“The What, Where and How of Wastewater Contaminant Removal in Poplar Plantations”

Bob Simmons
WSU Associate Professor
Water Resources
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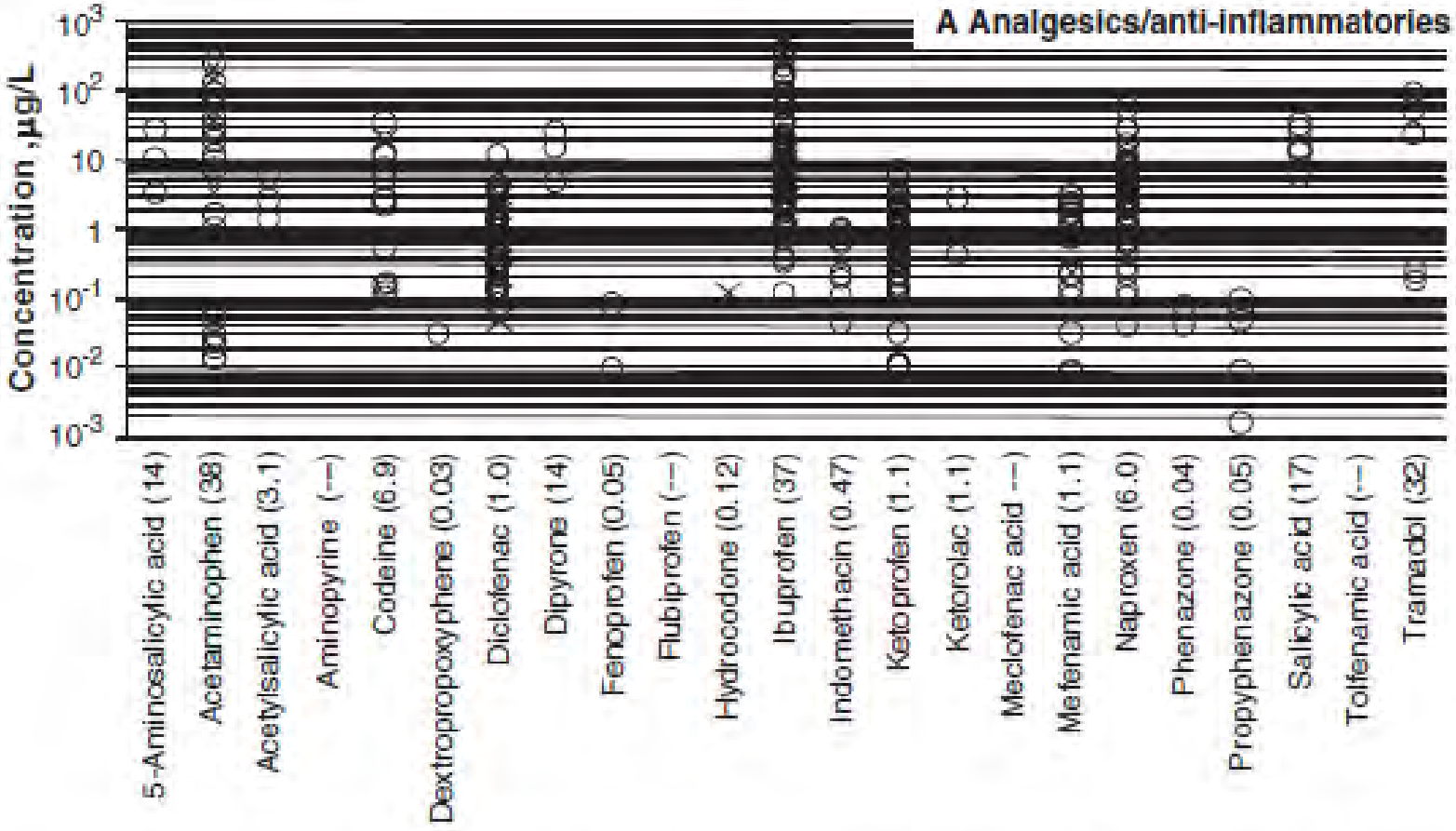
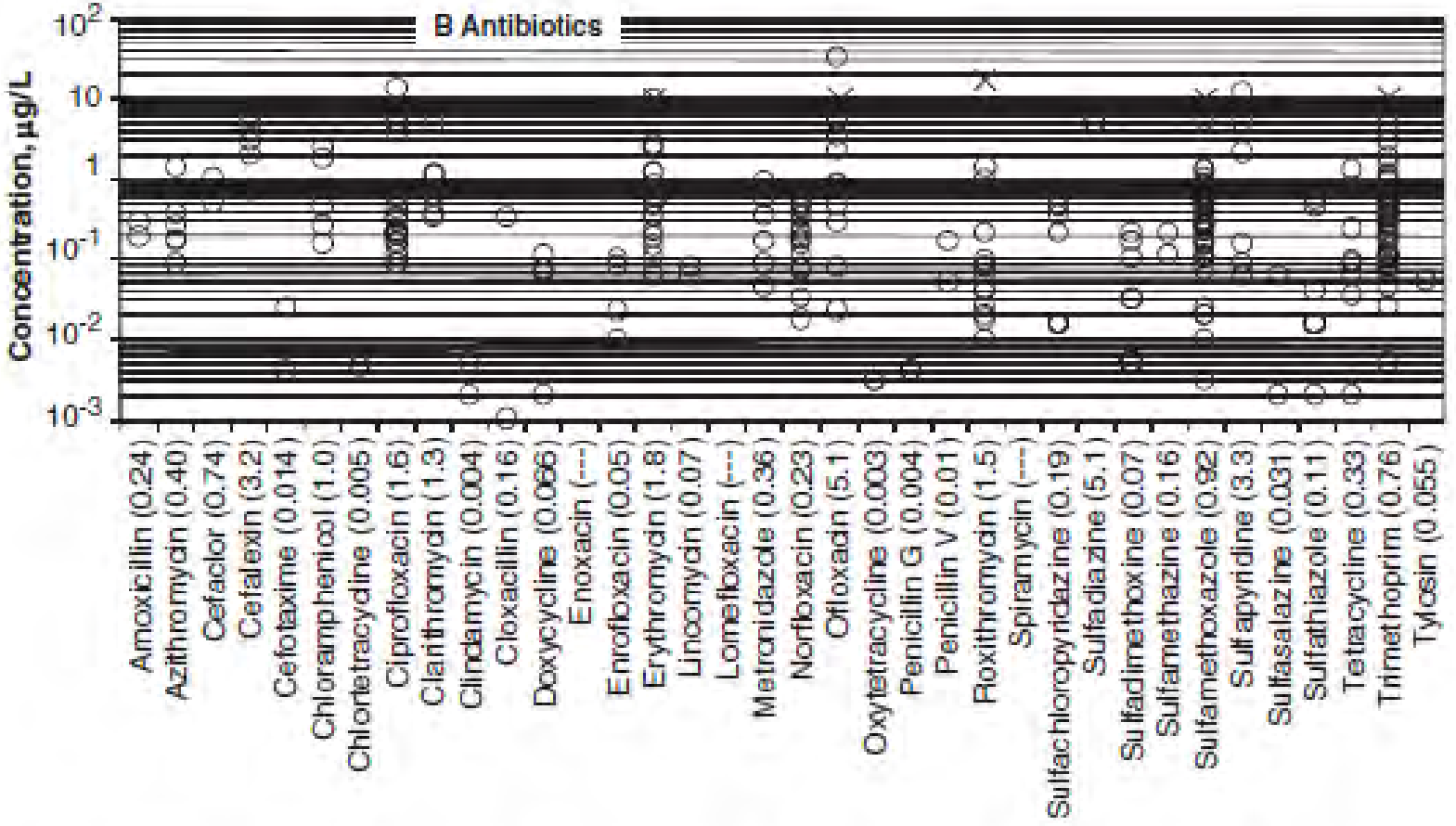
Contaminants of Concern

- Nitrates, ammonia, phosphorus
- Fecal coliform, enterococcus, viruses, parasites, pathogens
- Synthetic organic compounds used in food production, personal care products, plastics manufacturing, and other industrial processes such as flame retardants, dioxins, and steroid hormones
- Heavy metals
- Pharmaceuticals



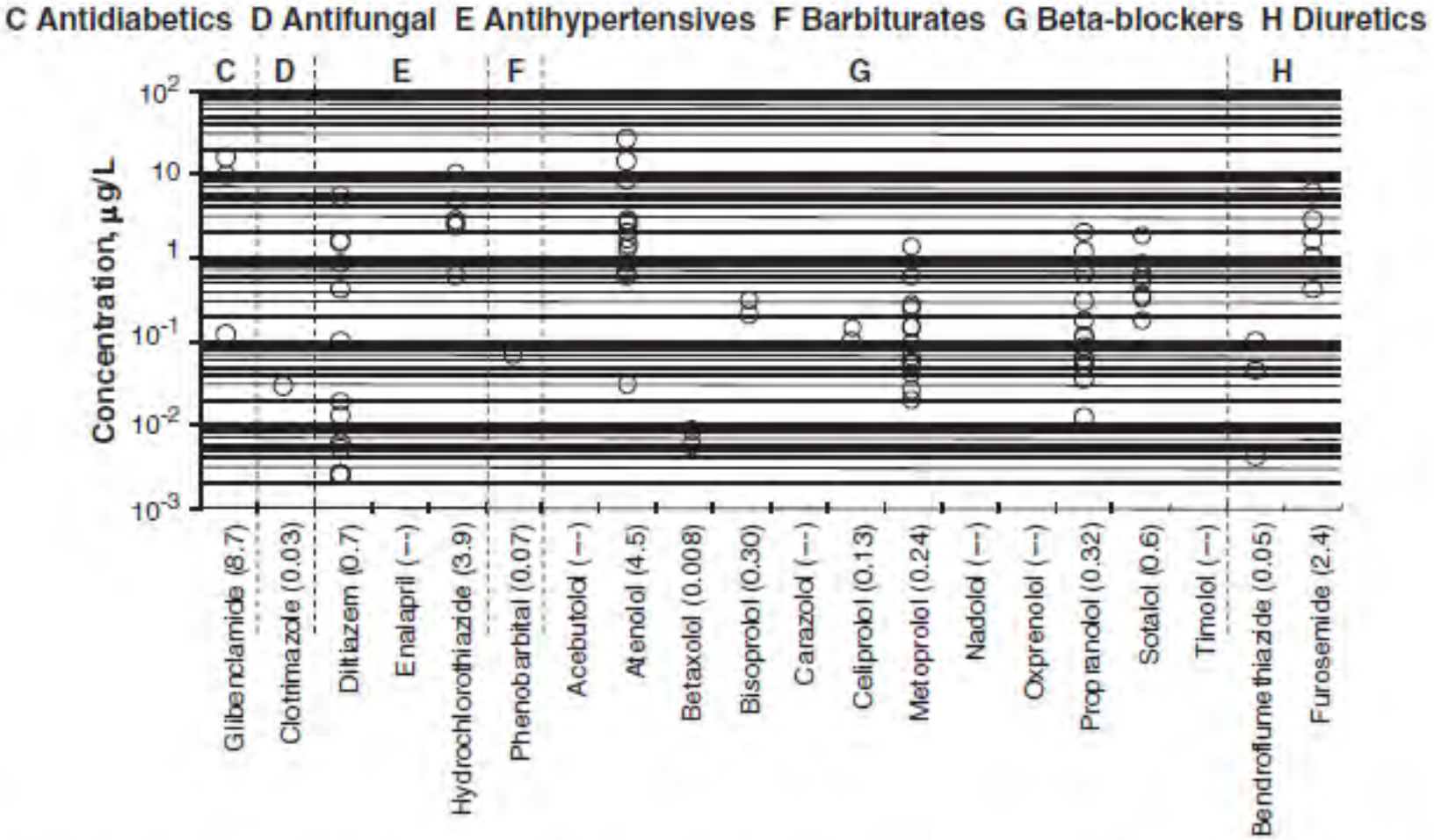
Concentration of selected analgesics/anti-inflammatories measured in the raw influent to municipal WWTP (○ refers to CAS and × to MBR) an
ackets).

P. Verlicchi, et. al., 2012



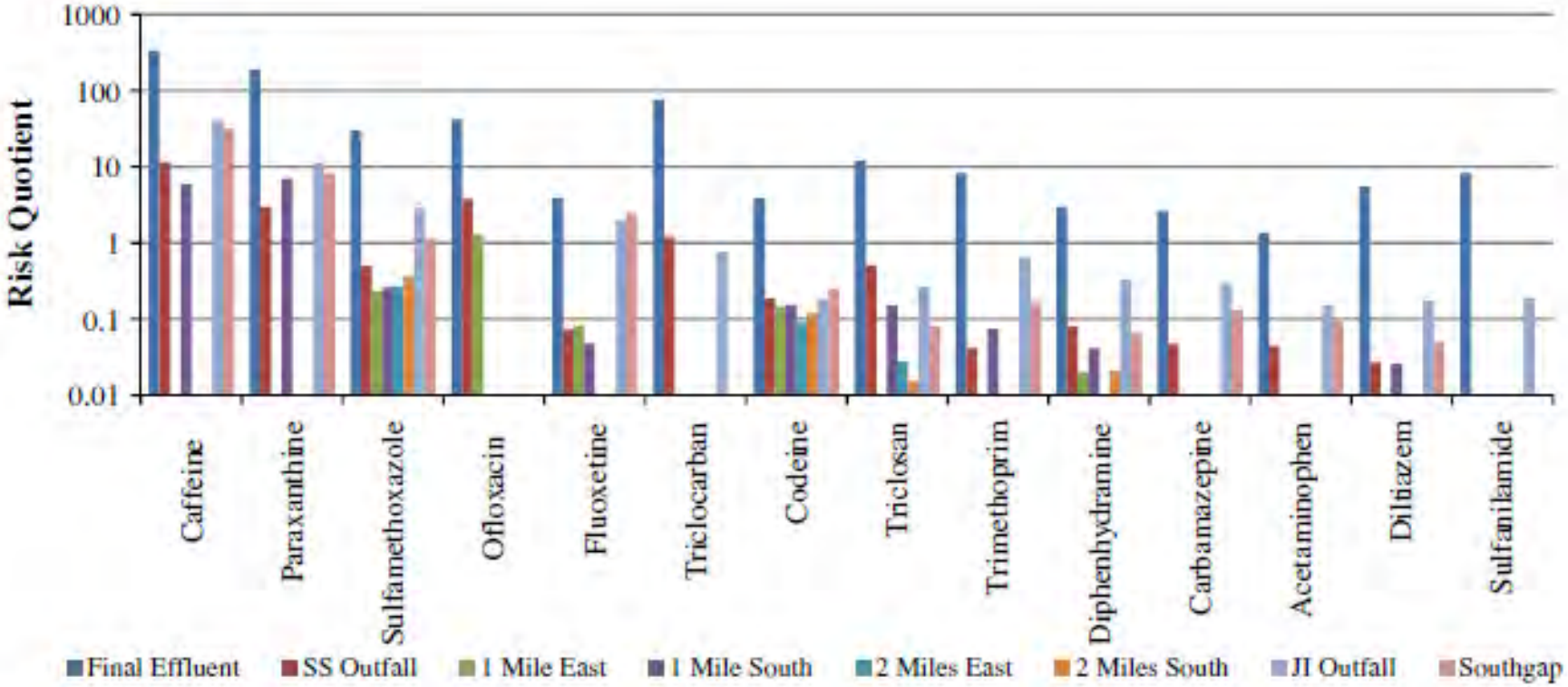
Concentrations of selected antibiotics measured in the raw influent to municipal WWTPs (○ refers to CAS and × to MBR) and correspondi

P. Verlicchi, et. al., 2012



Concentrations of selected PhCs belonging to six therapeutic classes measured in the raw influent to municipal WWTPs (○ refers to CAS and × to MBR) a

P. Verlicchi, et. al., 2012



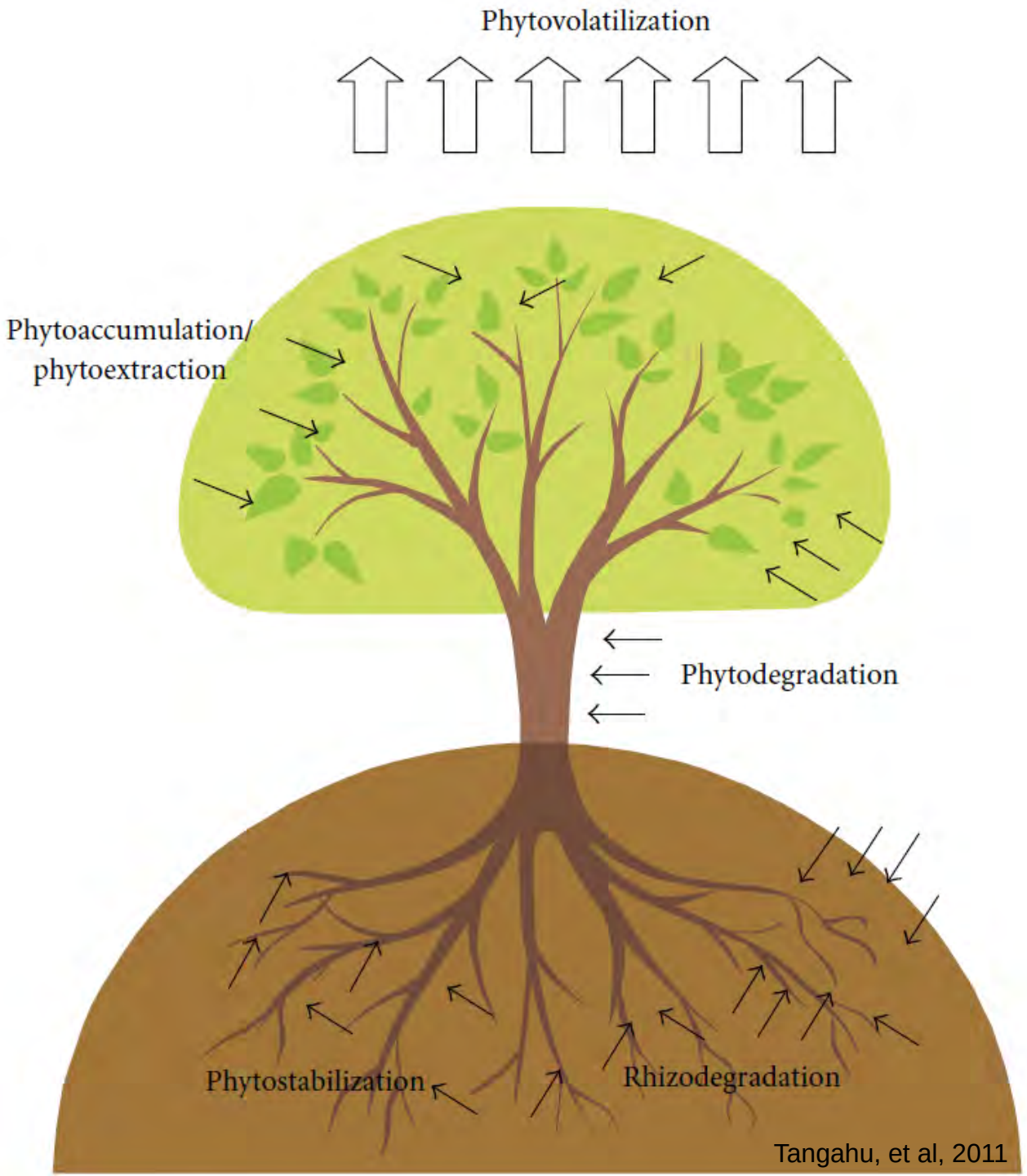
Risk quotient for 14 PPCPs in wastewater effluent and in Lake Michigan (RQ > 1 is high risk, RQ from 0.1 to 1 is medium risk, and RQ < 0.1 is low risk).

Blair, et. al., 2013

Table 4-1: Metals content of treatment plant effluent and outflow water from phytoboxes, sampled 8/22/2014
(TREES LEAFY) All units = µg/L

Metal	Treatment Plant Effluent	Output From Phytoboxes: Perlite + Trees	Heavy Soil + Perlite + Trees	Sandy Soil + Trees	Sandy Soil + Compost + Trees
Mercury	0.007	0.001	0.008	0.015	0.011
Aluminum	60.3	19.4	25.6	37.4	55.5
Antimony	<0.3	<0.3	0.57	<0.3	0.35 (2)
Arsenic	4.15	6.02	16.12	14.44	10.28
Barium	38.20	26.90	55.40	69.87	65.40
Beryllium	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	0.13	0.07 (1)	0.07 (1)	0.14 (1)	0.35 (2)
Calcium	56900	63700	65800	81500	71100
Chromium	0.55	0.24	0.59	0.72	0.82
Cobalt	0.18	0.17	8.77	28.55	31.27
Copper	46.6	11.1	4.8	3.1	8.8
Iron	93	168	1515	19893	17193
Lead	1.89	1.68	0.61	0.20	0.27
Magnesium	41200	56333	55900	59533	57333
Manganese	15	14	1220	1477	1592
Nickel	2.25	2.85	13.24	25.47	30.19
Potassium	24100	12430	20250	28133	30400
Selenium	0.63	0.51 (2)	0.59 (2)	0.65	0.77
Silver	0.041	<0.04	<0.04	<0.04	0.042
Sodium	200000	358667	403000	433333	366667
Thallium	<0.04	<0.04	<0.04	<0.04	0.062 (1)
Tin	0.68	<0.3	<0.3	<0.3	<0.3
Vanadium	2.50	0.38	3.76	3.16	5.67
Zinc	177.0	9.6	13.8	16.4	63.4

n=1 for all measures of Treatment Plant Effluent; n=3 for all measures of phytoboxes except those with (n).



Tangahu, et al, 2011

Removal Processes

Phytoextraction:

the uptake and translocation of contaminants from groundwater into plant tissue.

Phytovolatilization:

the transfer of contaminants to air via plant transpiration.

Rhizosphere degradation:

breakdown of contaminants within the rhizosphere by microbes.

Phytodegradation:

the breakdown of contaminants within plant tissue.

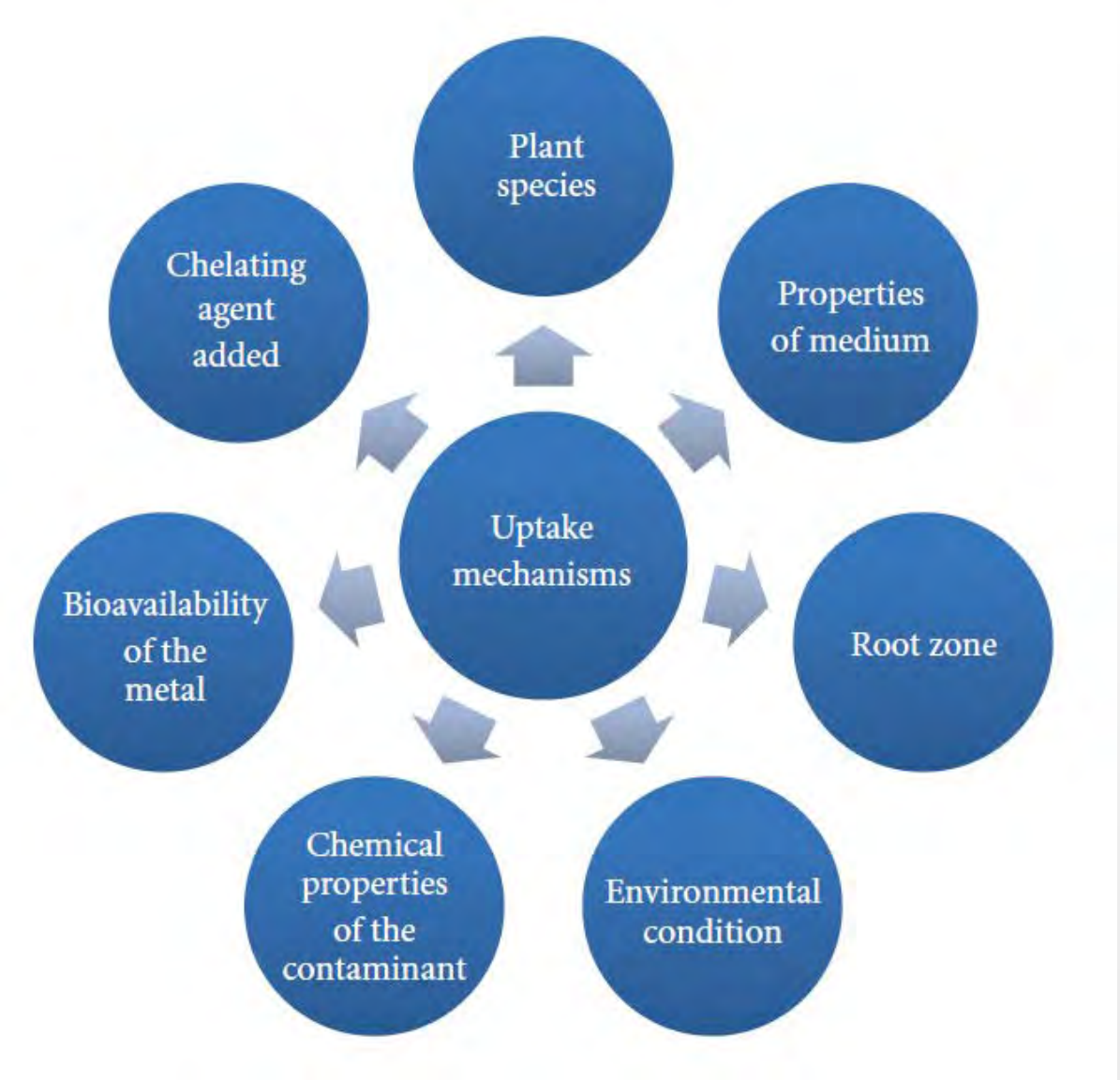
Phytostabilization:

the stabilization of contaminants in the soil and groundwater through absorption and accumulation on to plant roots.

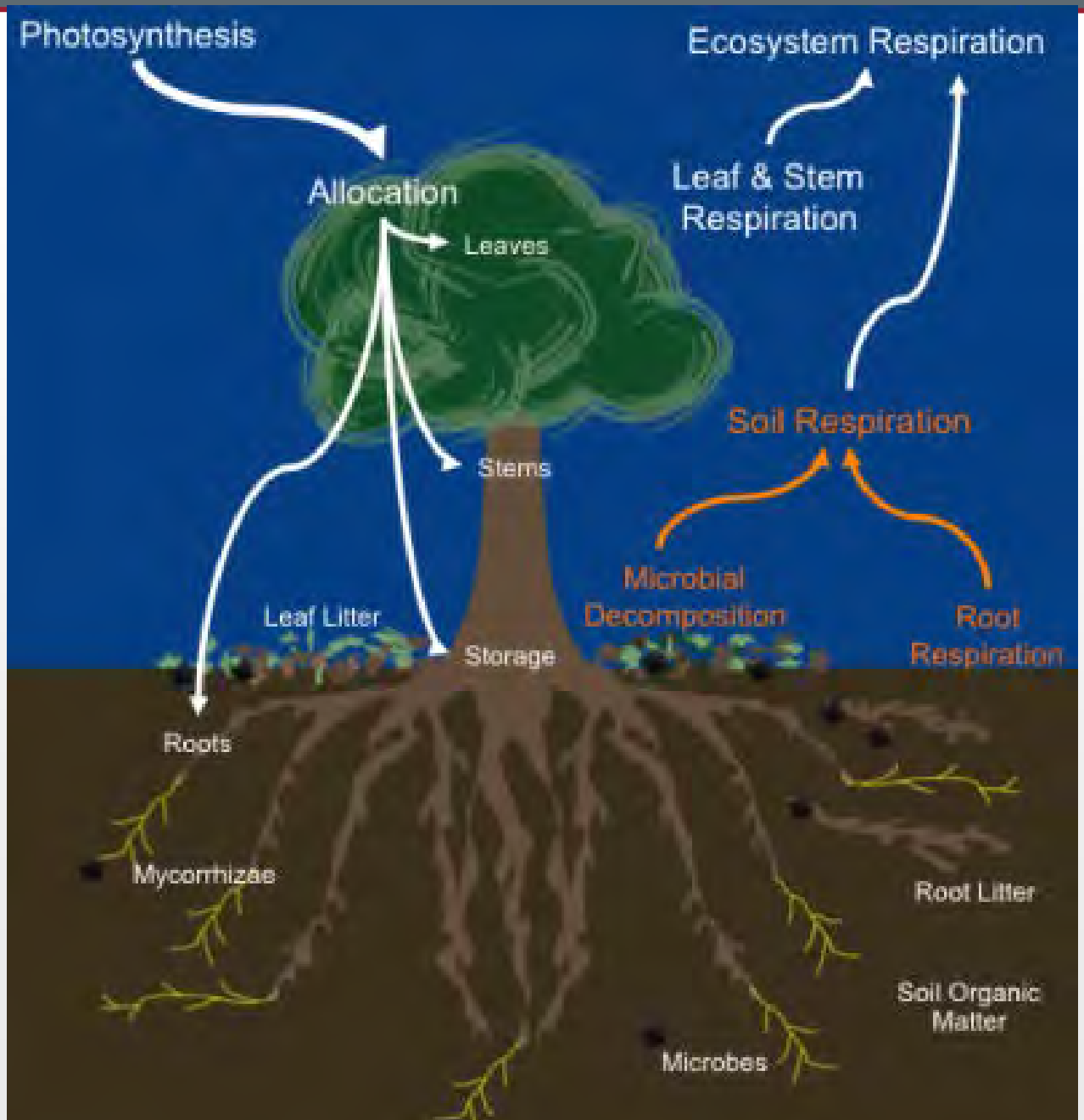
Hydraulic control:

intercepting and transpiring large quantities of water to contain and control migration of contaminants.

(Isebrands et al.)



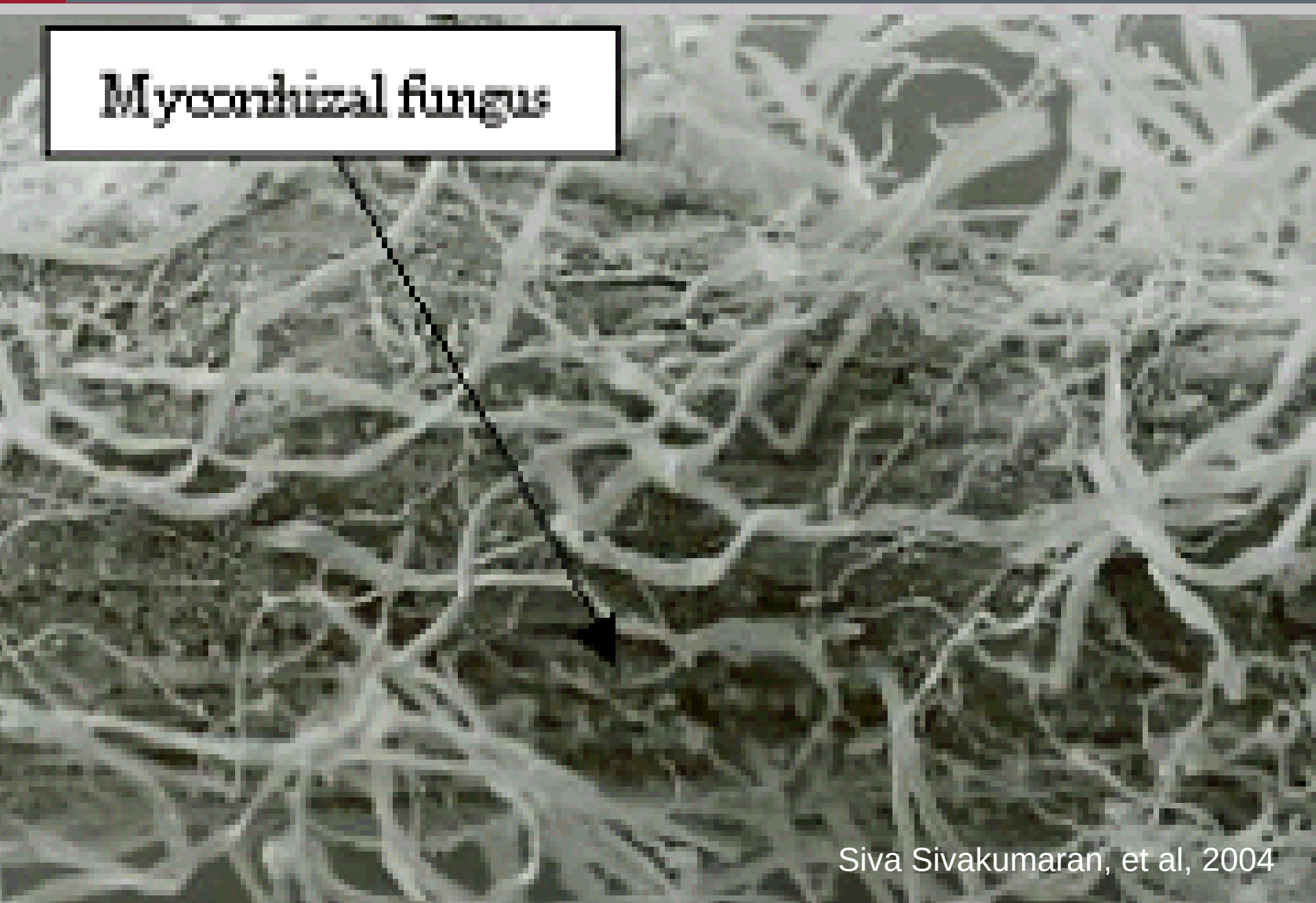
Tangahu, et al, 2011


Photosynthesis
Ecosystem Respiration
Allocation
Leaf & Stem Respiration
Leaves
Soil Respiration
Stems
Microbial Decomposition
Root Respiration
Leaf Litter
Storage
Roots
Mycorrhizae
Root Litter
Soil Organic Matter
Microbes

NCEAS, 2013

Mycorrhizas of the Fly Agaric toadstool (Amanita muscaria) [Jim Deacon]

Mycorrhizal short roots of pine seedlings [Jim Deacon]



Siva Sivakumaran, et al, 2004

Key Messages

- There is a lot more in wastewater than is routinely tested for
- Our current model of discharging to waterways is not sufficient in the long term
- There is a lot more to phytoremediation than what is happening in the plants
- As we have heard through other presentations, it can be a cost effective way to manage wastewater
  - Lower treatment costs
  - Reduce biosolid disposal costs
  - Potential markets for poplar can subsidize operational costs
- We need more people like you to move this forward - for a more sustainable society

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