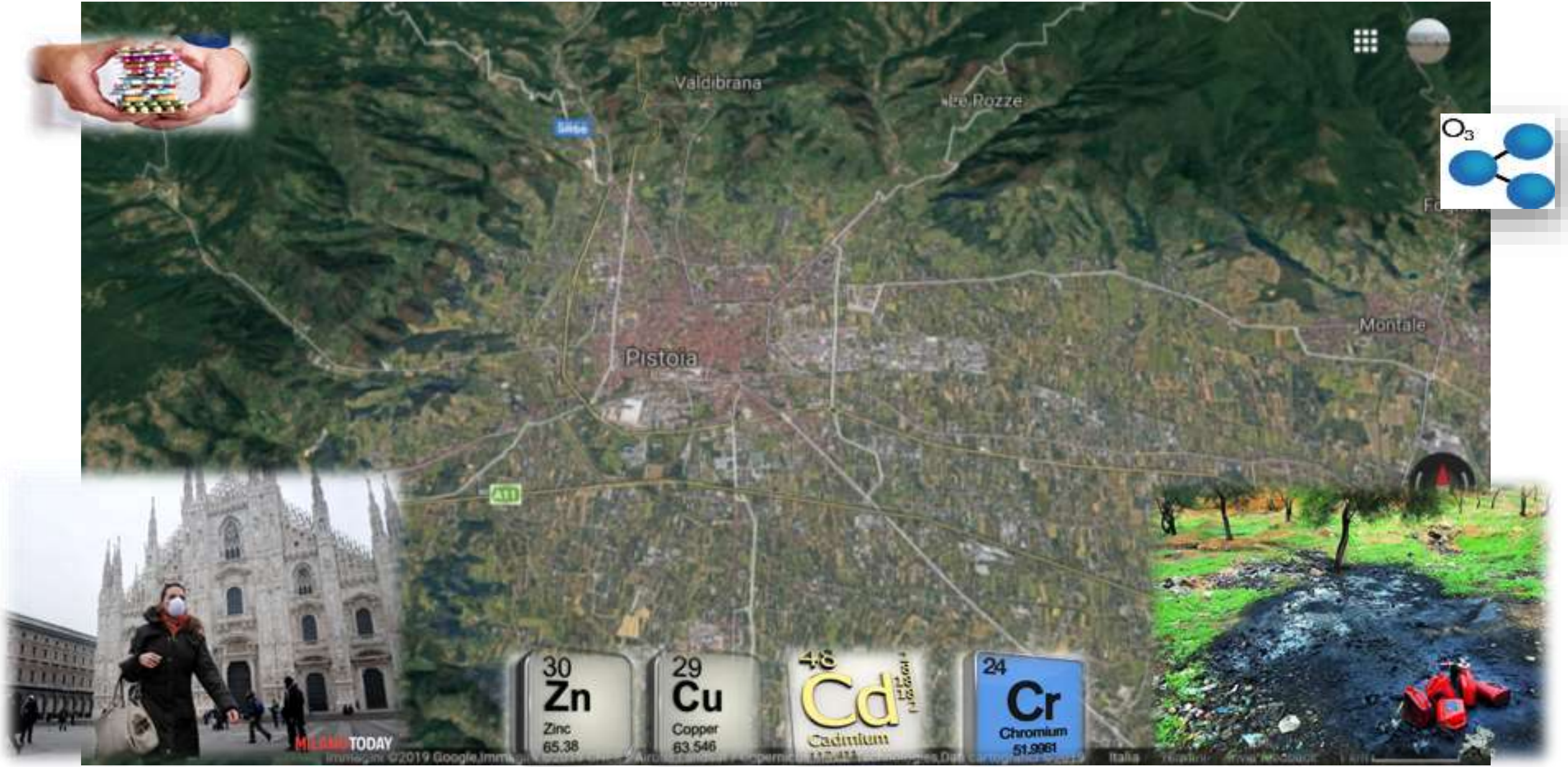
Sant'Anna Scuola Universitaria Superiore Pisa

Alberi e inquinamento: cosa fa la ricerca

Luca Sebastiani – luca.sebastiani@santannapisa.it

25 Ottobre 2019

Inquinamento Quali Sostanze e Dove?

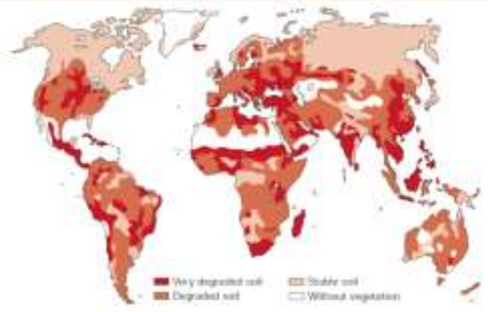


Antropocène

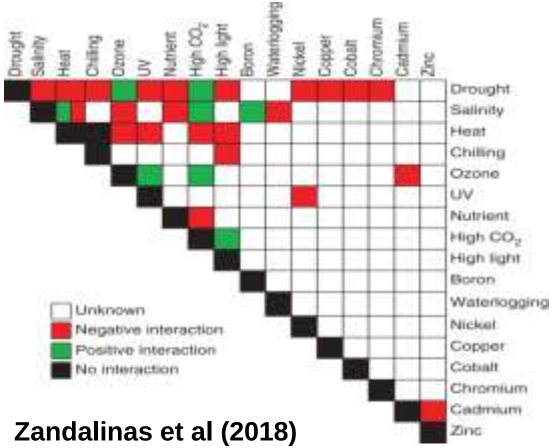
(*Paul Crutzen* - Nobel per la chimica atmosferica)

Cambiamento Climatico

Degradazione Suolo



Inquinamento



Zandalinas et al (2018)
Physiologia Plantarum 162: 2–12

Quali sono gli inquinanti più importanti ?

Inquinamento Atmosferico

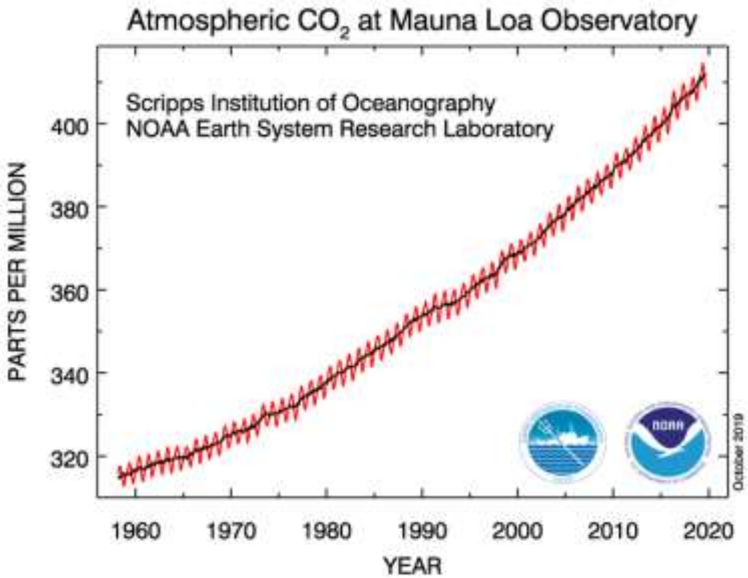
L'inquinamento atmosferico nuoce all'ambiente e alla salute umana. In Europa, **le emissioni di molti inquinanti atmosferici sono diminuite in modo sostanziale negli ultimi decenni**, determinando una migliore qualità dell'aria nella regione. **Le concentrazioni di inquinanti sono tuttavia ancora troppo elevate** e i problemi legati alla qualità dell'aria persistono. Una parte significativa della popolazione europea vive in zone, in particolar modo nelle città, in cui si superano i limiti fissati dalle norme in materia di qualità dell'aria: l'inquinamento da **ozono, biossido di azoto e particolato** pone gravi rischi per la salute. Diversi paesi hanno superato uno o più dei loro limiti relativi alle emissioni per il 2010 per quattro importanti inquinanti atmosferici. Ridurre l'inquinamento atmosferico, quindi, continua a essere importante

Agenzia europea dell'ambiente

Inquinamento Atmosferico

2019-10-22 20:00

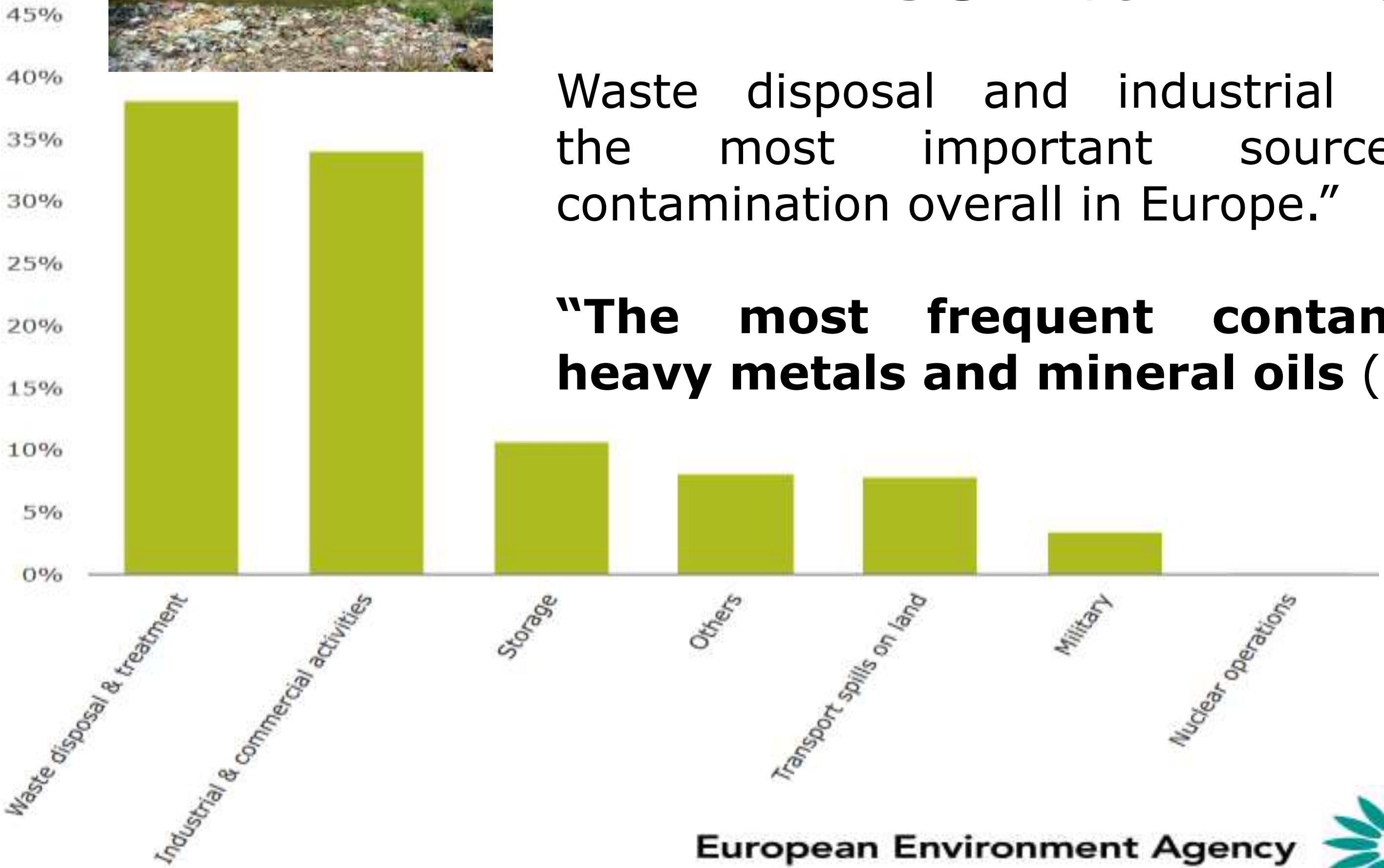
Ozono
Anidride Solforosa
Particolato
Anidride Carbonica



Soil contamination

Waste disposal and industrial activities are the most important sources of soil contamination overall in Europe.”

“The most frequent contaminants are heavy metals and mineral oils (EEA, 2014)”



European Environment Agency

Introduction to Organic Contaminants in Soil: Concepts and Risks

L. Valentín, A. Nousiainen, and A. Mikkonen

Table 1 Type and source of the most relevant group of contaminants in European soils

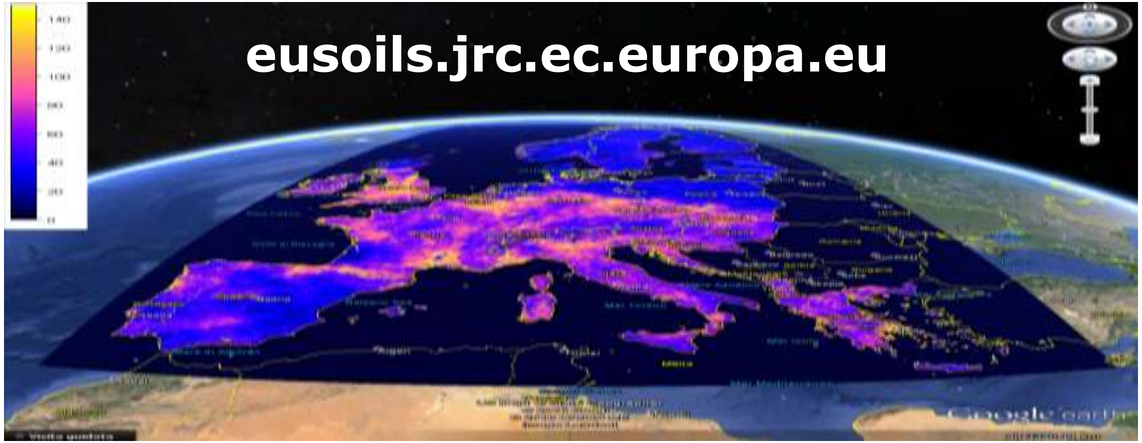
Contaminants	Example of compounds	Source of contamination[a]	Estimated percentage[b]	References
Heavy metals	Cu, Zn, Cd, Pb, Hg, Cr	Application of animal manure (D) Military facilities (P) Gasoline stations (P) Sawmills and wood preservation sites (P) Mining and metallurgical industry (P,D)	37.3	[21, 42]
Oil hydrocarbons	Alkanes, alkenes, cycloalkanes	Oil industry (P,D)	33.7	[23]
Chlorinated compounds	PCP, PCBs, PCDD/Fs	Manufacture of pesticide and herbicide (D) Wood preservation sites (P) Pulp and paper production (P) Municipal waste incineration (P,D) Plastics, fire-retardants manufacture (P,D)	Chlorinated phenols – 3.6 Chlorinated hydrocarbons – 2.4	[43, 44]
Monomeric aromatic hydrocarbons	Benzene, toluene, ethylbenzene, xylene (BTEX)	Oil industry (P,D) Gasoline stations (P) Manufactured gas plants (P,D)	6	[43]
PAHs	Benzo[a]pyrene, chrysene, fluoranthene	Oil industry (P,D) Gasoline stations (P) Manufactured gas plants (P,D) Wood preservation sites (P) Municipal waste incineration (P,D) Automobile exhaust (D)	13.3	[43, 45]
Nitroaromatics	TNT, nitrobenzene, nitrophenols, atrazine	Manufacture of aniline, dyes, drugs (P,D) Explosive industry, military facilities (P, D) Manufacture of pesticides and herbicides (D)	[c]	[46]

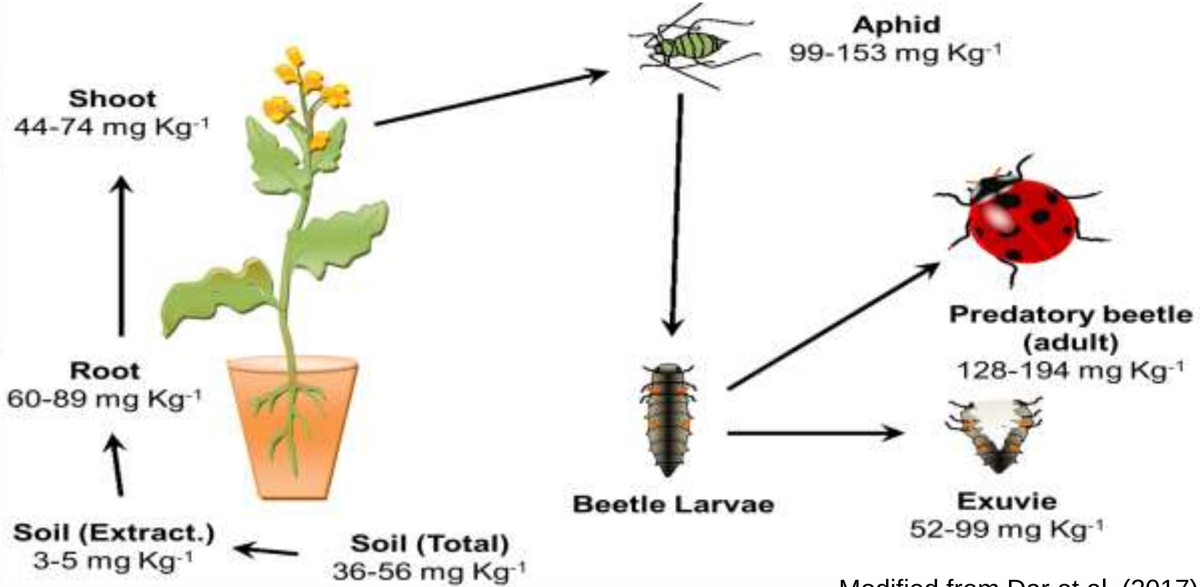
[a]P = point contamination; D = diffuse contamination
[b]According to the European Environmental Agency, the estimated percentage is based on the frequency with which a specific contaminant is reported to be the most important in the investigated site [23]
[c]Information not available

Zinc is an essential element for both plants and humans, but it is toxic in excess amounts

Zinc is propagated throughout the food chain by bioaccumulation

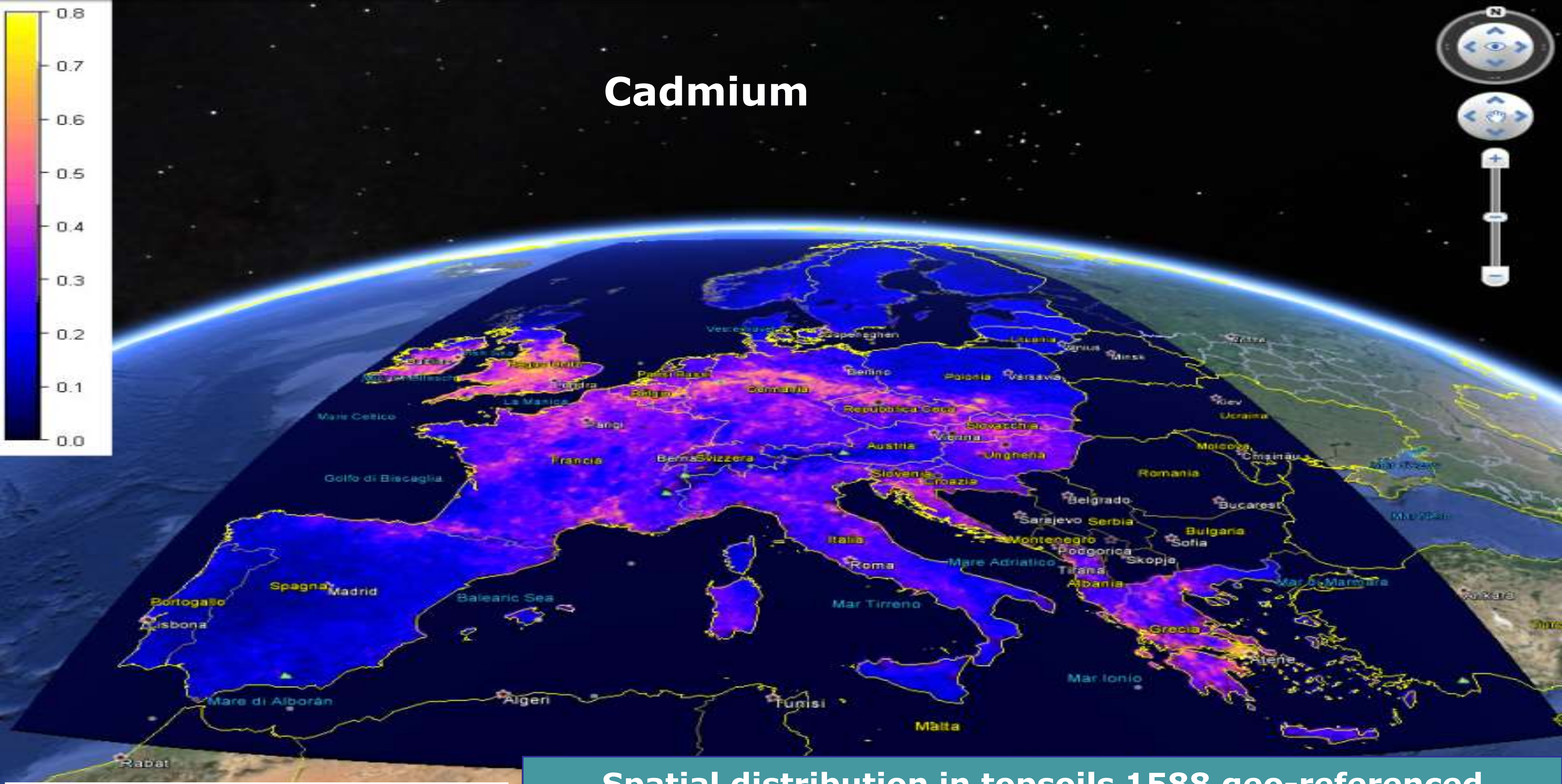
Zinc excess in soil might be either of geological or anthropogenic origin.





Modified from Dar et al. (2017)

Cadmium



JOINT RESEARCH CENTRE
EUROPEAN SOIL DATA CENTRE (ESDAC)

Spatial distribution in topsoils 1588 geo-referenced samples FOREGS Geochemical database (Source: European Soil Data Center, http://eusoils.jrc.ec.europa.eu/)

A GLOBAL WATER-QUALITY CRISIS AND THE ROLE OF AGRICULTURE

Xenobiotici Emergenti

Emerging Contaminants

Pharmaceutical and Personal Care Products







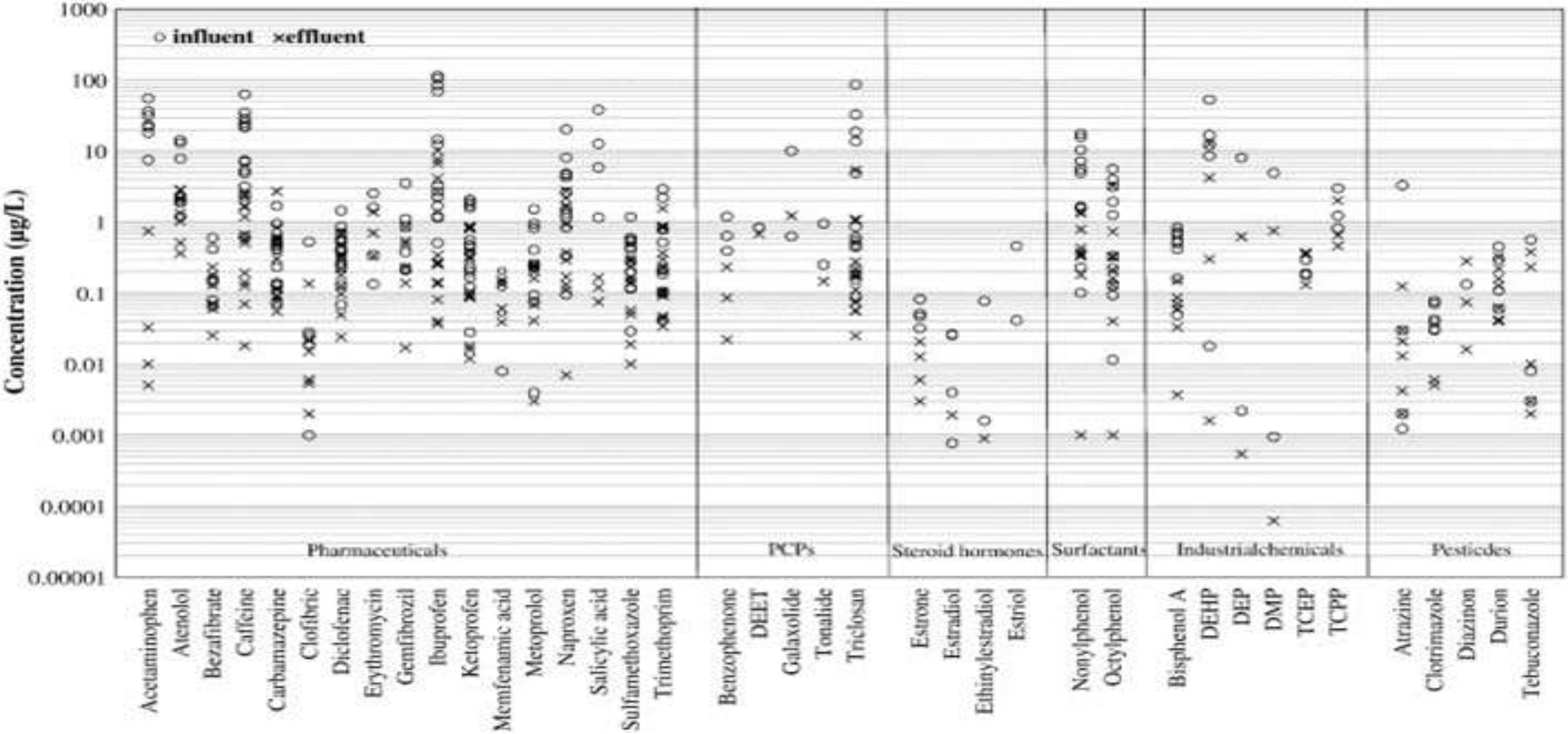




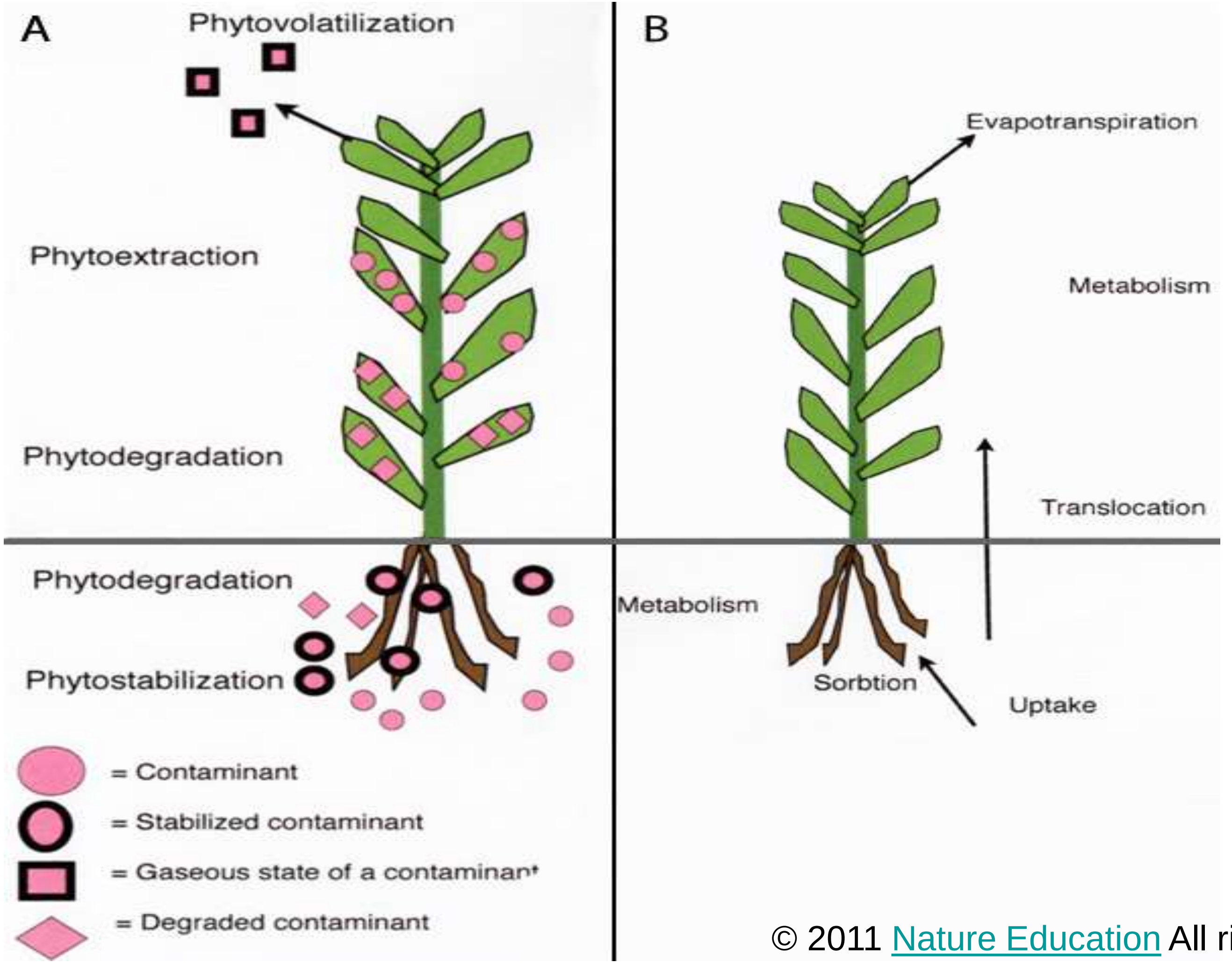
Continuously released into the aquatic environment

Not efficiently removed by traditional wastewater treatment plants

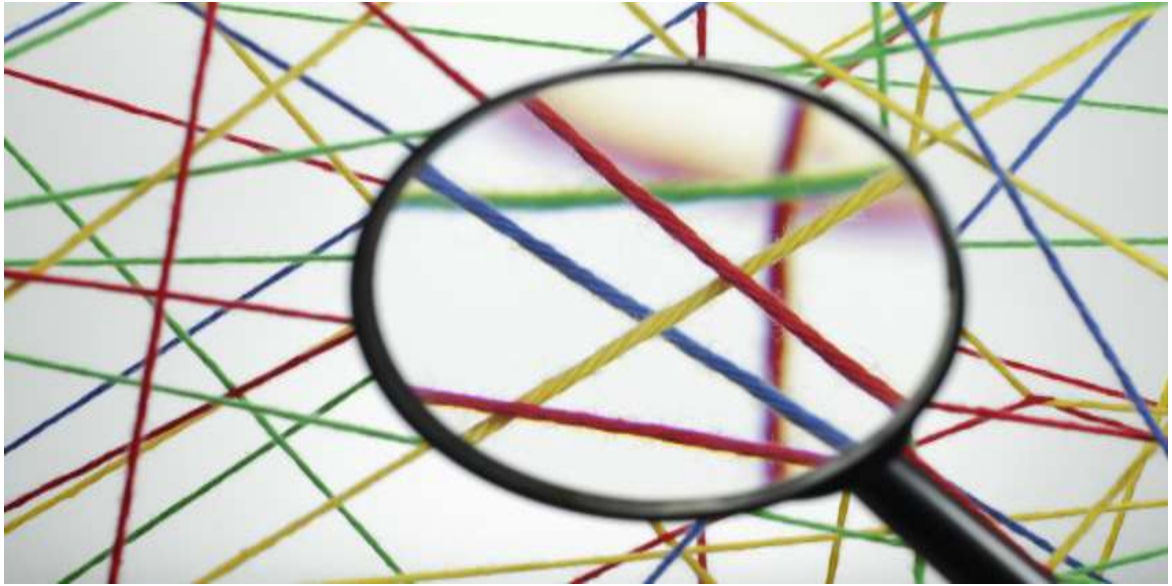
Luo et al., 2014

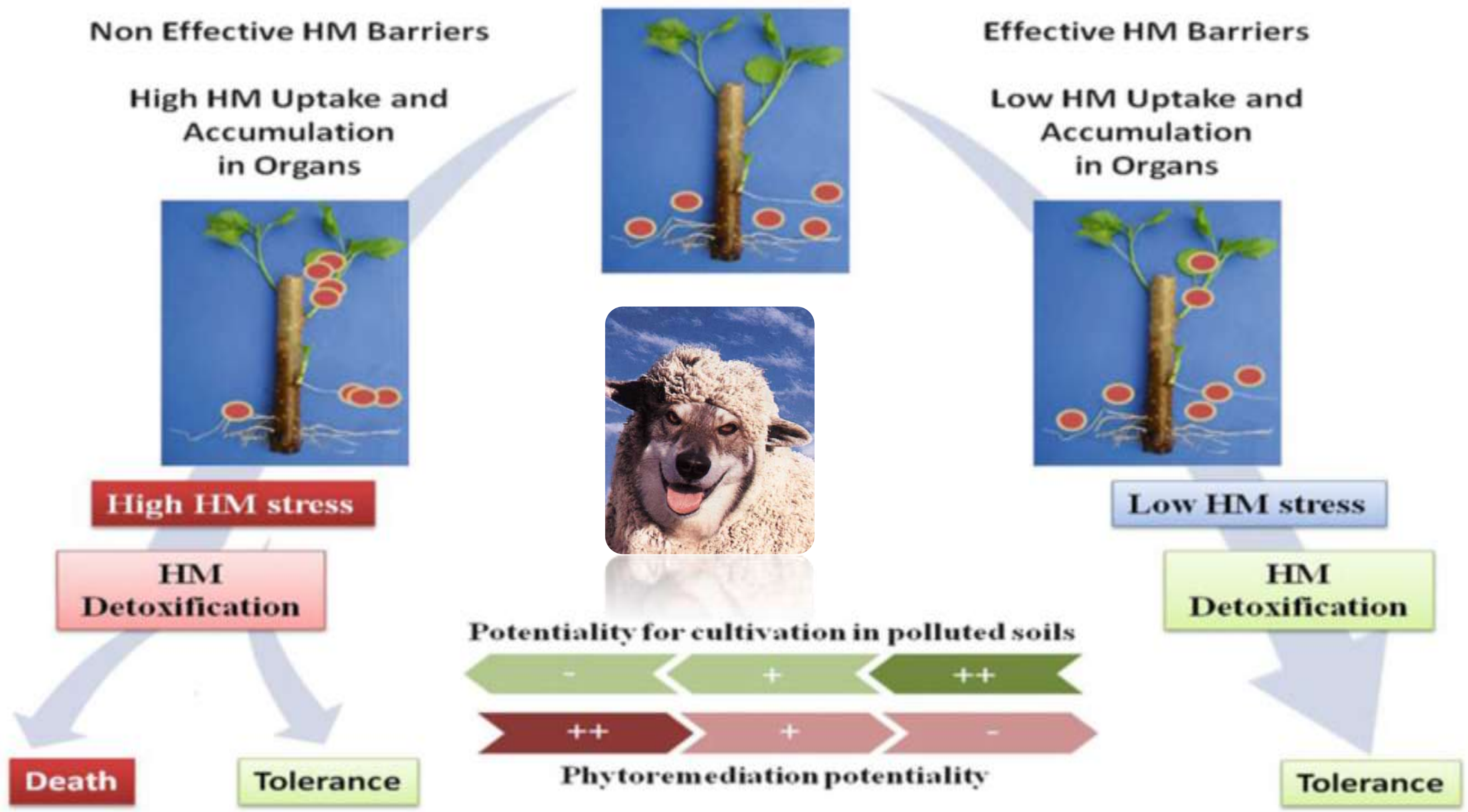


Piante ?


A
Phytovolatilization
Phytoextraction
Phytodegradation
Phytodegradation
Phytostabilization
= Contaminant
= Stabilized contaminant
= Gaseous state of a contaminant
= Degraded contaminant
B
Evapotranspiration
Metabolism
Translocation
Metabolism
Sorbtion
Uptake

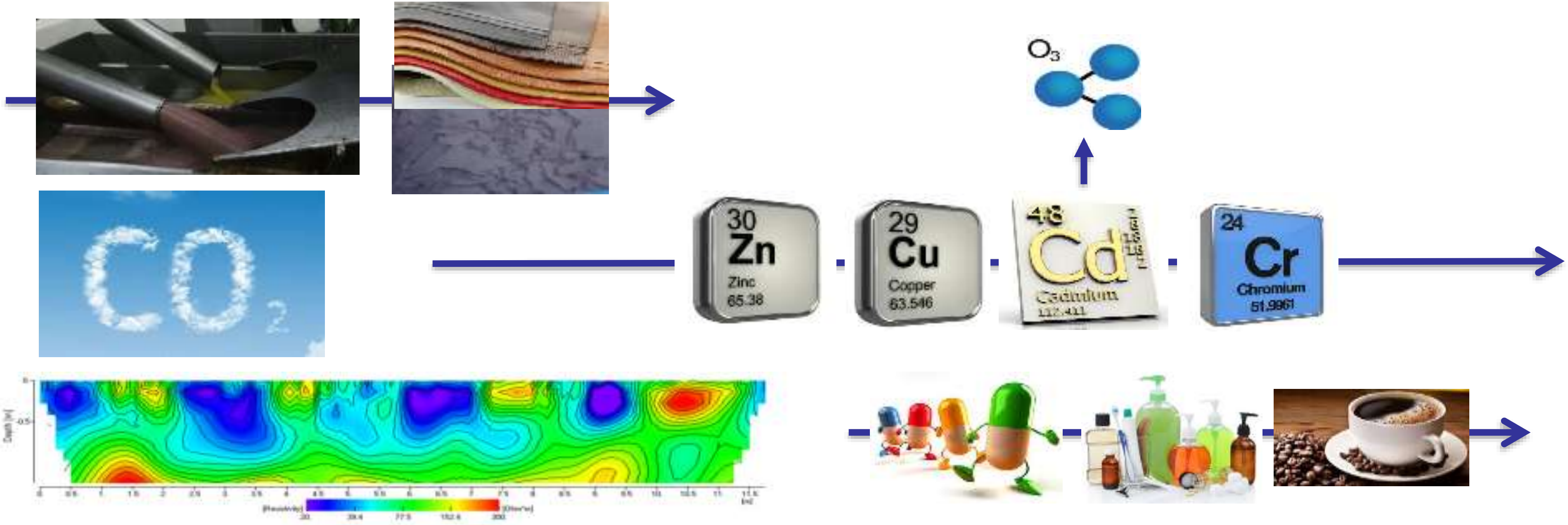
Il nostro approccio al problema

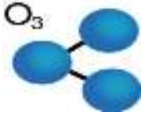




Sebastiani L. et al. (2014). Heavy metals stress on poplar: molecular and anatomical modifications. In: Approaches to Plant Stress and their Management, pp 267-279 – Springer.

Campo Serra Cella di Crescita Vitro




O_3


CO_2

Ozone: **100 ppb**

Control: **< 3 ppb**

5 h day-1

Tree Physiology 19, 391–397

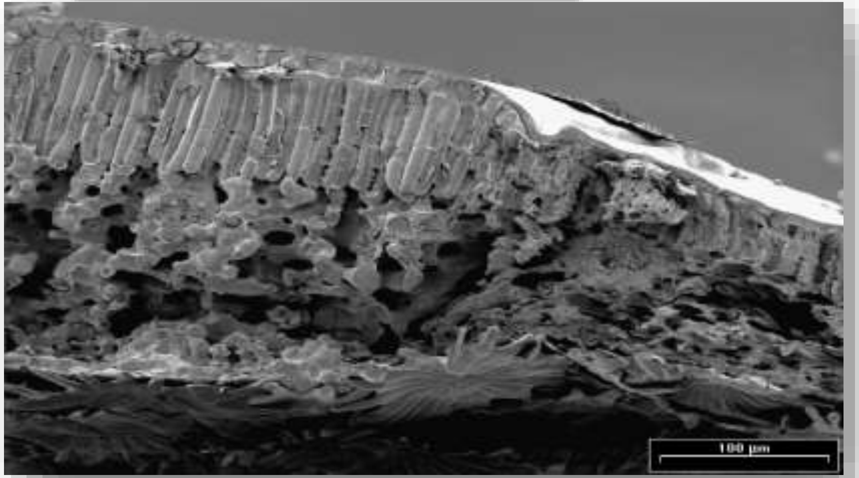
Physiological and morphological responses of olive plants to ozone exposure during a growing season

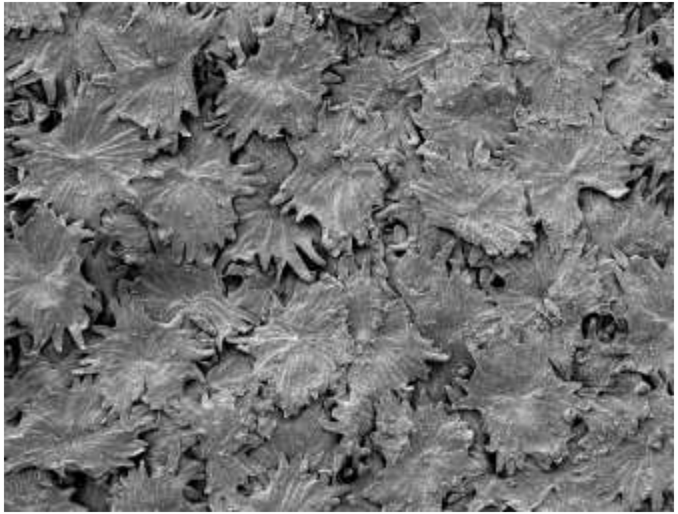
ANTONIO MINNOCCI,[1] ALBERTO PANICUCCI,[2] LUCA SEBASTIANI,[1] GIACOMO LORENZINI[2] and CLAUDIO VITAGLIANO[1]

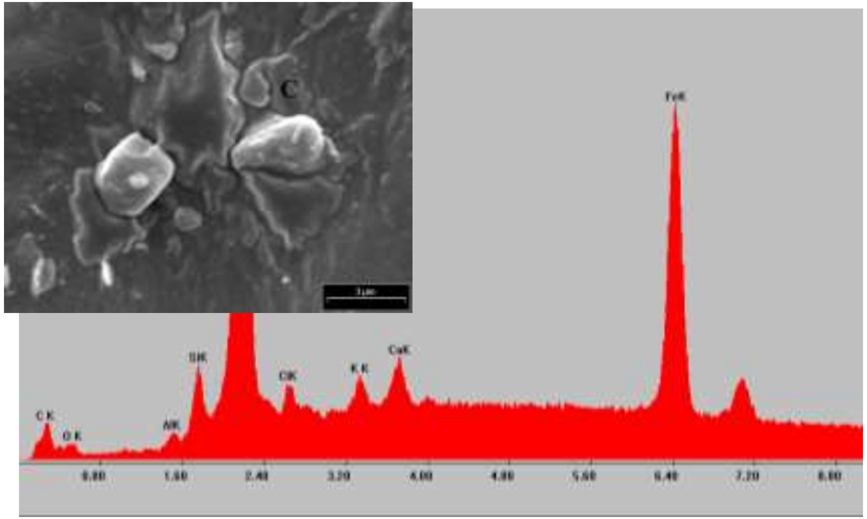
0 *Cv.* Frantoio — 100 — 120 (days)

Cv. Moraiolo

Leaf drop and development of necrotic spots





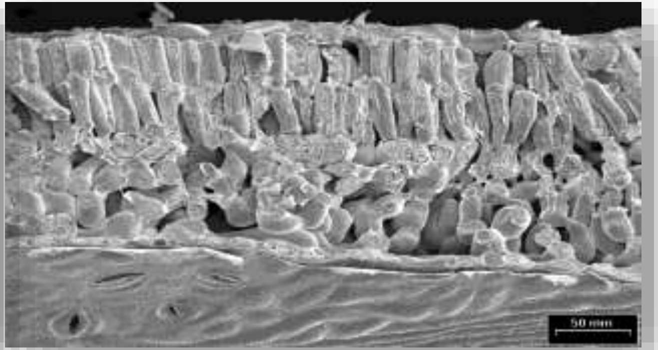

C
FeK
C K
O K
AlK
SiK
ClK
K K
CaK
1.60
2.40
3.20
4.00
5.60
6.40
7.20
8.00

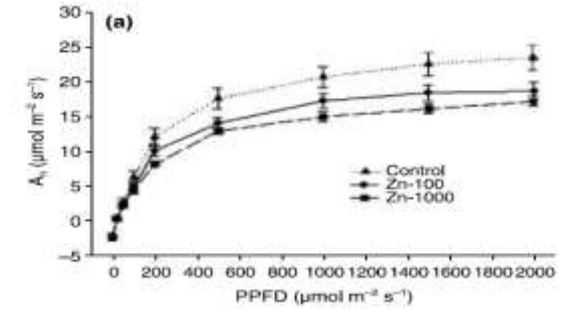

30
Zn
Zinc
65.38
29
Cu
Copper
63.546
48
Cd
Cadmium
24
Cr
Chromium
51.9961

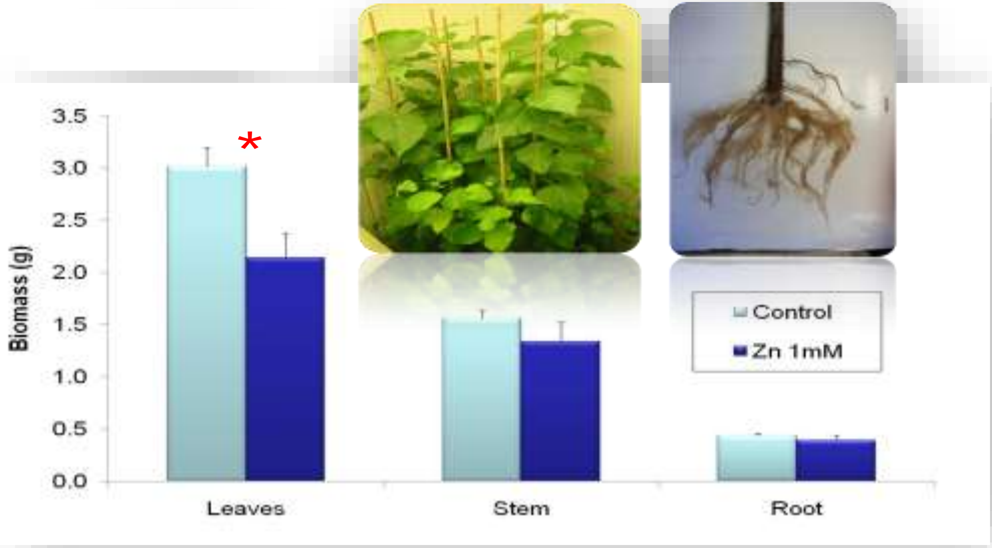
Modello sperimentale

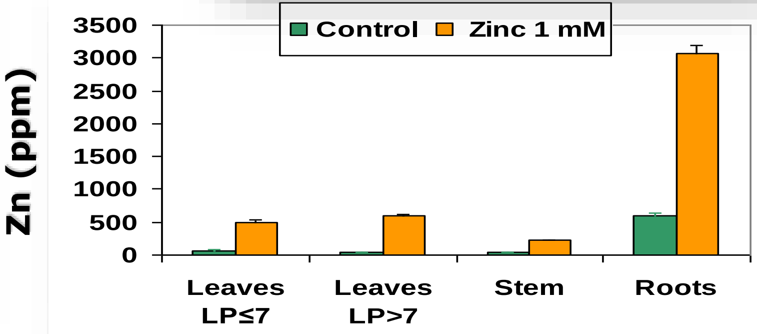
I-214

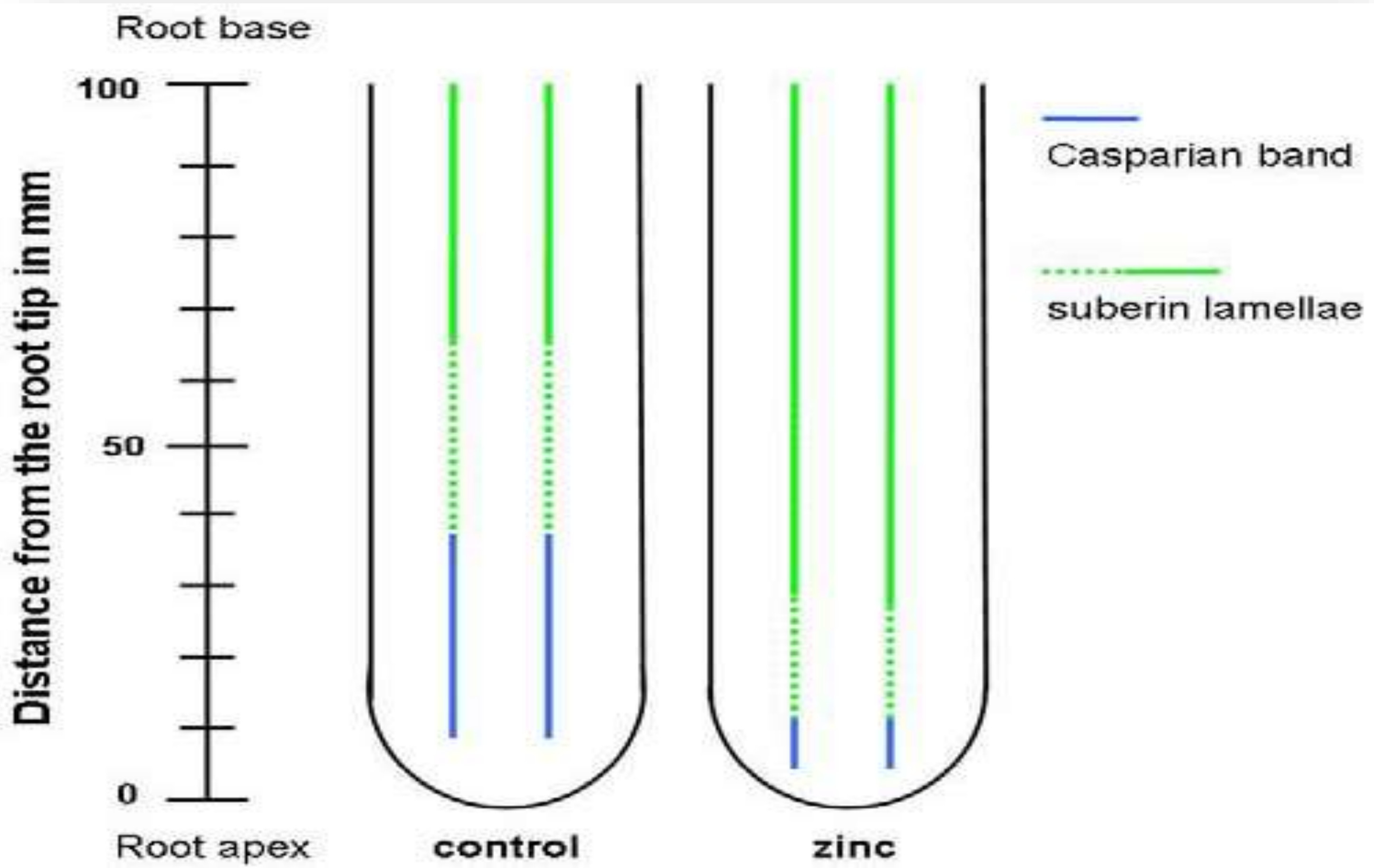
- **Biomassa**
- **Fotosintesi**
- **Zn Uptake**

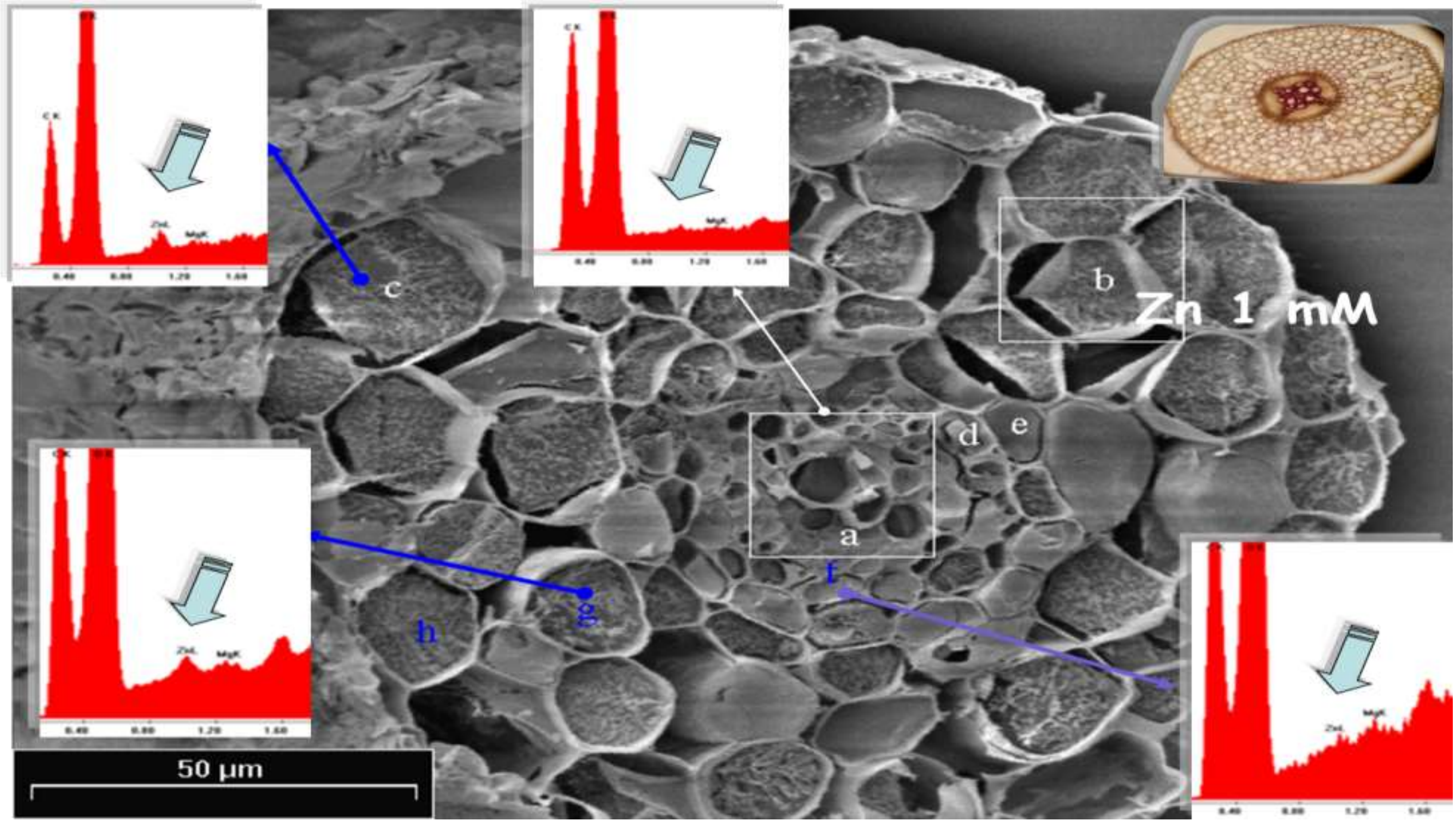






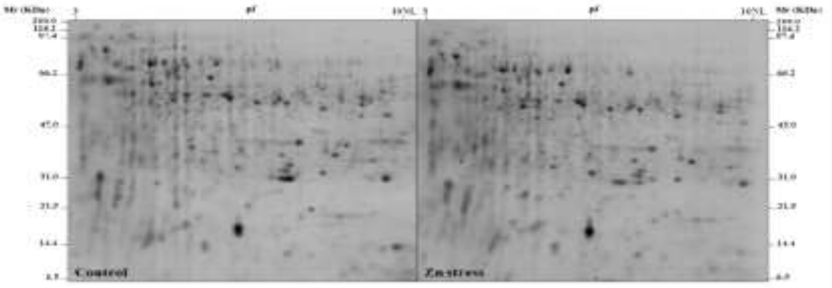



Root base
100
50
0
Root apex
Distance from the root tip in mm
control
zinc
Casparian band
suberin lamellae



Zn 1 mM
a
b
c
d
e
f
g
h
50 µm

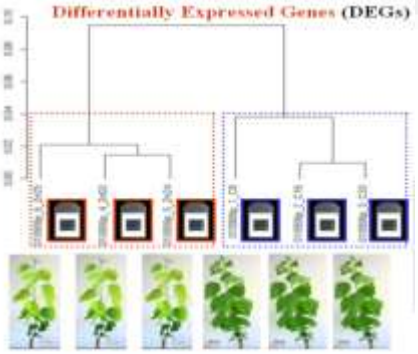
Meccanismi molecolari coinvolti nell’omeostasi



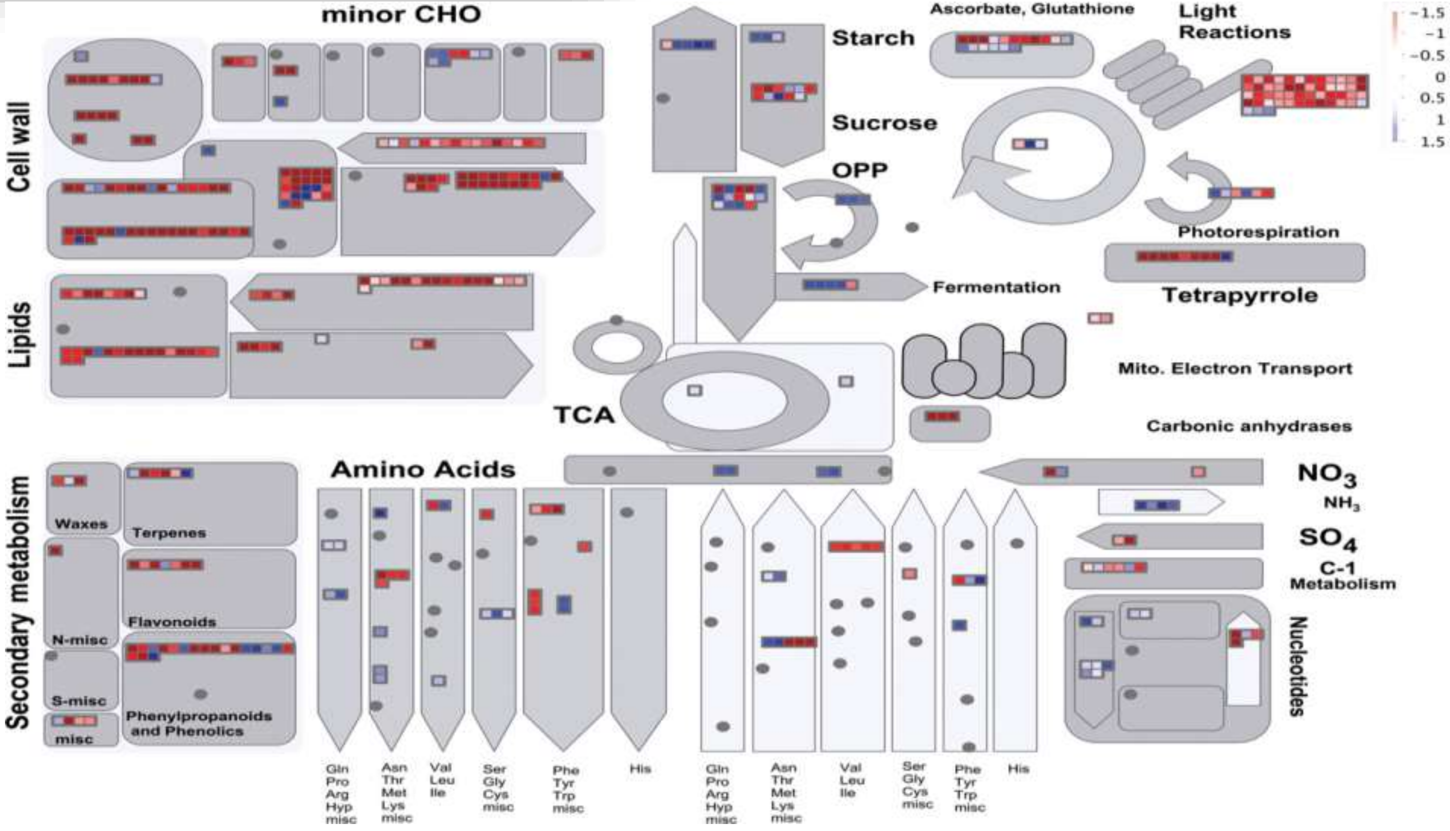
Transcriptome analyses of *Populus* × *euramericana* clone I-214 leaves exposed to excess zinc

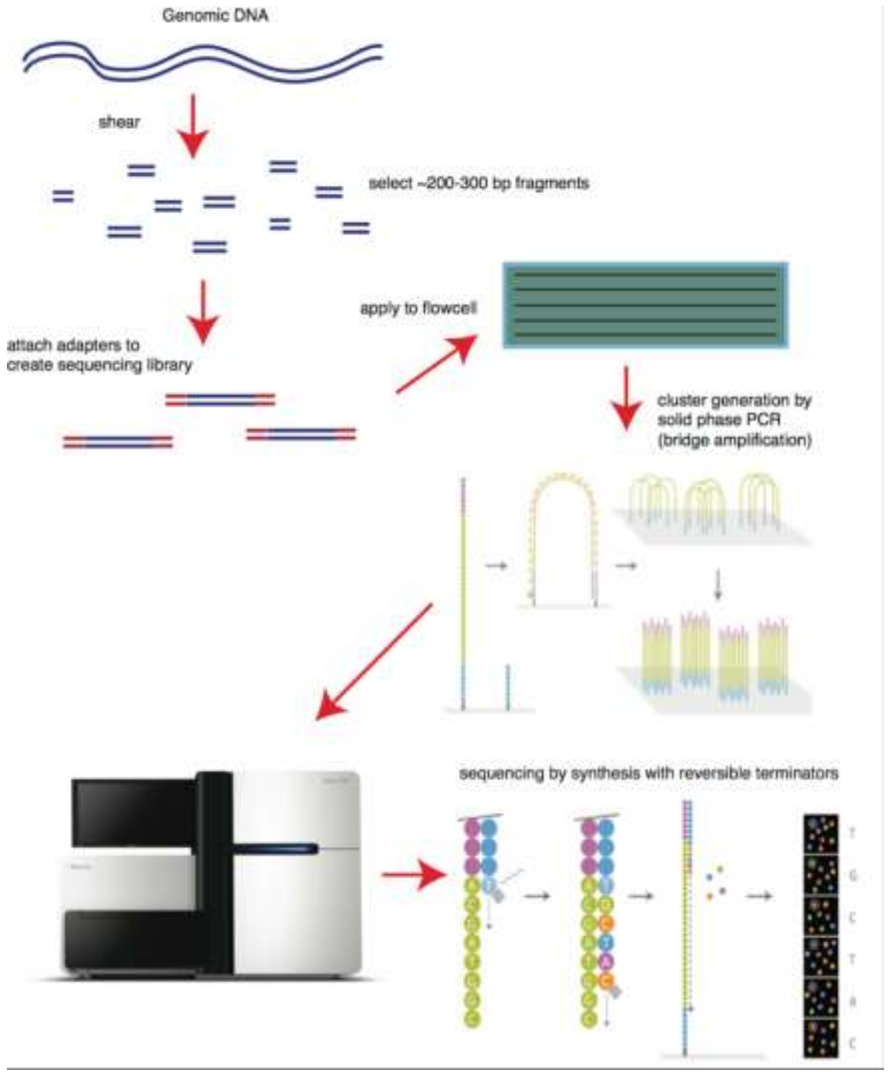
Daniela Di Baccio[1,5], Giulio Galla[2], Tania Bracci[1], Andrea Andreucci[3], Gianni Barcaccia[2], Roberto Tognetti[4] and Luca Sebastiani[1]

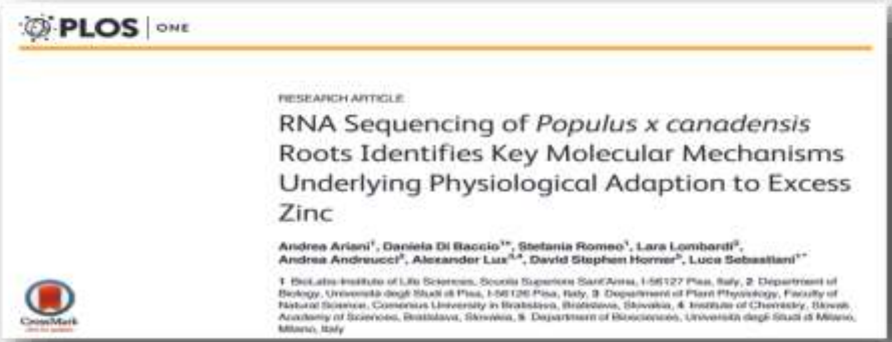
[1] BioLabs, Life Sciences Institute, Scuola Superiore Sant'Anna, Piazza Martiri della Libertà 33, I-56127 Pisa, Italy; [2] Department of Environmental Agronomy and Crop Science, Università degli Studi di Padova, Viale dell'Università 16, I-35020 Legnaro (Padova), Italy; [3] Department of Biology, Università di Pisa, Via L. Ghini 5, I-56100 Pisa, Italy; [4] EcoGeoFor and Dendro Labs—Dipartimento di Scienze e Tecnologie per l'Ambiente e il Territorio, Università degli Studi del Molise, Contrada Fonte Lappone, I-86090 Pesche, Italy; [5] Corresponding author (d.dibaccio@sssup.it)



AFFYMETRIX®





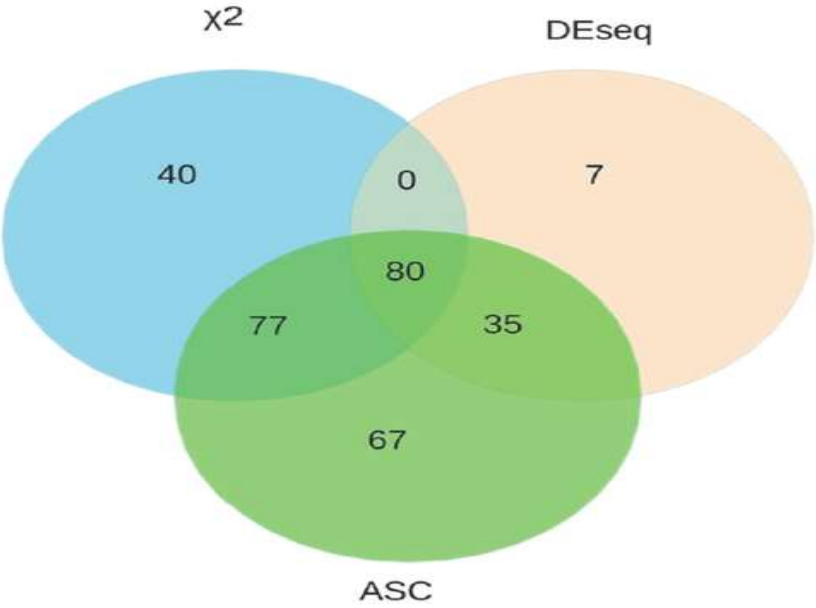

PLOS | ONE

RESEARCH ARTICLE

RNA Sequencing of *Populus x canadensis* Roots Identifies Key Molecular Mechanisms Underlying Physiological Adaption to Excess Zinc

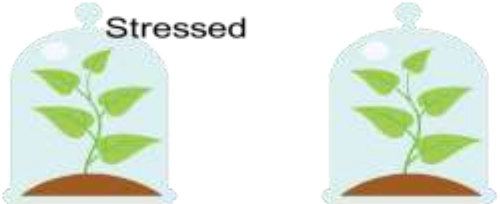
Andrea Ariani[1], Daniela Di Baccio[1*], Stefania Romeo[1], Lara Lombardi[2], Andrea Andreucci[2], Alexander Lux[3,4], David Stephen Horner[5], Luca Sebastiani[1*]

1 BioLabs Institute of Life Sciences, Scuola Superiore Sant'Anna, I-56127 Pisa, Italy, 2 Department of Biology, Università degli Studi di Pisa, I-56126 Pisa, Italy, 3 Department of Plant Physiology, Faculty of Natural Science, Comenius University in Bratislava, Bratislava, Slovakia, 4 Institute of Chemistry, Slovak Academy of Sciences, Bratislava, Slovakia, 5 Department of Biosciences, Università degli Studi di Milano, Milano, Italy



Control

Stressed



Protein extraction and sample preparation in TCA/acetone

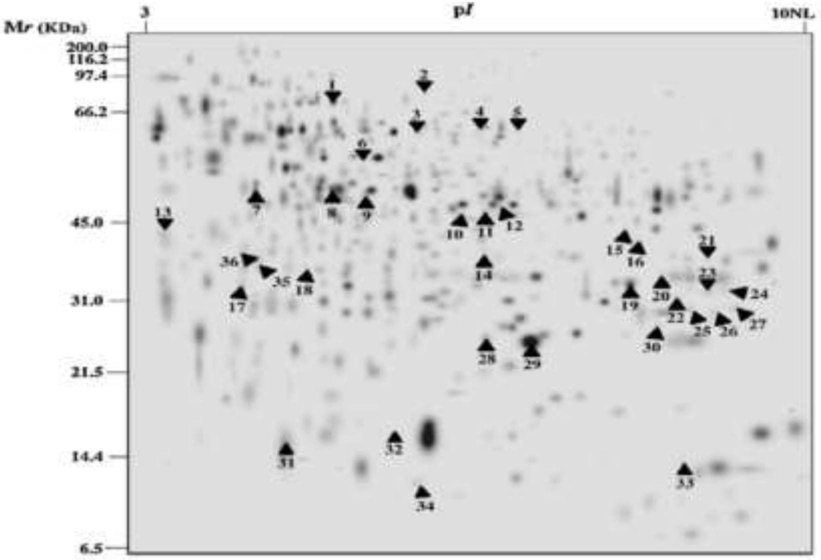


Fig. 3. Filtered image of the two-dimensional electrophoresis proteome reference map of *Populus × euramericana* (I-214 clone) root. Differentially represented protein spots between Zn-treated and control roots are indicated. Spot numbering corresponds to the proteins listed in Table 2.

Journal of Plant Physiology 171 (2014) 1054–1063

Contents lists available at ScienceDirect

Journal of Plant Physiology

journal homepage: www.elsevier.com/locate/jplph

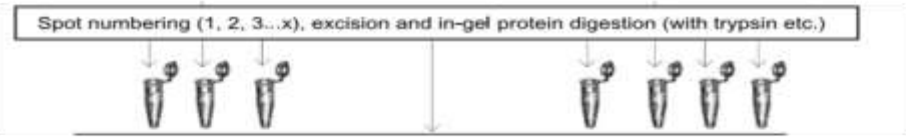
Physiology

Proteomic analysis of *Populus × euramericana* (clone I-214) roots to identify key factors involved in zinc stress response

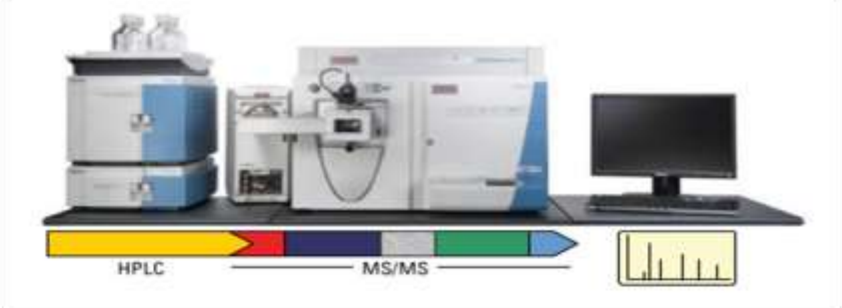
Stefania Romeo[a,1], Dalila Trupiano[b,1], Andrea Ariani[a], Giovanni Renzone[c], Gabriella S. Scippa[b], Andrea Scaloni[c], Luca Sebastiani[a,*]

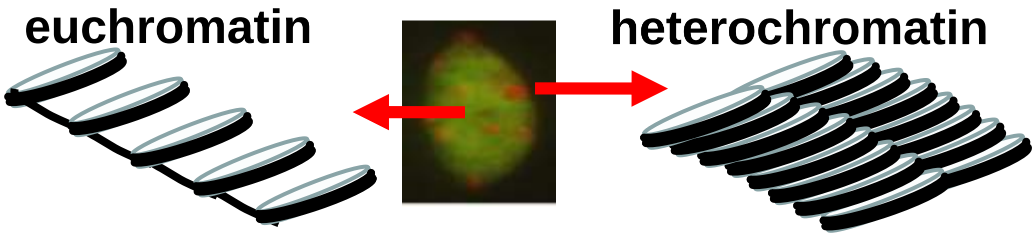
Spot identification and gel protein digestion

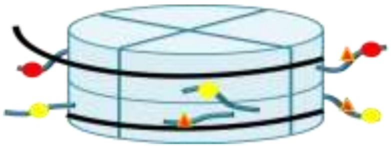
Protein identification

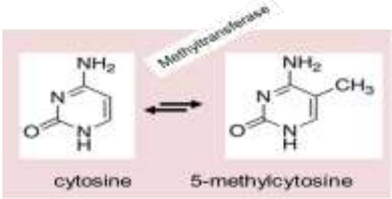


nanoLC-ESI-LIT-MS/MS and protein identification









Epigenetic modifications of chromatin structure are extremely important in mediating stress responses in plants. Epigenetic modifications are especially important in perennial species such as trees, where they contribute to phenotypic plasticity and adaptation to unfavorable environments.

Environmental and Experimental Botany 132 (2016) 16–27

Contents lists available at ScienceDirect

Environmental and Experimental Botany

journal homepage: www.elsevier.com/locate/envexpbot

ELSEVIER

Comparative epigenomic and transcriptomic analysis of *Populus* roots under excess Zn

Andrea Ariani[a,*], Stefania Romeo[a], Andrew T. Groover[b,c], Luca Sebastiani[a]

[a] BioLabs, Institute of Life Sciences, Scuola Superiore Sant'Anna, Piazza Martiri della Libertà, 33, 56127 Pisa, Italy
[b] US Forest Service, Pacific Southwest Research Station, Davis, CA 95618, USA
[c] Department of Plant Biology, University of California, Davis, CA 95618, USA

Water Air Soil Pollut (2014) 225:1813
DOI 10.1007/s11270-013-1813-9

Variabilità genetica …

Phytoremediation of Zn: Identify the Diverging Resistance, Uptake and Biomass Production Behaviours of Poplar Clones Under High Zinc Stress

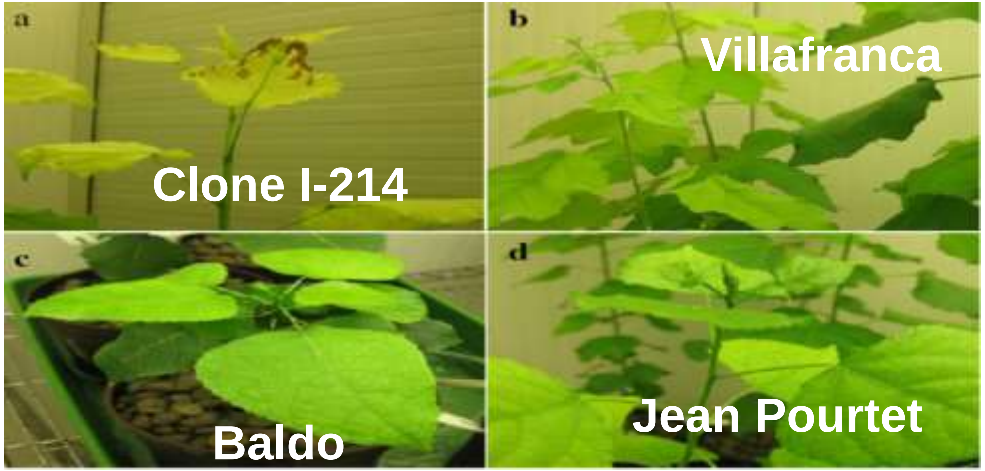
Stefania Romeo · Alessandra Francini ·
Andrea Ariani · Luca Sebastiani

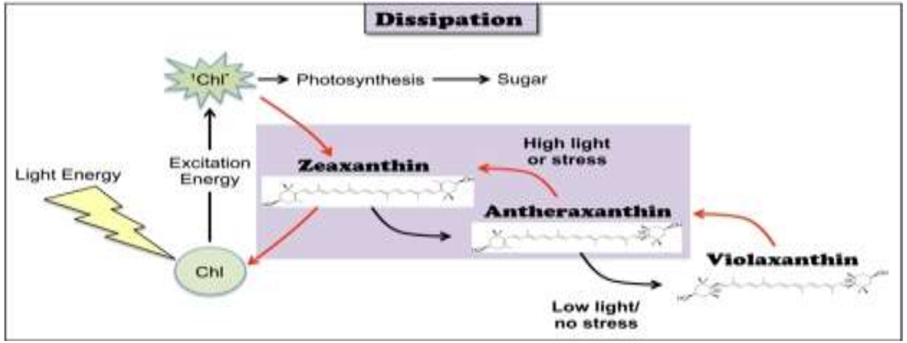
I-214
Populus x euramericana

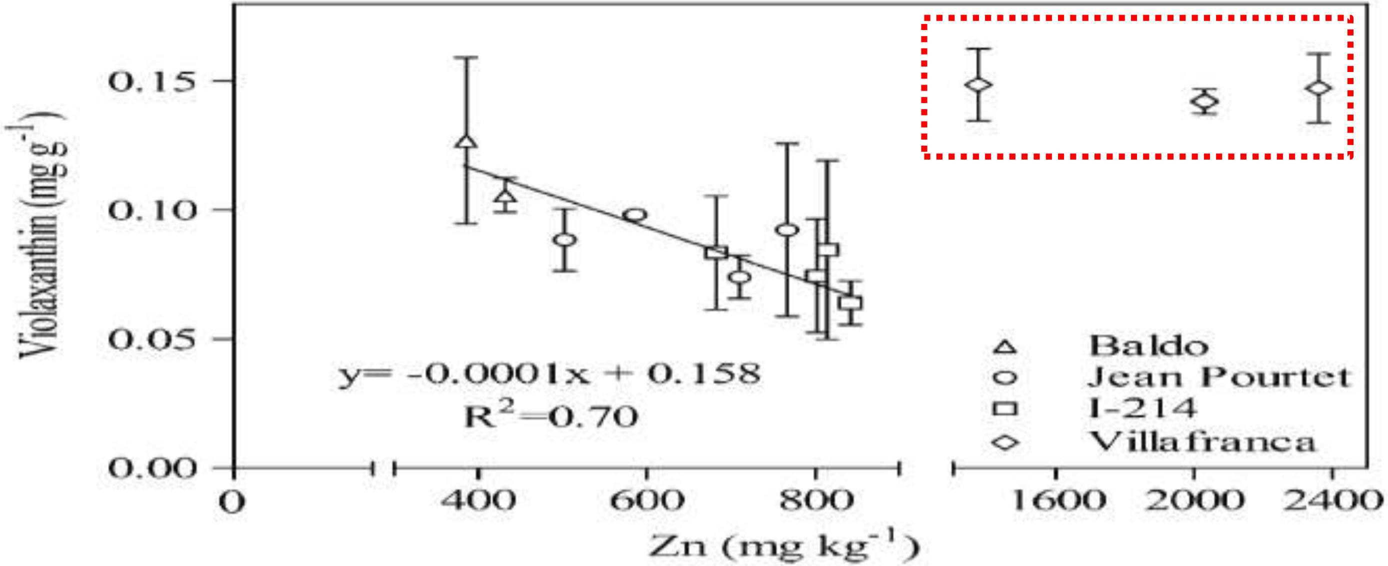
Jean Pourtet
Populus nigra

Baldo
Populus deltoides

Villafranca
Populus alba

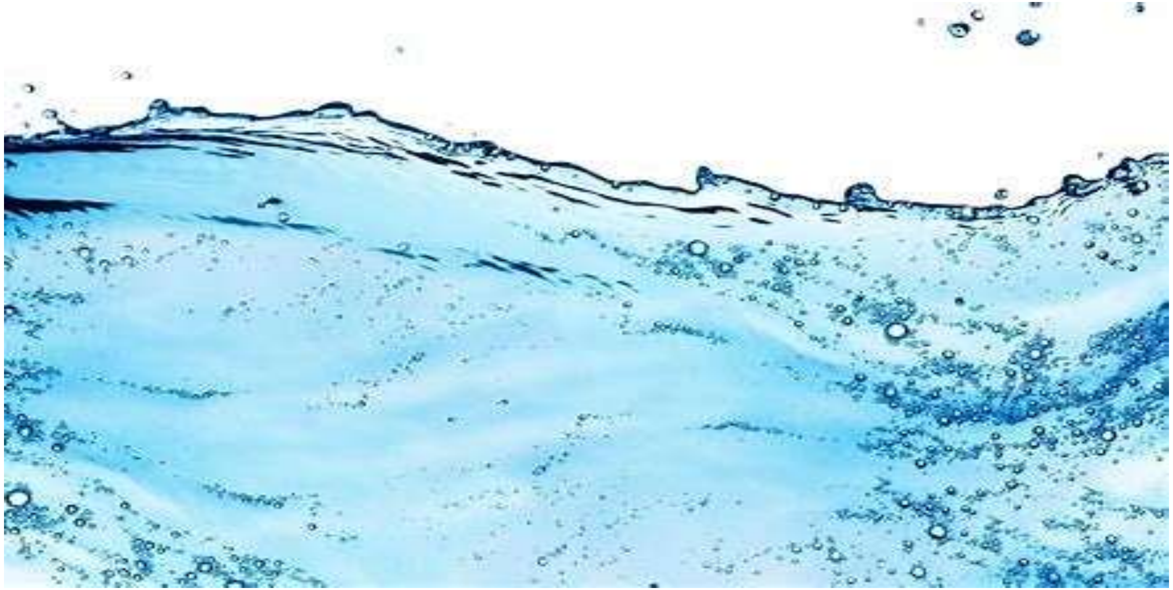

a
b
Villafranca
Clone I-214
c
d
Baldo
Jean Pourtet


Dissipation
¹Chl*
Photosynthesis
Sugar
Excitation Energy
Light Energy
Chl
Zeaxanthin
High light or stress
Antheraxanthin
Violaxanthin
Low light/ no stress

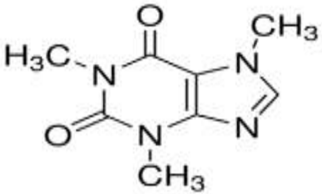

Violaxanthin (mg g-1)
0.15
0.10
0.05
0.00
0
400
600
800
1600
2000
2400
Zn (mg kg-1)
y= -0.0001x + 0.158
R2=0.70
Baldo
Jean Pourtet
I-214
Villafranca


30
Zn
Zinc
65.38

Inquinamento Acqua



Caffeine



- One of the most consumed drug worldwide

- Persistent in the aquatic environment

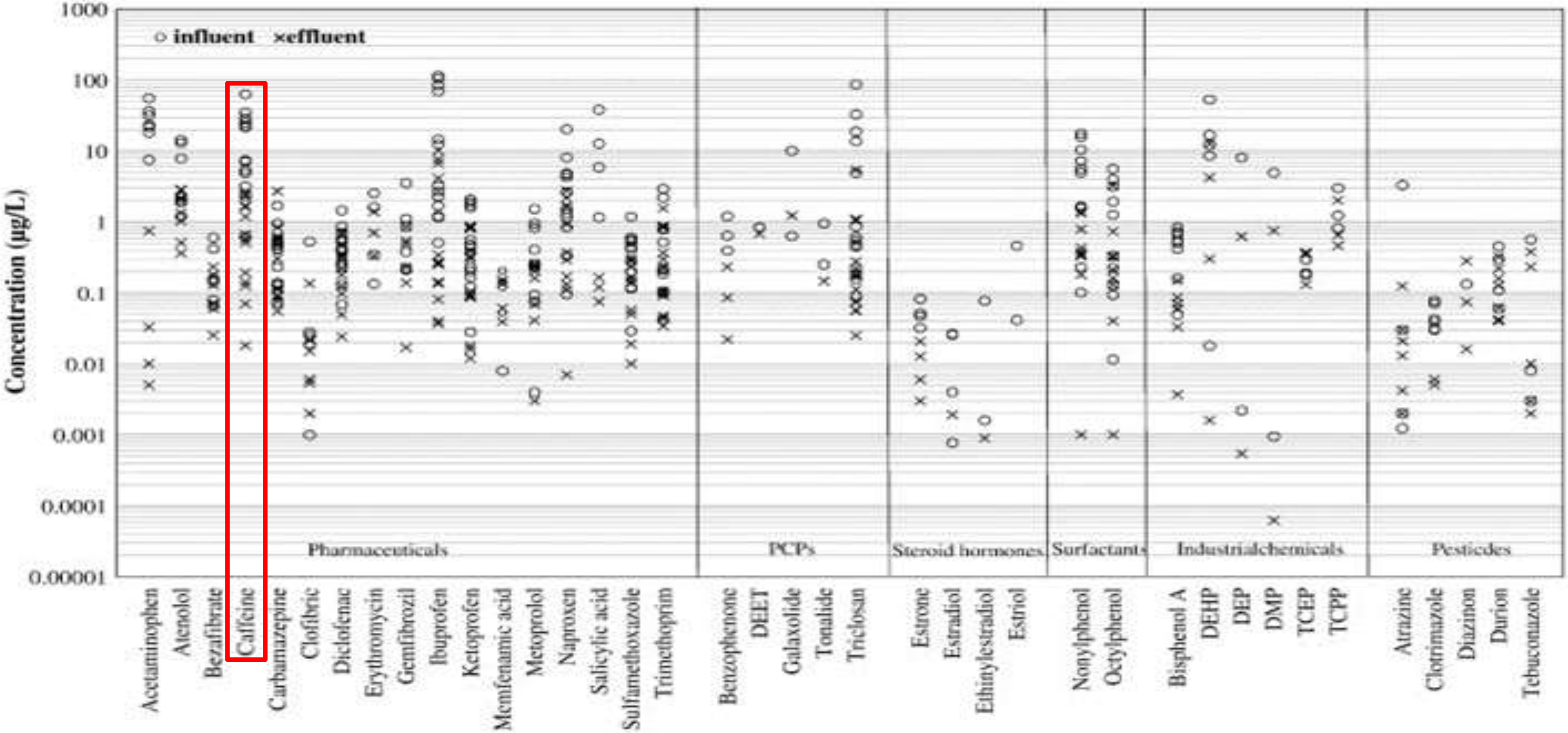
Int J Sports Med. 2005 Nov;26(9):714-8.
Van Thuyne W1, Roels K, Delbeke FT.

Espresso (30 mL)
47-64 mg

Black Tea (237 mL)
25-48 mg

1.22 μg ml^{-1} ± 2.45 μg ml^{-1}

Luo et al., 2014



Pioppo e Caffeina?

Environ Sci Pollut Res (2016) 23:7298–7307
DOI 10.1007/s11356-015-5935-z

CrossMark

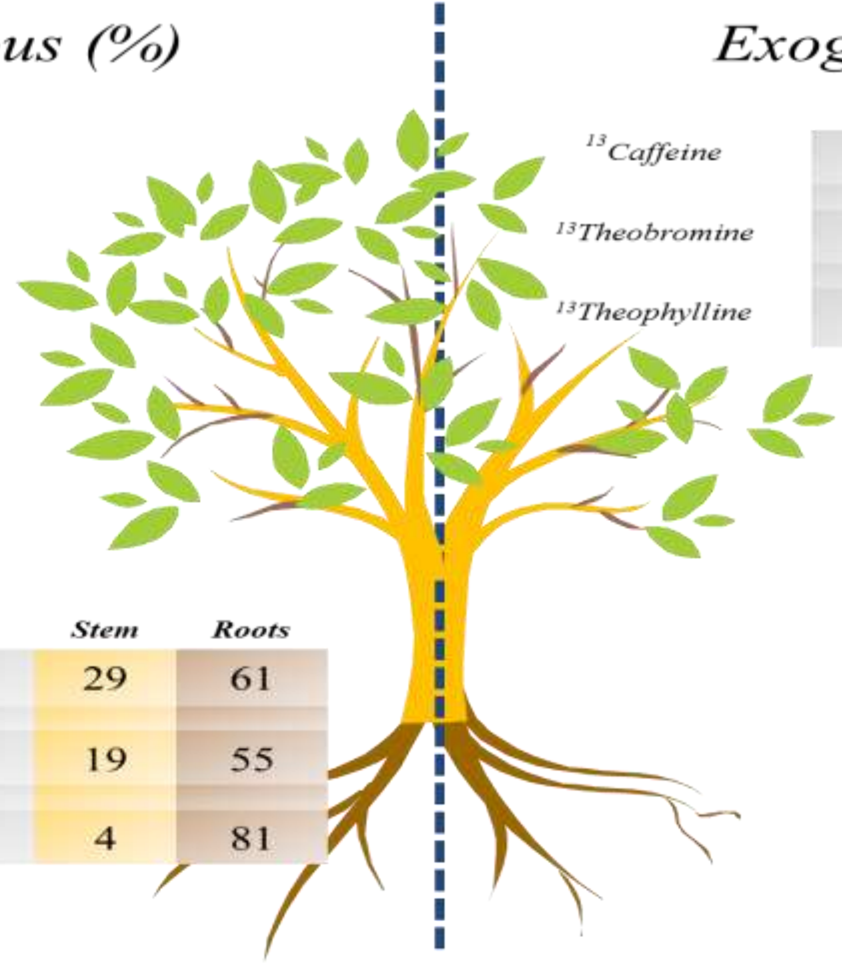
RESEARCH ARTICLE

Degradation of exogenous caffeine by *Populus alba* and its effects on endogenous caffeine metabolism

Erika C. Pierattini[1] · Alessandra Francini[1] · Andrea Raffaelli[2] · Luca Sebastiani[1]

Exogenous (%)

	Leaves	Stem	Roots
^{13}Caffeine	99	1	0
^{13}Theobromine	98	0	2
^{13}Theophylline	59	17	24



Endogenous (%)

	Leaves	Stem	Roots
Caffeine	10	29	61
Theobromine	26	19	55
Theophylline	15	4	81

Science of the Total Environment 569–570 (2016) 540–547

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Morpho-physiological response of *Populus alba* to erythromycin: A timeline of the health status of the plant

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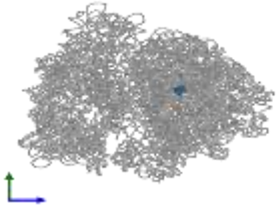
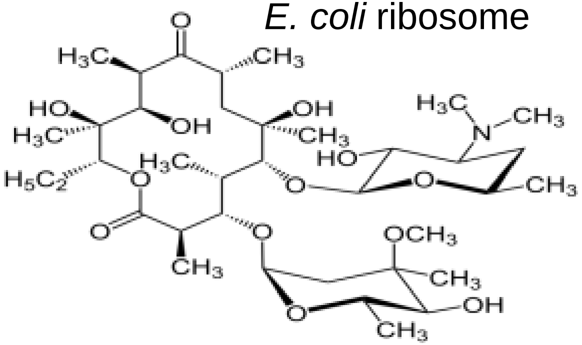


Erythromycin bound to *E. coli* ribosome



- Antibiotic inhibitor of protein synthesis in bacteria

- Persistence in the aquatic environment is a risk for the **rising and spreading of antibiotics resistance mechanisms**

- Stable and doesn't undergo photodegradation processes

Erythromycin

0 mg L^{-1} 0.01 mg L^{-1} 0.1 mg L^{-1} 1 mg L^{-1}

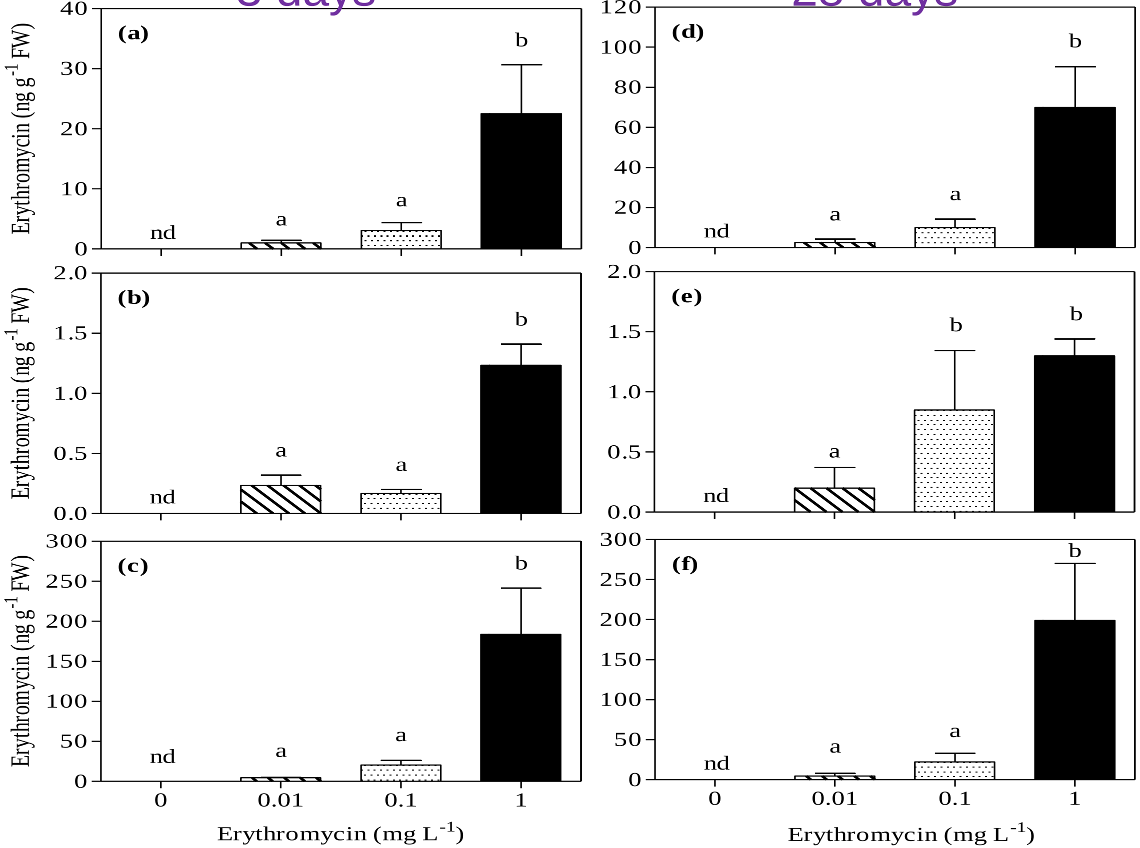
3 days

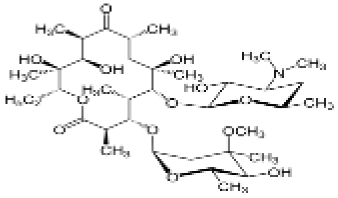
28 days

Leaves

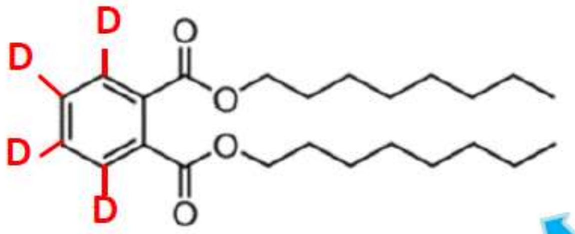
Stem

Roots

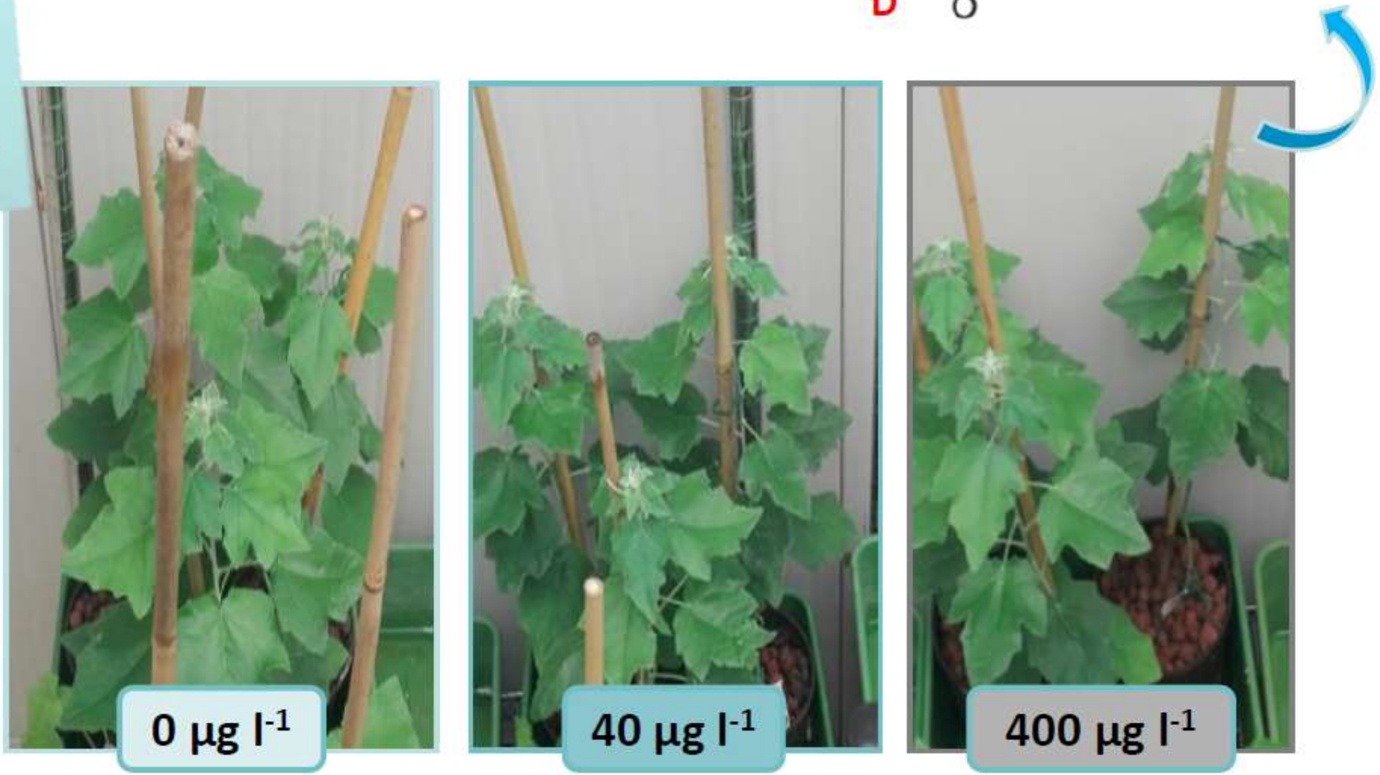


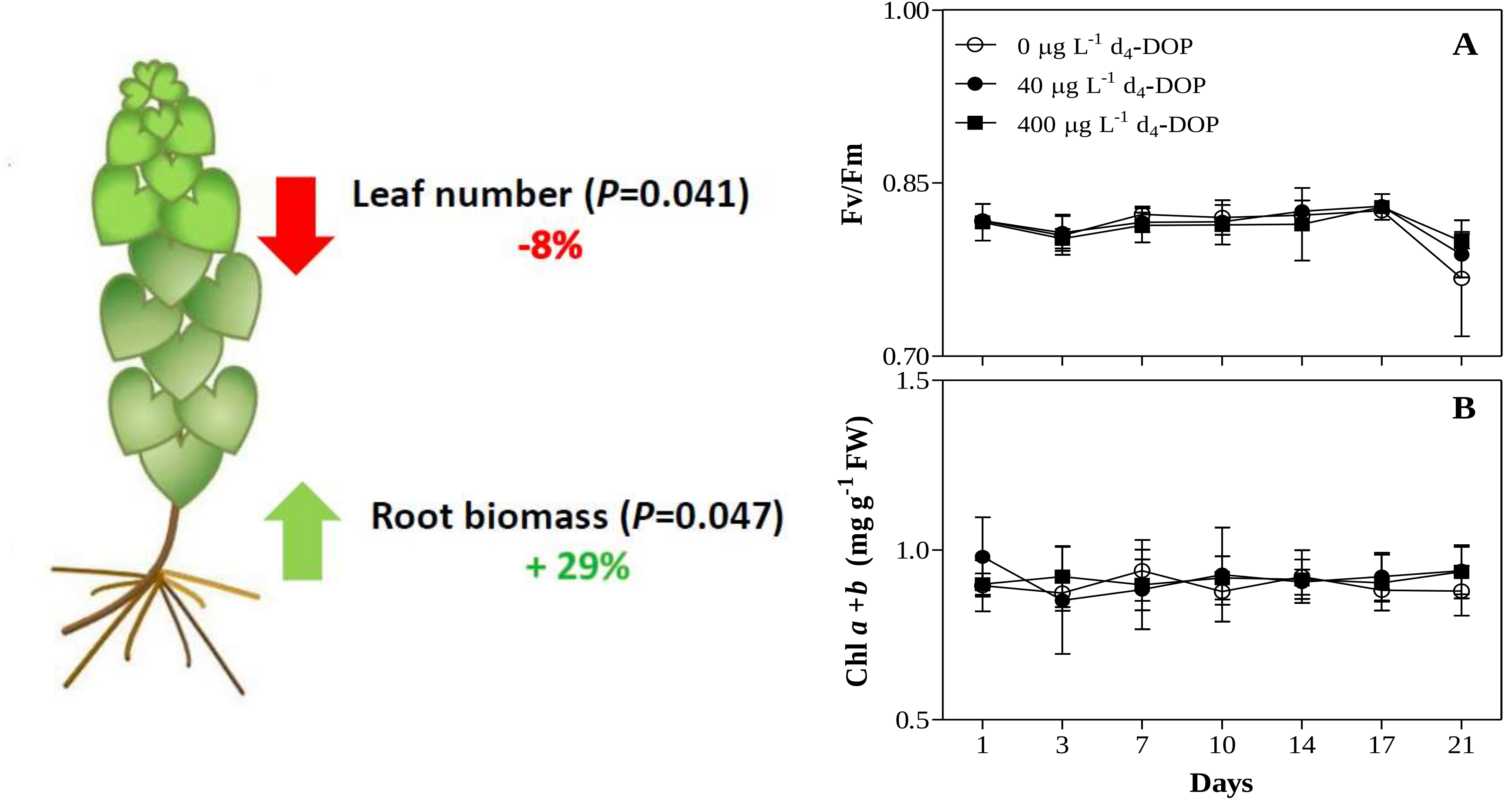


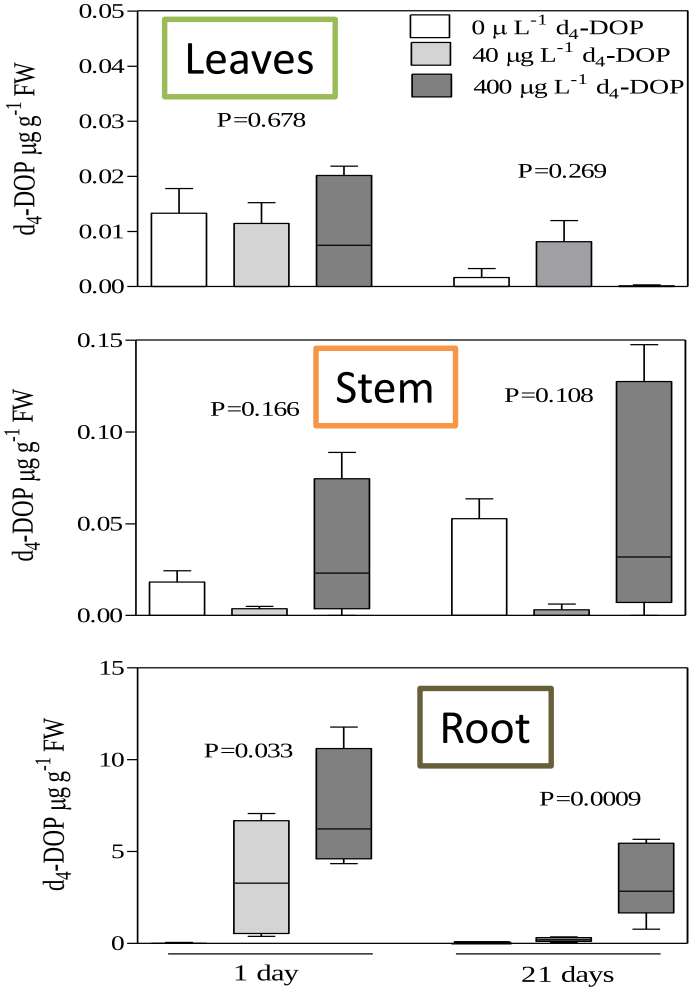
Application of d_4-DOP allows to differentiate such compound from one present in **laboratory environment**



Sampling time:
1 and 21 days



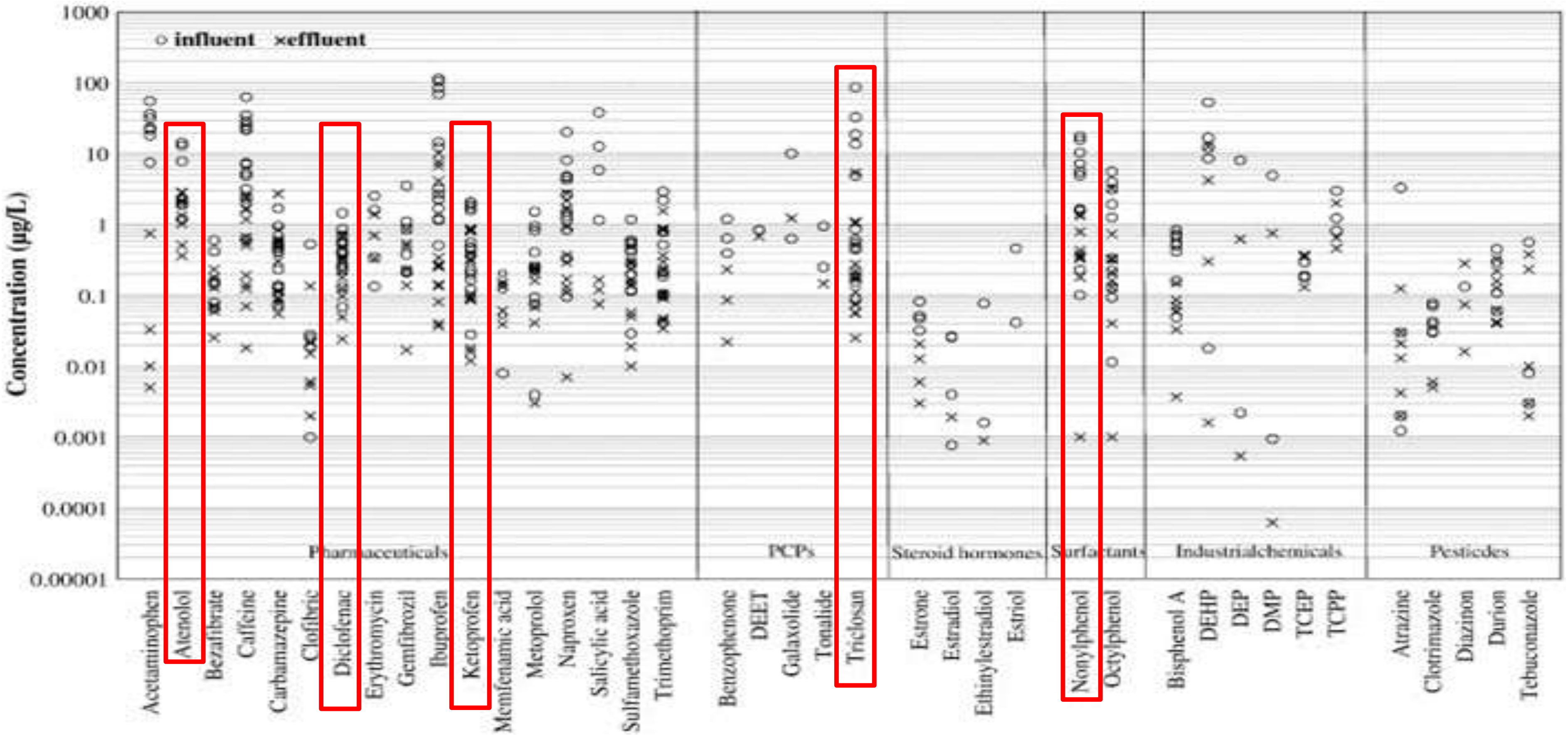

Leaf number (P=0.041)
-8%
Root biomass (P=0.047)
+ 29%
0 μg L-1 d4-DOP
40 μg L-1 d4-DOP
400 μg L-1 d4-DOP
A
B
Fv/Fm
Chl a +b (mg g-1 FW)
Days
1.00
0.85
0.70
1.5
1.0
0.5
1
3
7
10
14
17
21

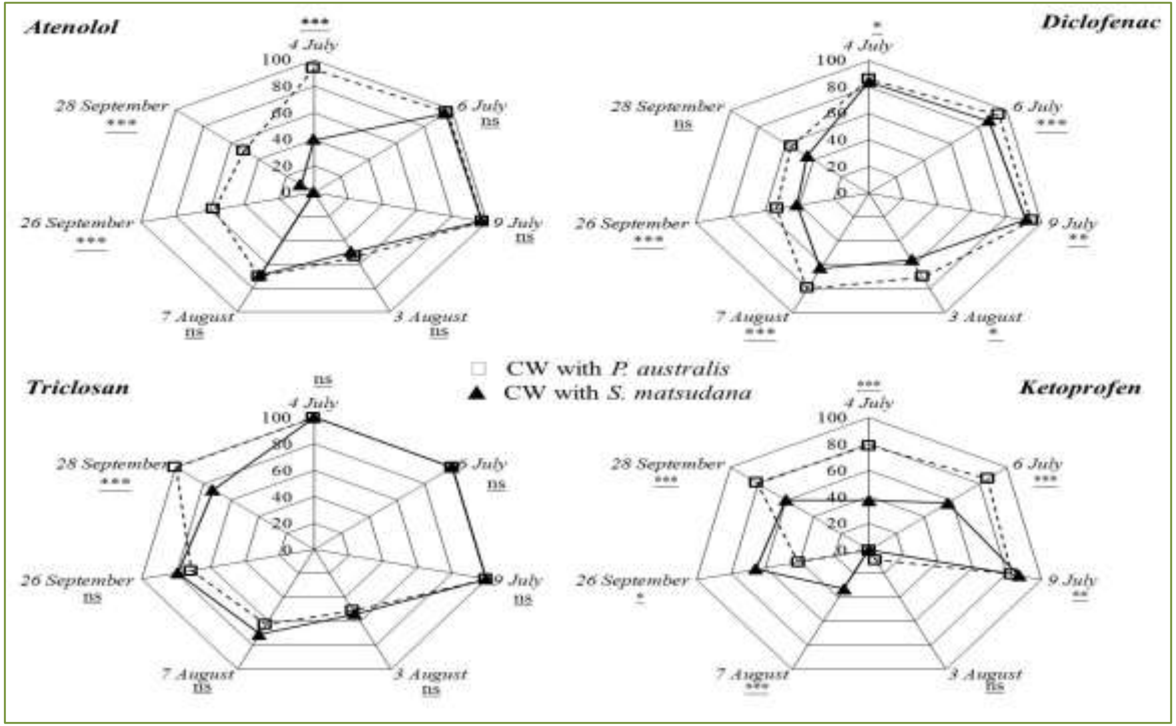

Leaves
$0\ \mu\ L^{-1}\ d_4$-DOP
$40\ \mu g\ L^{-1}\ d_4$-DOP
$400\ \mu g\ L^{-1}\ d_4$-DOP
P=0.678
P=0.269
d_4-DOP $\mu g\ g^{-1}$ FW
0.05
0.04
0.03
0.02
0.01
0.00
Stem
P=0.166
P=0.108
d_4-DOP $\mu g\ g^{-1}$ FW
0.15
0.10
0.05
0.00
Root
P=0.033
P=0.0009
d_4-DOP $\mu g\ g^{-1}$ FW
15
10
5
0
1 day
21 days

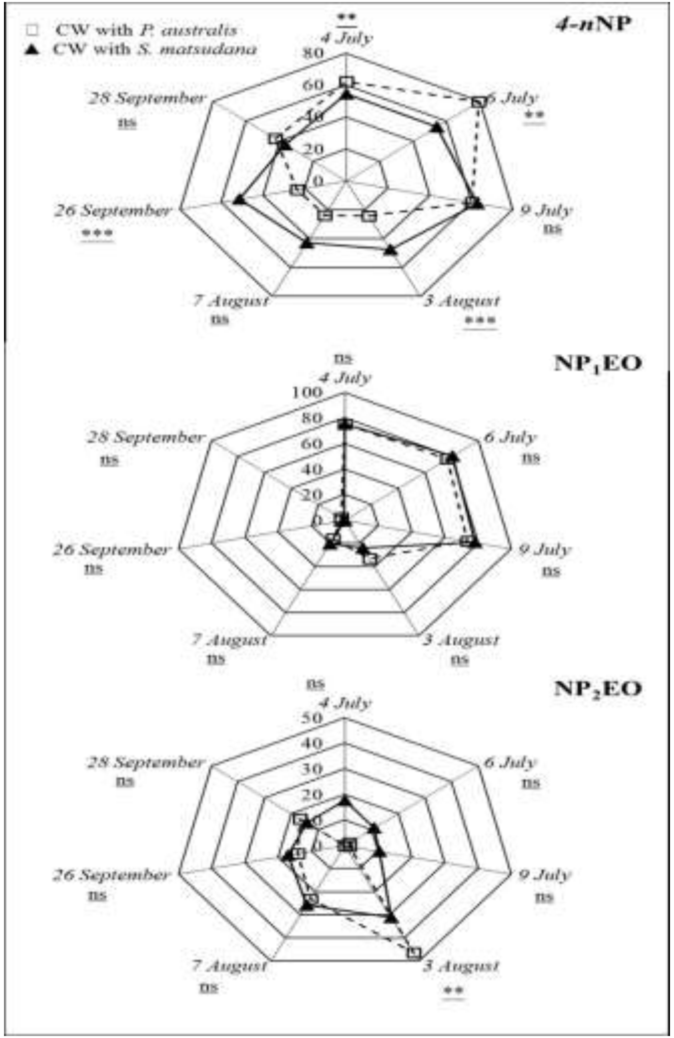
Funzionano ?

Removal of micro-pollutants from urban wastewater by constructed wetlands with *Phragmites australis* and *Salix matsudana*

Luo et al., 2014







Removal efficiency of micro-pollutants was evaluated by means of Eq. (1): Removal efficiency (%) = (M_{inf} –M_{eff})/ M_{inf} x 100, where M_{inf} is the load of micro-pollutant in CW influent and M_{eff} is the load of micro-pollutant in CW systems effluent. Removal efficiencies were calculated assuming that no evapotranspiration took place since losses by evaporation in a CWs are considered negligible compared with the great volumes of water treated.