

solutions

Pharmaceuticals and organic consumer chemicals in Sewage Sludge: Concentrations in Biosolids from Spain vs. the USA and China.



Damià Barceló, Bozo Zonja, Alicia Navarro
and Rolf Halden

Analysis of illicit and abused drugs, pesticides and PFCs in sewage sludge

SEWAGE SLUDGE SAMPLES

- ✖ 15 WWTPs in 4 Mediterranean watersheds in Spain
- ✖ Autumn 2010
- ✖ Pooled grab samples at the end of the sewage sludge treatment – 1 Kg

Basin	STP name	Sewage type	Population equivalent	Flow (m ³ day ⁻¹)	Water Treatment	Sludge Treatment
LLOBREGAT	LL1	D, I	196167	53500	Pre + BIO + DeN	ANA+BFP
	LL2	D	285666	20000	Pre + BIO	ANA+CF
	LL3	D	80000	23000	Pre + BIO + DeN	ANA+CF
EBRO	E1	D	776190	86141	Pre + BIO + DeN	ANA+CF
	E2	D	466560	51387	Pre + BIO + DeN	ANA+CF
	E3	D	46237	18573	Pre + BIO	ANA+CF
	E4	D	1200000	259200	Pre + BIO + DeN	GRAV+CF
	E5	D	186000	59706	Pre + BIO + DeN	ANA+CF
	E6	D	46847	6670	Pre + BIO	ANA+CF
JUCAR	J1	D	80000	15000	Pre + BIO	ANA+CF
	J2	D	232656	33584	T	ANA+CF
GUADALQUIVIR	G1	D	522000	108000	Pre + BIO	ANA+CF
	G2	D	30480	-	Pre + BIO	ANA+CF
	G3	D	30000	90000	Pre + BIO	ANA+CF
	G4	D	1487500	135000	Pre + BIO + DeN	ANA+CF
	G5	D	555000	90000	T	ANA+CF



D= domestic wastewater

I= industrial wastewater

Pre – Pretreatment: screening, sand and fat-free

BIO – Biological treatment: aeration, flocculation and settling

DeN – denitrification;

T= Tertiary treatment: microfiltration, osmosis, disinfection;

ANA – Anaerobic digestion

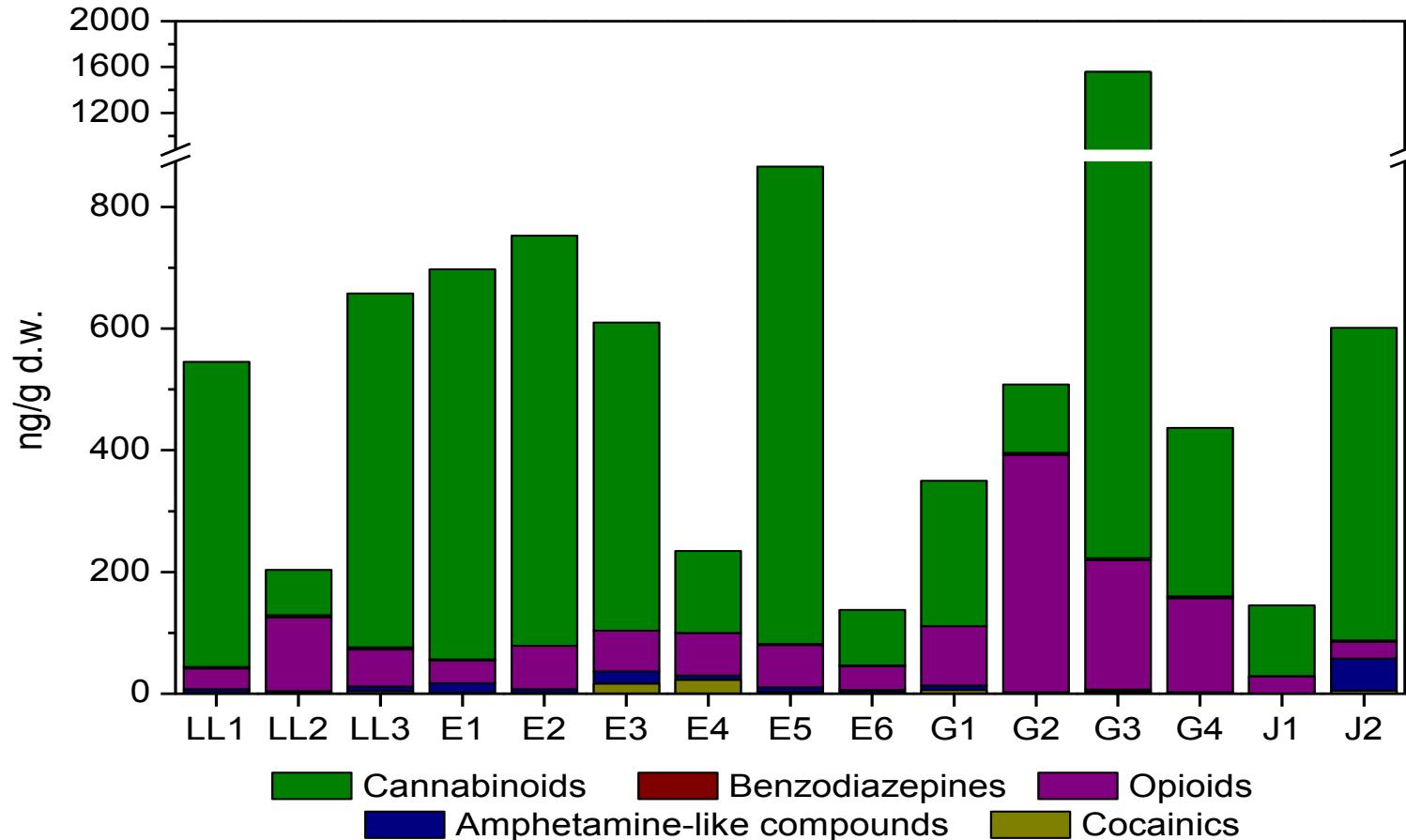
CF – centrifuge thickening and dewatering

BFP – belt filter press thickening and dewatering

GRAV – gravity thickening and dewatering

Analysis of illicit and abused drugs in sewage sludge

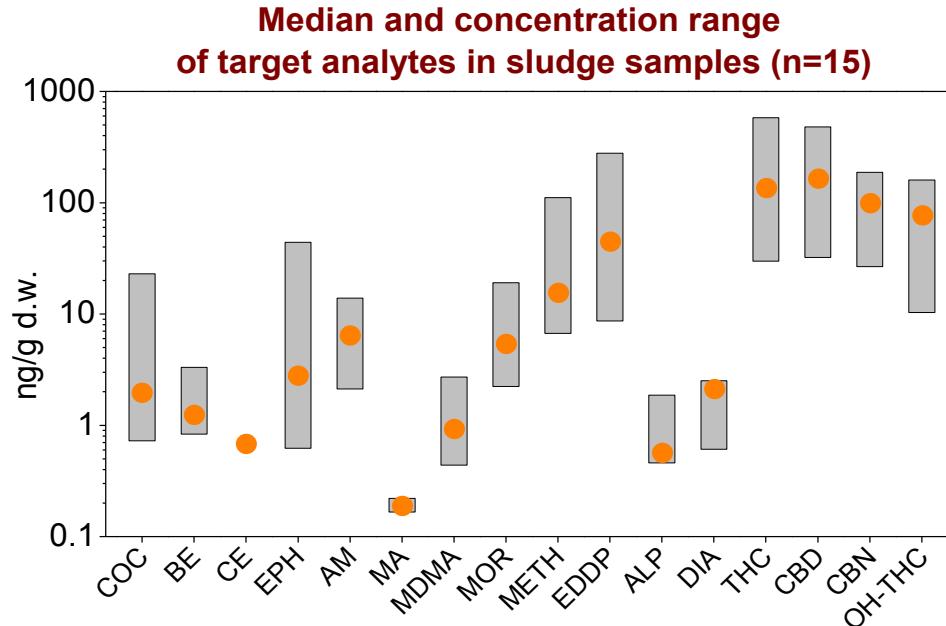
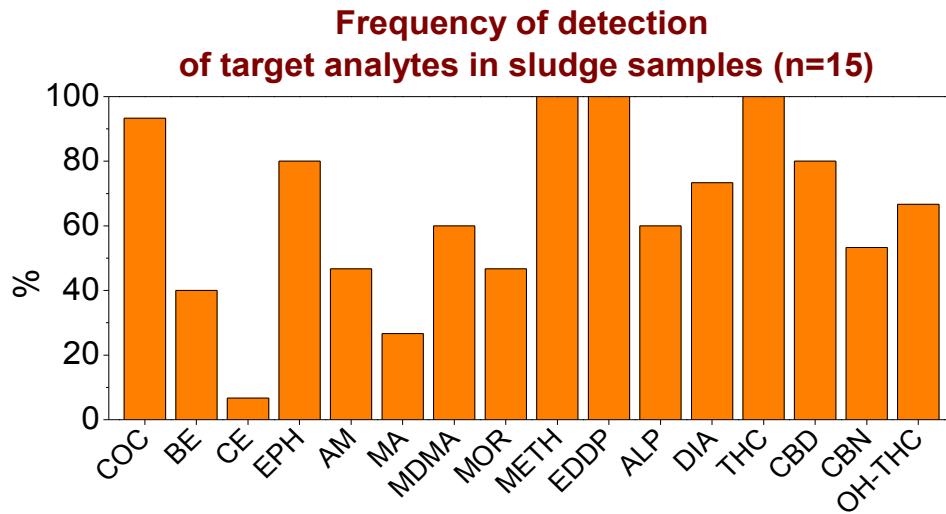
CONCENTRATIONS FOUND IN SEWAGE SLUDGE SAMPLES



- Total amounts of target abused and illicit drugs and metabolites= 138-1560 ng/g d.w.

Analysis of illicit and abused drugs in sewage sludge

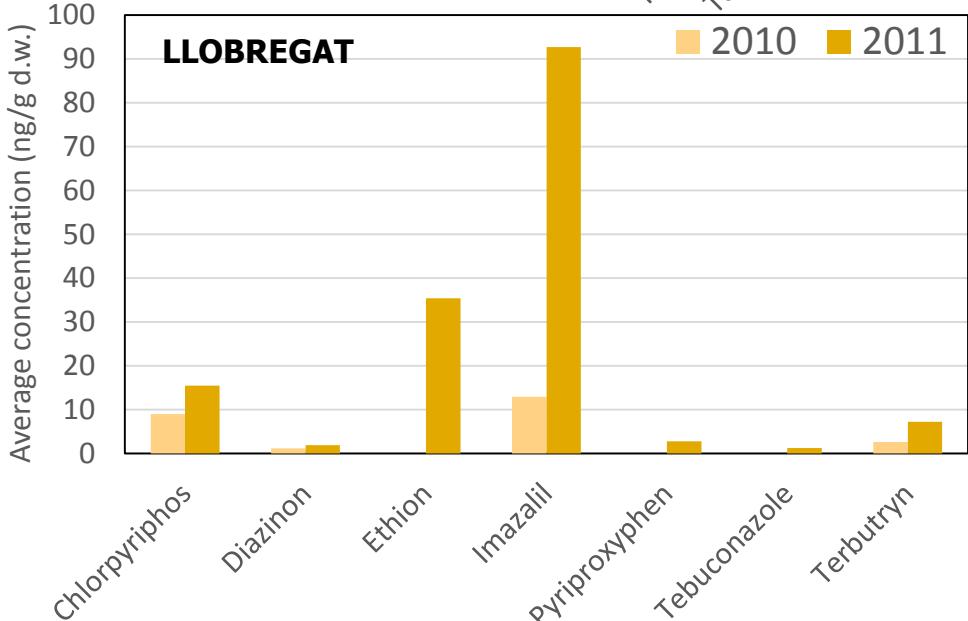
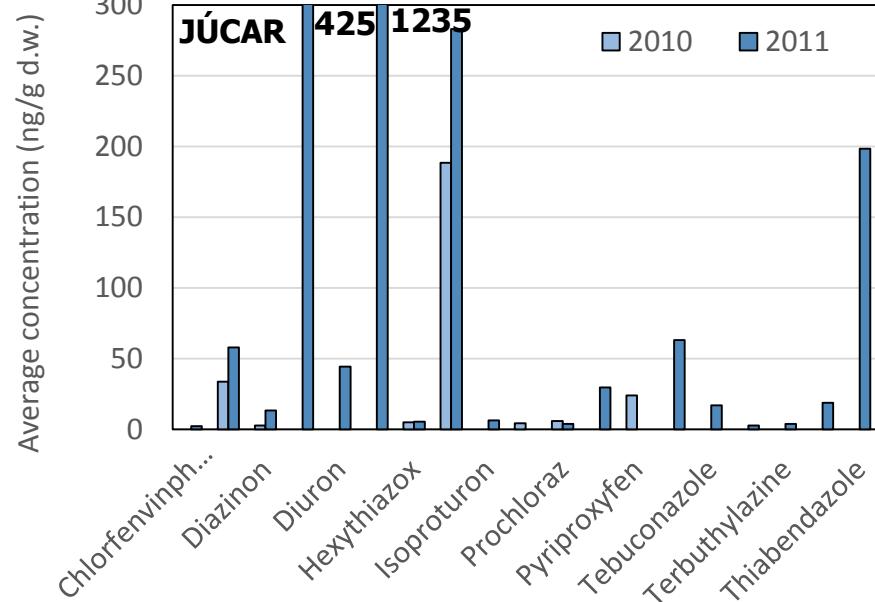
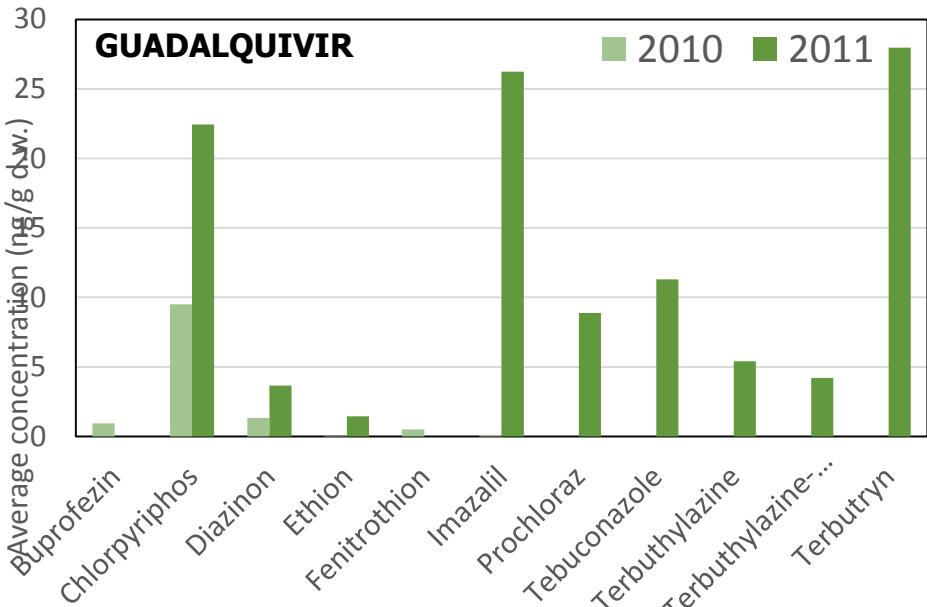
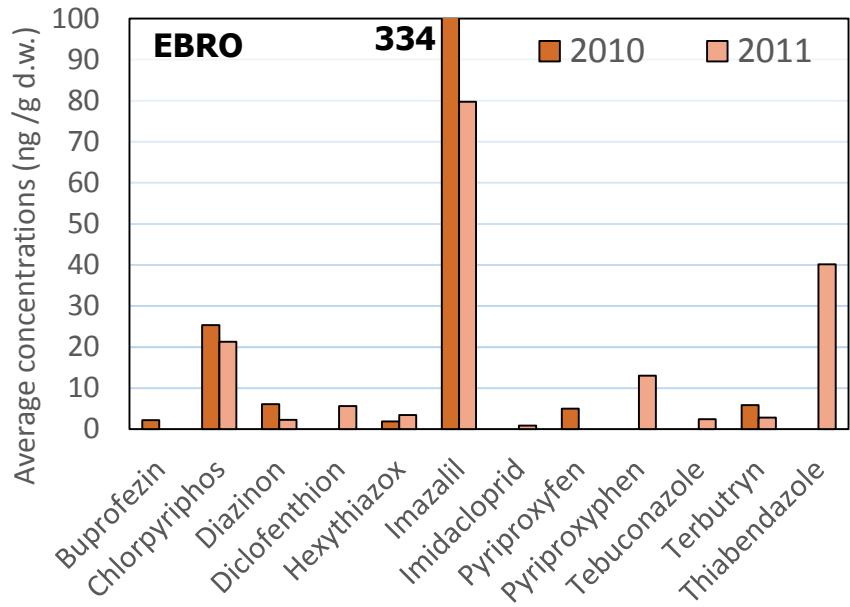
Occurrence of target analytes in sludge samples



- ✖ HER, 6ACM, LSD and OH-LSD were not detected
- ✖ The most ubiquitous compounds were METH, EDDP and THC ($\text{Log } K_{\text{ow}} > 3$) (100%), followed by COC, EPH and CBD ($\geq 80\%$)
- ✖ The most abundant compounds were the cannabinoids (median concentrations ranged from 78.4 ng/g d.w. (OH-THC) to 168 ng/g d.w. (CBD)), followed by EDDP (45.6 ng/g d.w.) and METH (15.9 ng/g d.w.).
- ✖ The remaining compounds presented median concentrations lower than 6.6 ng/g d.w.

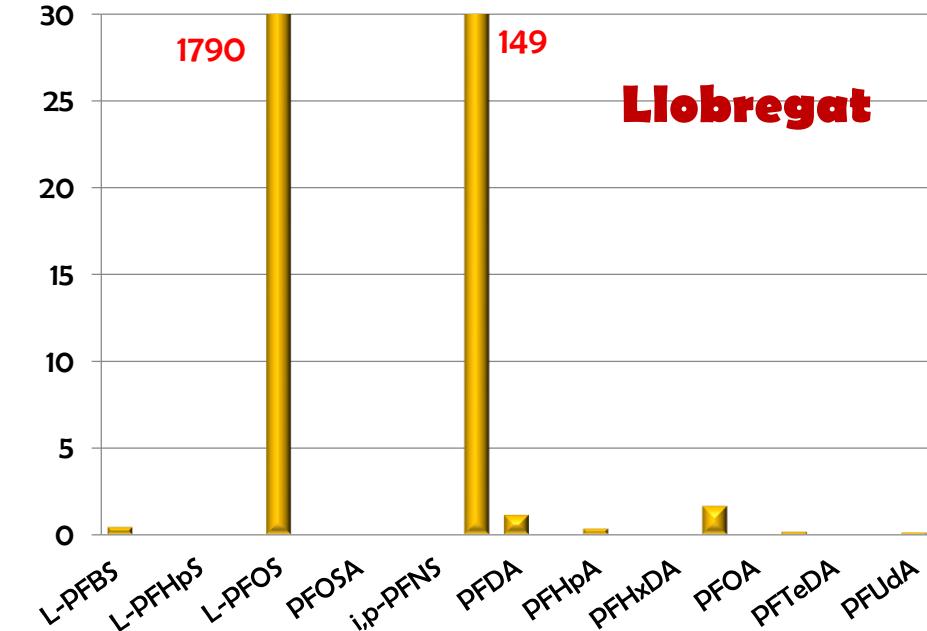
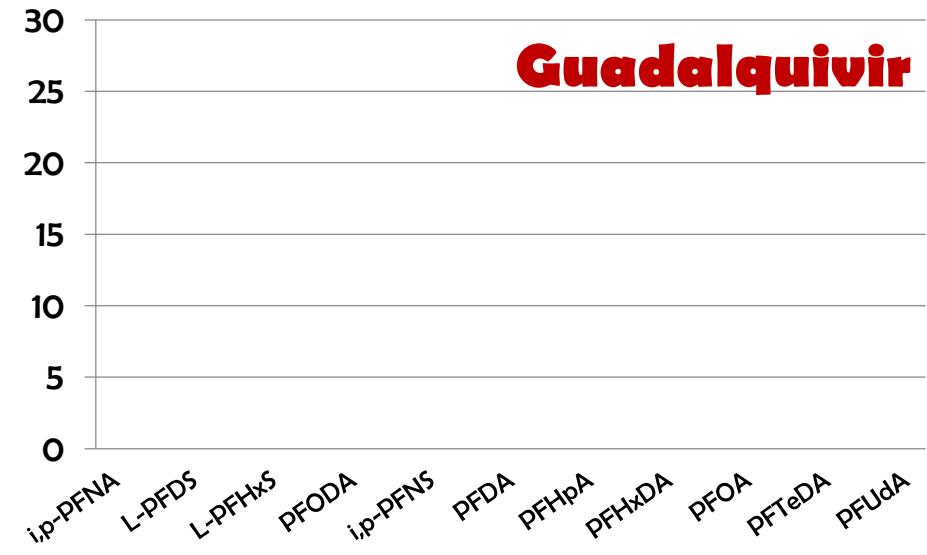
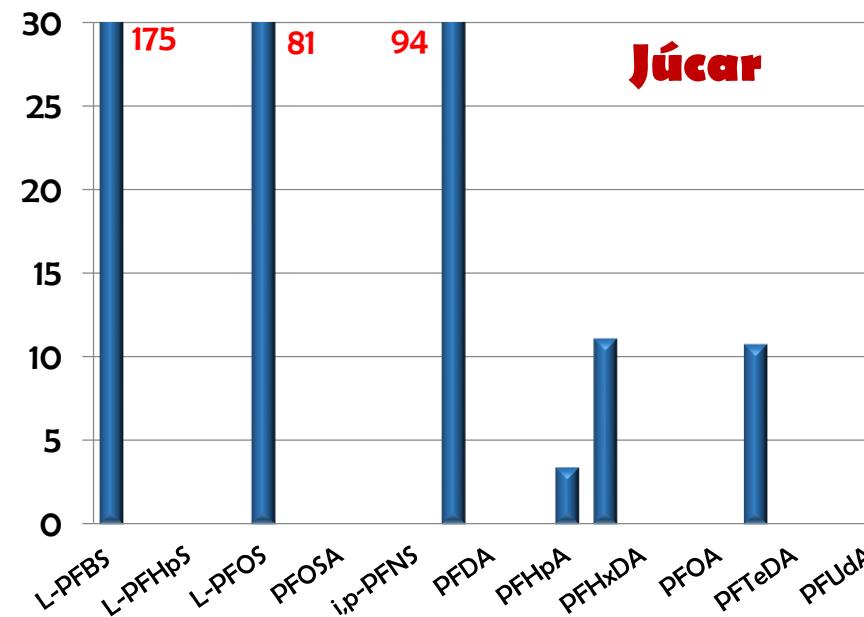
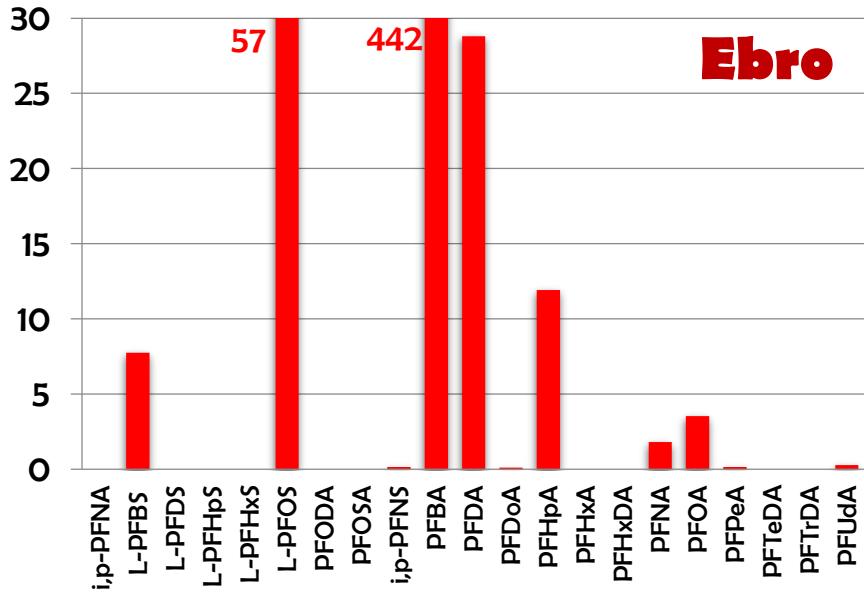
Analysis of pesticides in sewage sludge

CONCENTRATIONS FOUND IN SEWAGE SLUDGE SAMPLES



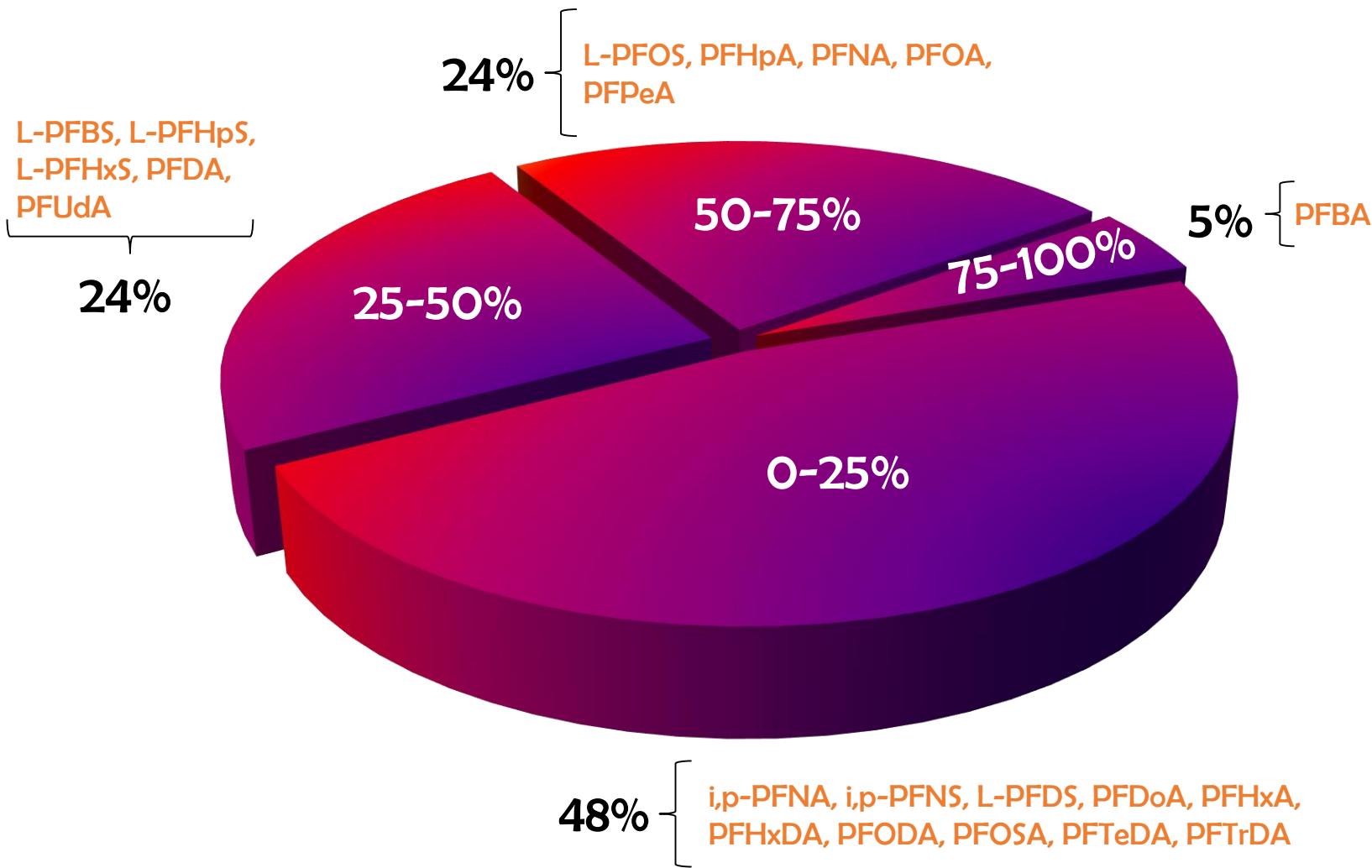
Analysis of PFCs in sewage sludge

CONCENTRATIONS FOUND IN SEWAGE SLUDGE SAMPLES



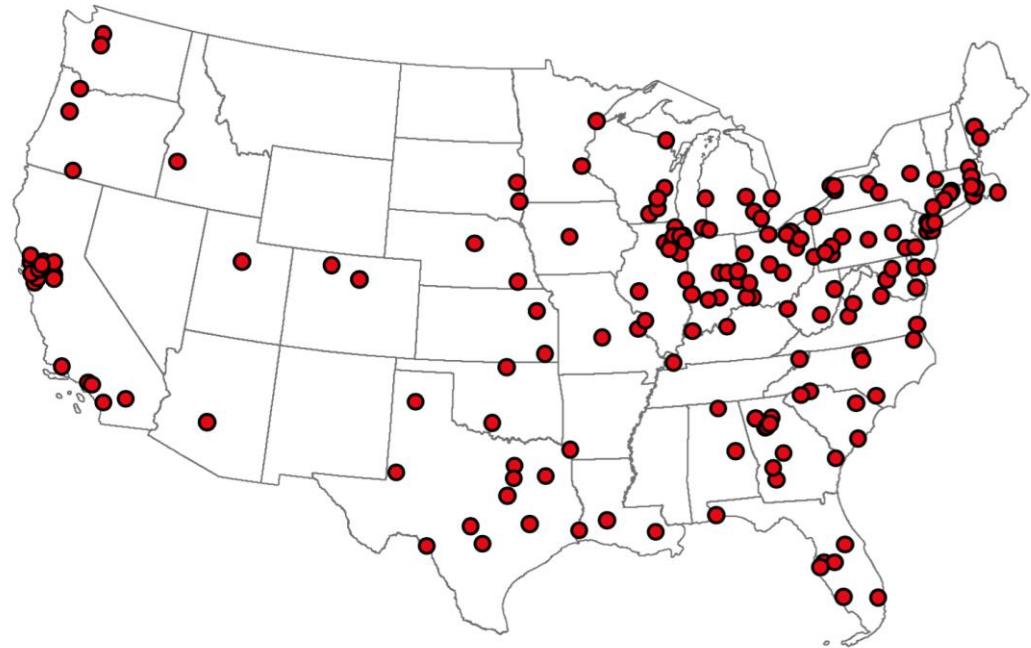
Analysis of PFCs in sewage sludge

OCURRENCE FREQUENCY IN THE 15 STPs



National Sewage Sludge Repository at ASU (NSSR)

- >200 WWTPs
 - Representative of 16,000+ plants
 - Unbiased national estimates
- >10% of U.S. population
- >32M people
- Largest, most studied archive in the U.S.
- Anonymity through size
- E.g.: ~200,000 kg/yr of antimicrobials to US soils



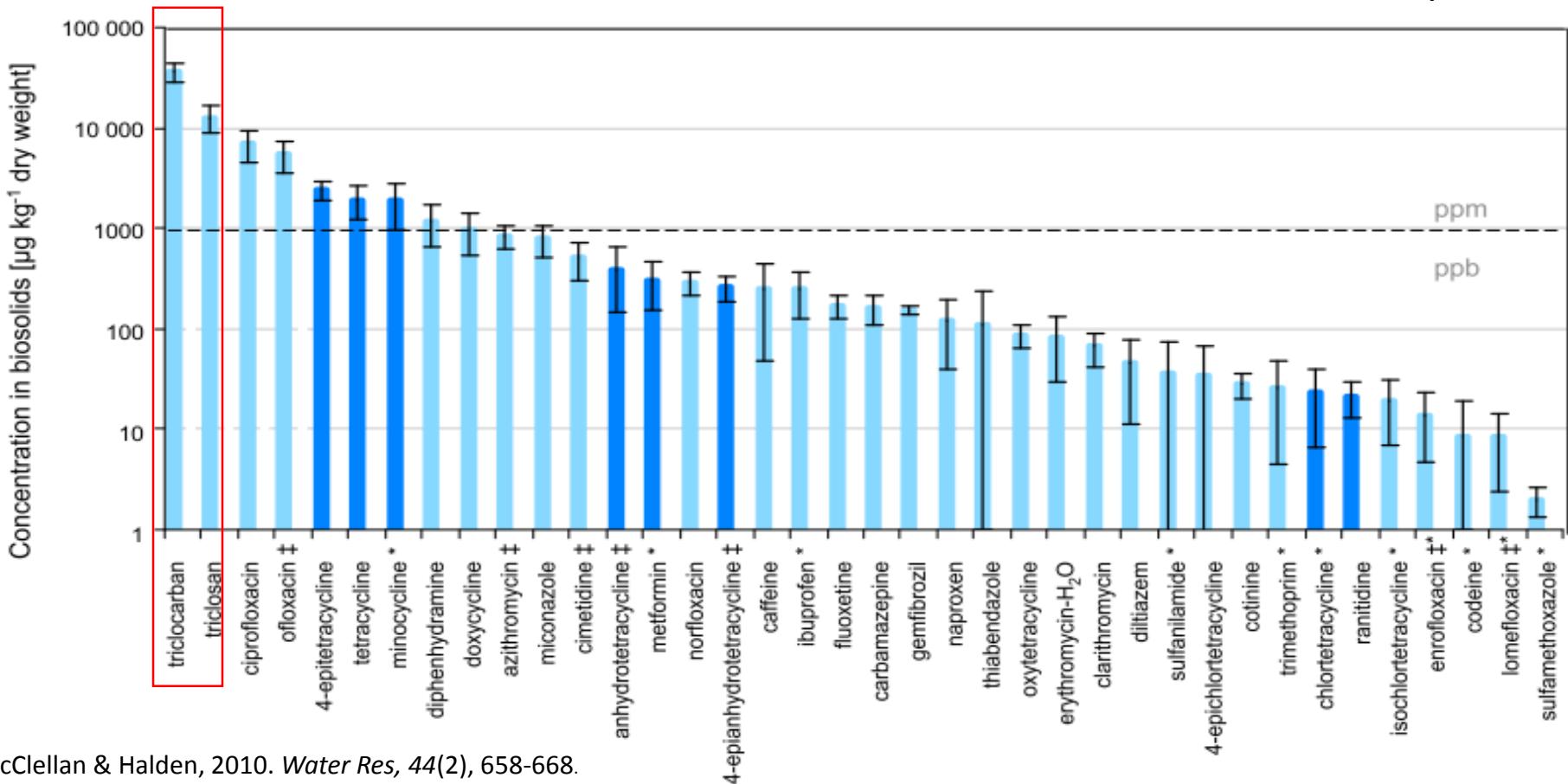
Arjun Venkatesan

Halden, 2014. *Environ. Sci. Technol.* 2014, 48, 3603–3611

Venkatesan & Halden, 2014. *Environ. Sci. Pollut. Res.* 22 (3), 1577-1586.

Pharmaceuticals in NSSS collected in 2001

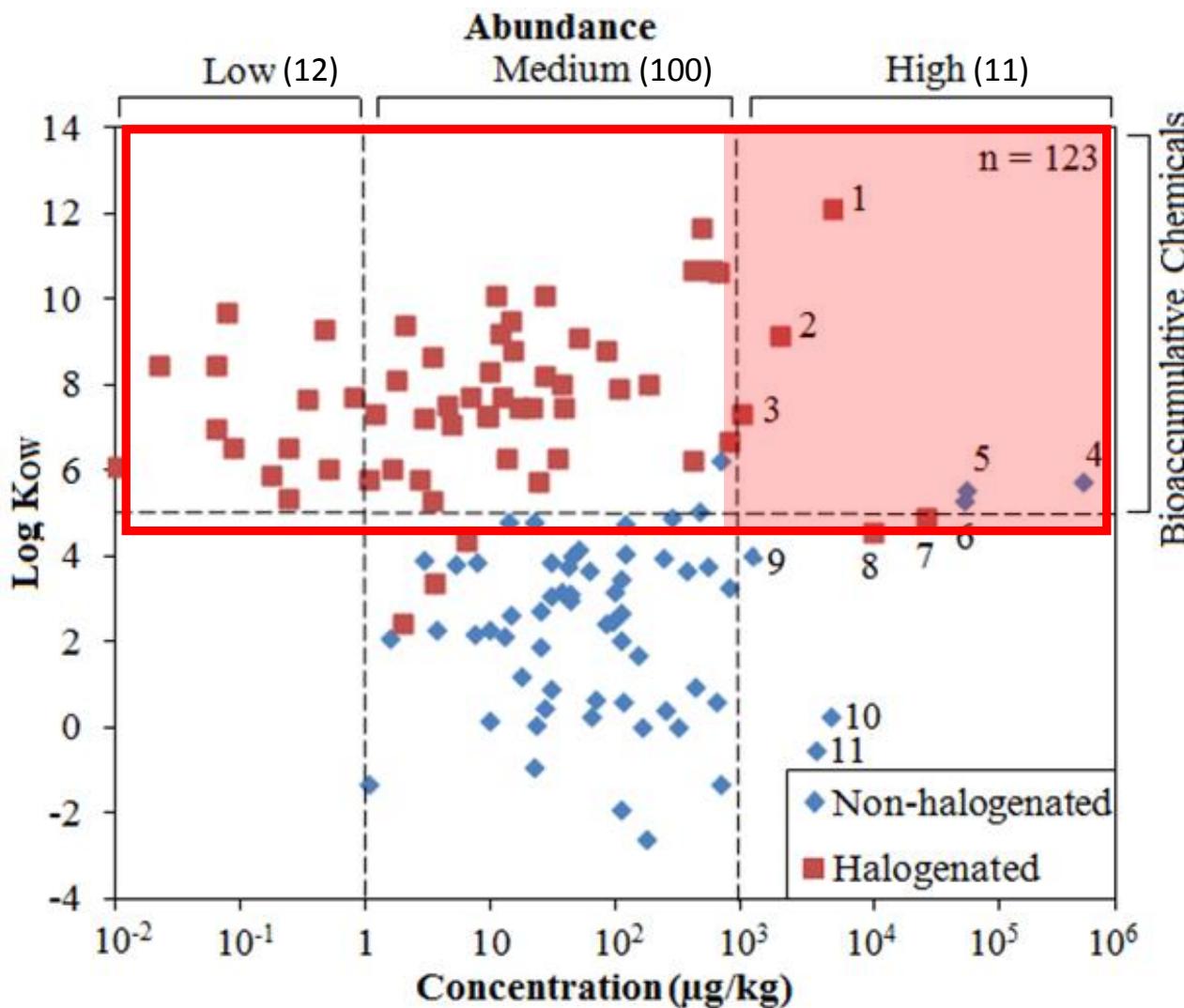
- 38 out of 72 detected
 - 0.002 to 48 mg/kg dw
- TCC & TCS most abundant
 - 36 ± 8 & 12.6 ± 3.8 mg/kg dw
- Σ PPCPs load in biosolids
 - 210 – 250 metric t
- 2001 vs 2006/7
 - => Limited fluctuation over years



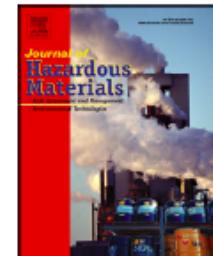
- A globally shared resource at ASU
- Environmental samples
 - Wastewater, sediments, sludge, surface water, plants, dust etc.
- Human samples
 - Urine, blood, serum etc.



Using Sewage Sludge Analysis as a Diagnostic Tool Informing Chemical Regulation



- 123 chemicals
- 55 potentially bioaccumulative chemicals
 - 93 % halogenated
- 8 priority chemicals
 - 3 BFRs
 - 3 Surfactants
 - 2 Antimicrobials



Epistemology of contaminants of emerging concern and literature meta-analysis

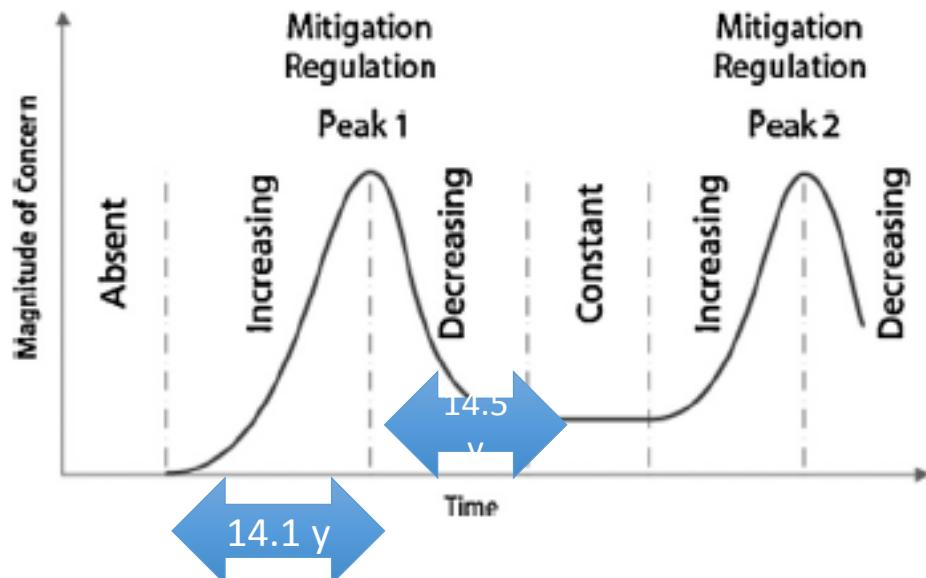


Rolf U. Halden ^{a,b,*}

HIGHLIGHTS

- Meta-analysis of 143,000 papers reveals common pattern of emergence of contaminants.
- CECs emerge from obscurity to height of concern over a period of 14.1 ± 3.6 years.
- It typically takes 14.5 ± 4.5 years for a CEC to descend from the peak of concern to a new, lower baseline level.
- Regulatory actions are shown to play an important role in managing concern over contaminants.

GRAPHICAL ABSTRACT



Where is the Value in Sludge?

**City of 1M people:
metals & P in sludge
=> \$13M/y**

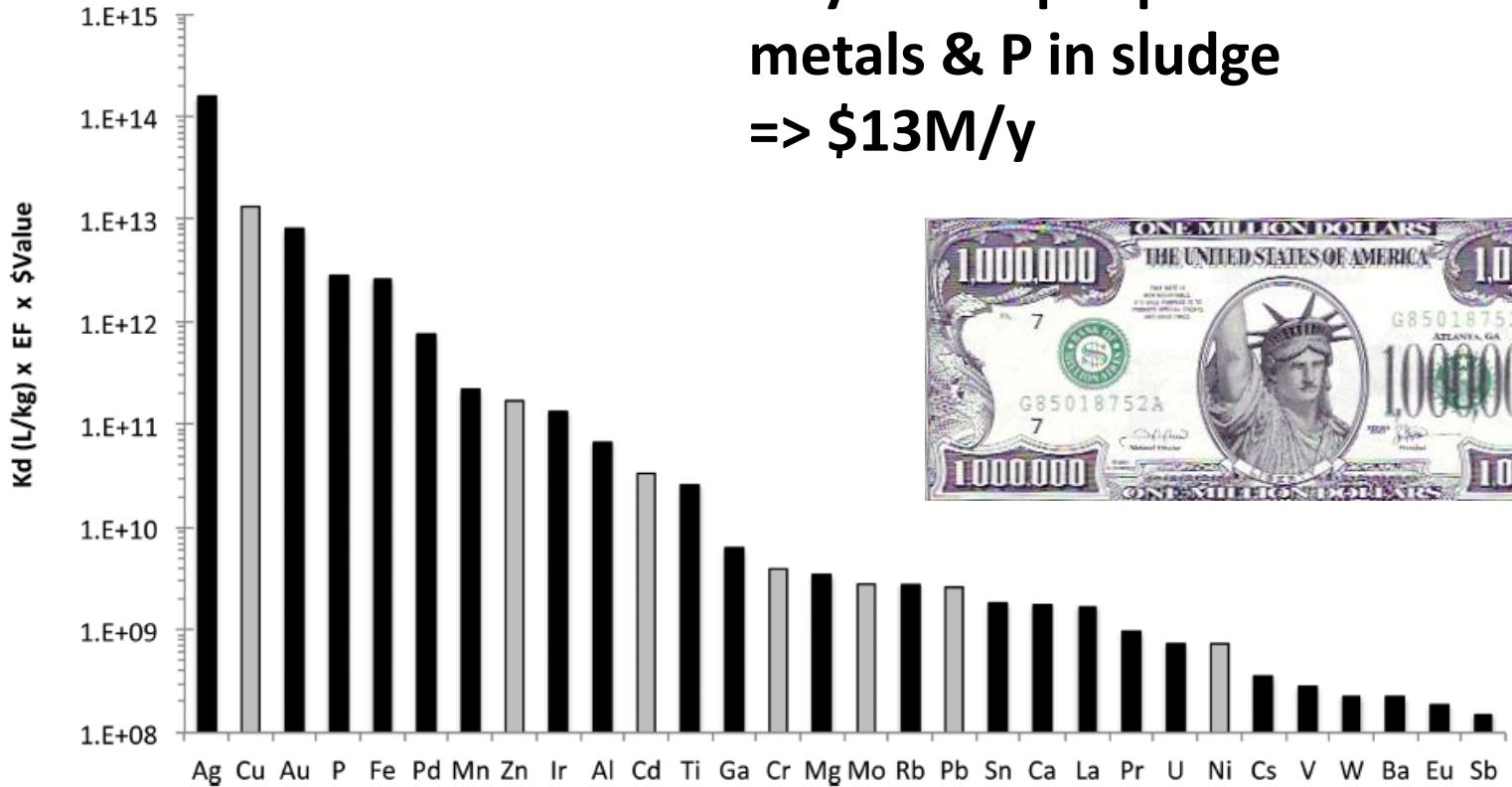


Figure 5. Relative potential (y-axis) for economic value from biosolids for the top 30 elements based upon a community of 1 000 000 people producing 26 kg/person-year of dry biosolids. Gray bars indicate elements considered potentially toxic for land application and have dry weight concentration limits on their land application regulated by the Part 503 Biosolids Rule.

Ag > Cu > Au > P > Fe > Pd > Mn > Zn > Ir > Al > Cd > Ti...

Thanks to:



US EPA
NIEHS
CDC

Dr. Arjun Venkatesan
Dr. Kristin McClellan
Erin Driver

AND MANY OTHERS



National Institute of
Environmental Health Sciences



IDAEA-CSIC team



NIEHS R01ES015445; R01ES020889
ESTCP 200914; 201122
Virginia G. Piper Charitable Trust: LTR 05/01/12
Johns Hopkins Center for a Livable Future

