

Contaminants of Emerging Concern in Biosolids with Special Emphasis on Land Application

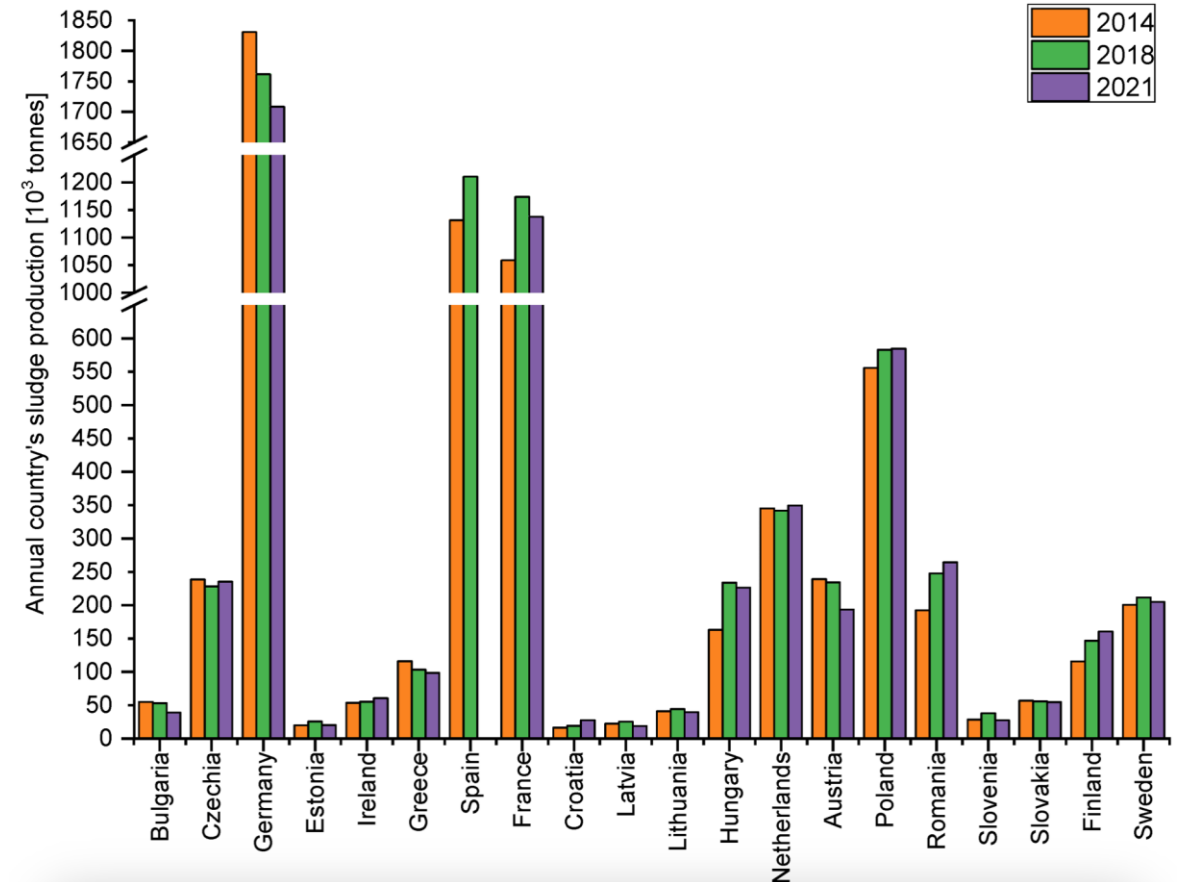
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The 19th IWA Conference on Sludge Management, October 21-24, 2025, Kyoto Japan

Challenges in Sludge Management

- Sludge production rates
- Presence of contaminants
 - Conventional Pollutants
 - Pathogens
 - Heavy Metals
 - Nutrients
 - Emerging Contaminants
 - Emerging concerns on pathogens



Grobelak et al 2024, Energies

Emerging Contaminants and Federal Facilities

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Runoff of pharmaceuticals and personal care products following application of dewatered municipal biosolids to an agricultural field

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Emerging Contaminants*

- ⊙ really new contaminants, new compounds or molecules that were not previously known or that just recently appeared in the scientific literature,
- ⊙ contaminants of emerging interest which were known to exist but the environmental contamination issues were not fully realized, and
- ⊙ emerging issues about “old” contaminants

* Sauvé and Desrosiers (2014)

Emerging Contaminants (CEC)



Nonregulated (mostly), natural and synthetic chemical compounds which include

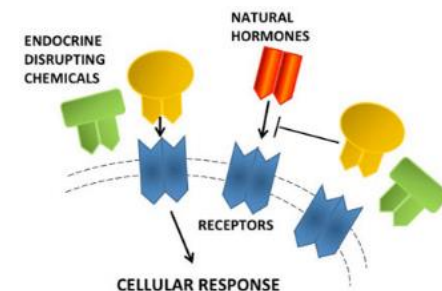
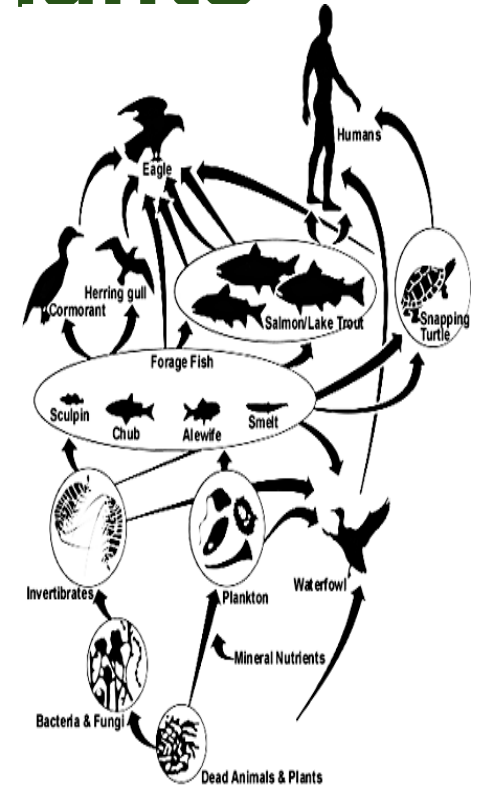
- ⊙ Hormones
- ⊙ Detergents and Surfactants
- ⊙ Personal care products
- ⊙ Prescription and nonprescription drugs
- ⊙ Flame retardants
- ⊙ Microplastics
- ⊙ Antibiotic resistance genes (AGR)
- ⊙ Disinfectants
- ⊙ Plasticizers
- ⊙ Fumigants
- ⊙ Pesticides and repellents
- ⊙ Nanomaterials
- ⊙ PFAS



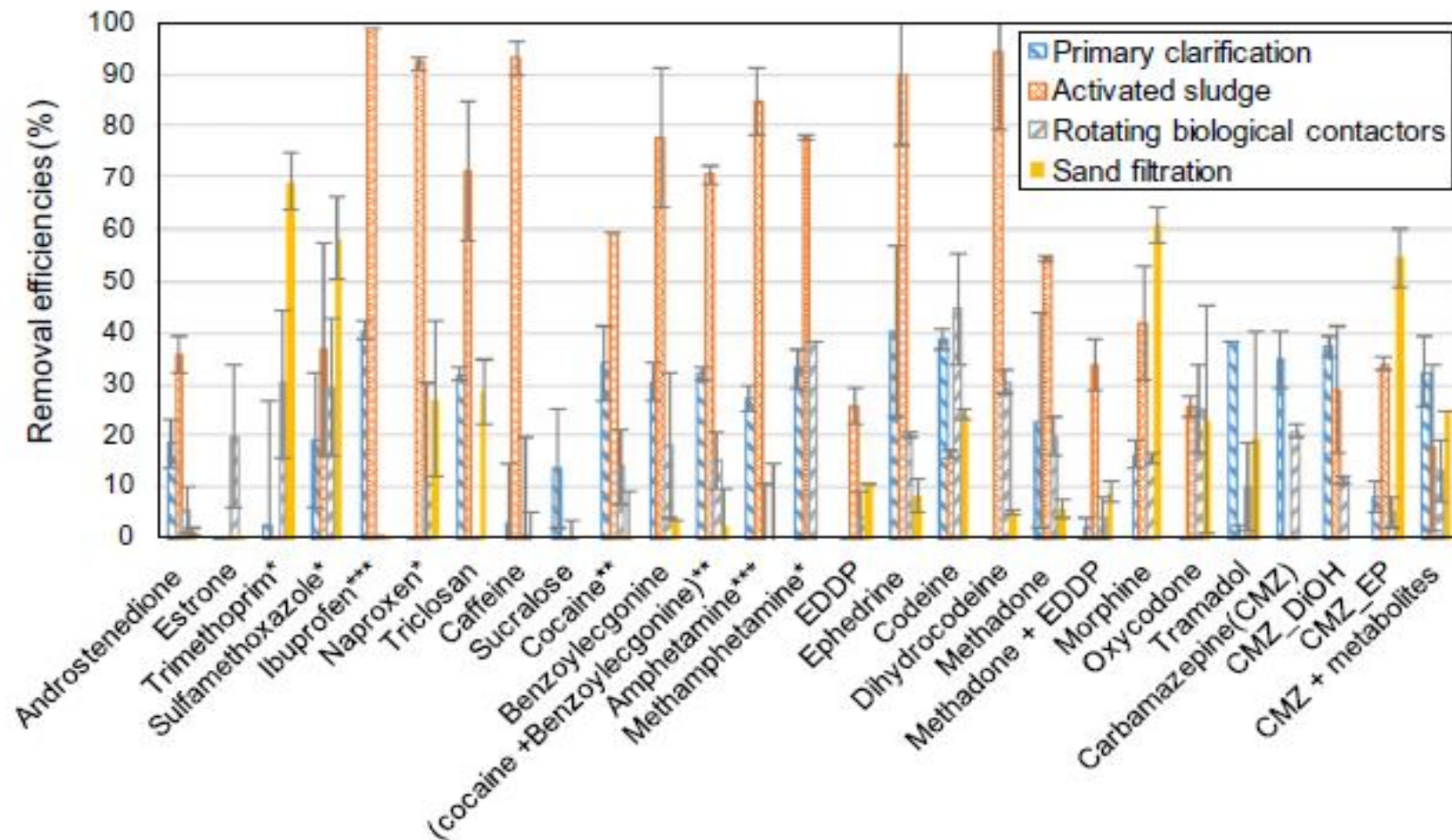
These contaminants are often called as “micropollutants”

Characteristics of Emerging Contaminants

- ⊙ Have negative impact on aquatic organisms
 - ⊙ Cause feminization of male fish
- ⊙ Bioaccumulate in fatty tissues and in food chain
- ⊙ Toxic or carcinogenic
- ⊙ Have complex nature which makes them difficult to degrade
- ⊙ Listed among the endocrine disrupting substances



What Happens during Wastewater Treatment?

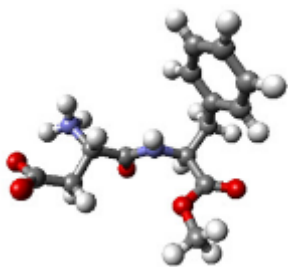


Baalbaki et al. (2016) *Science of the Total Environment*

Emerging Contaminants in Biosolids

Pollutant

- ⊙ Hydrophobicity/lipophilicity
- ⊙ Water solubility
- ⊙ Molecular structure/weight
- ⊙ pKa
- ⊙ Biodegradability



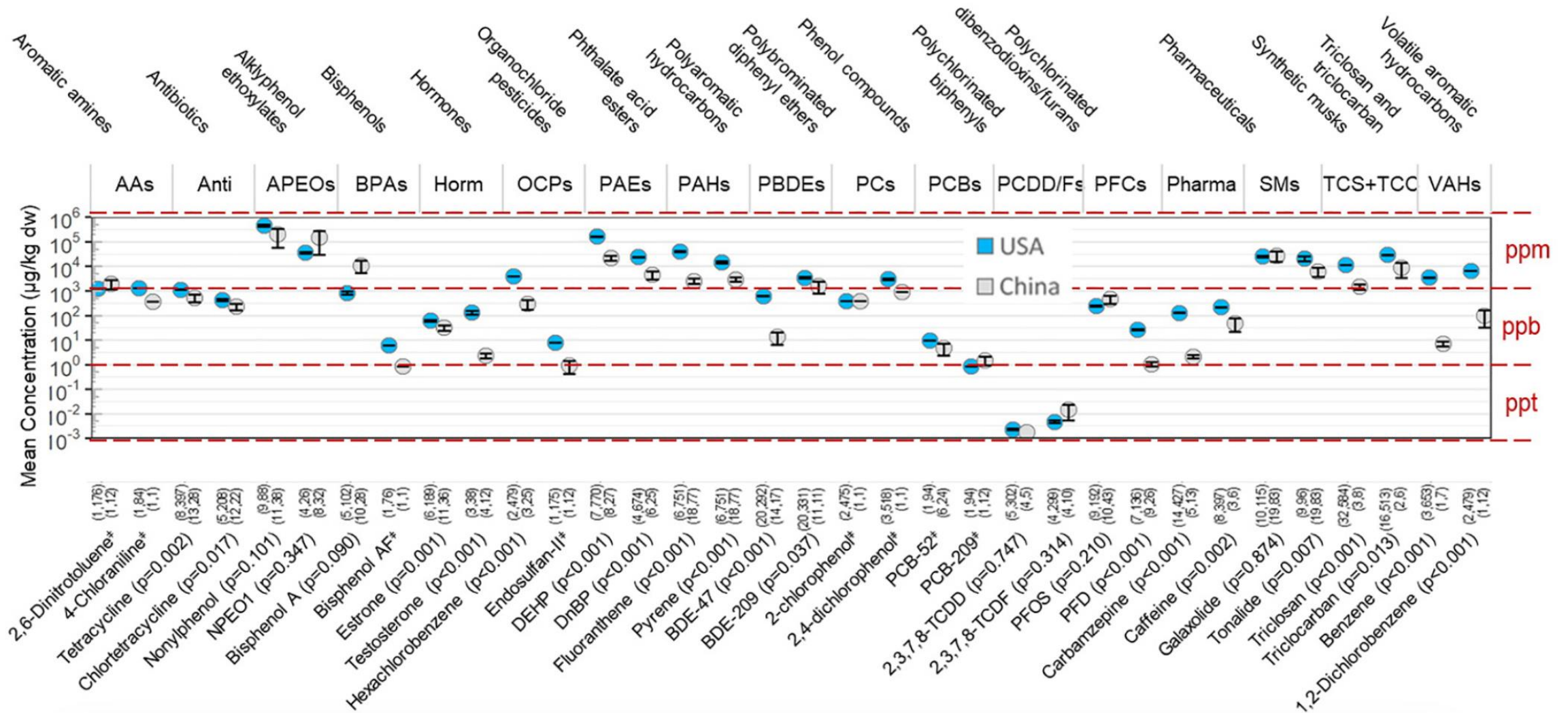
WWTP Operation

- ⊙ Incoming WW characteristics
- ⊙ Presence/absence of PC
- ⊙ HRT
- ⊙ SRT
- ⊙ Presence/absence of stabilization

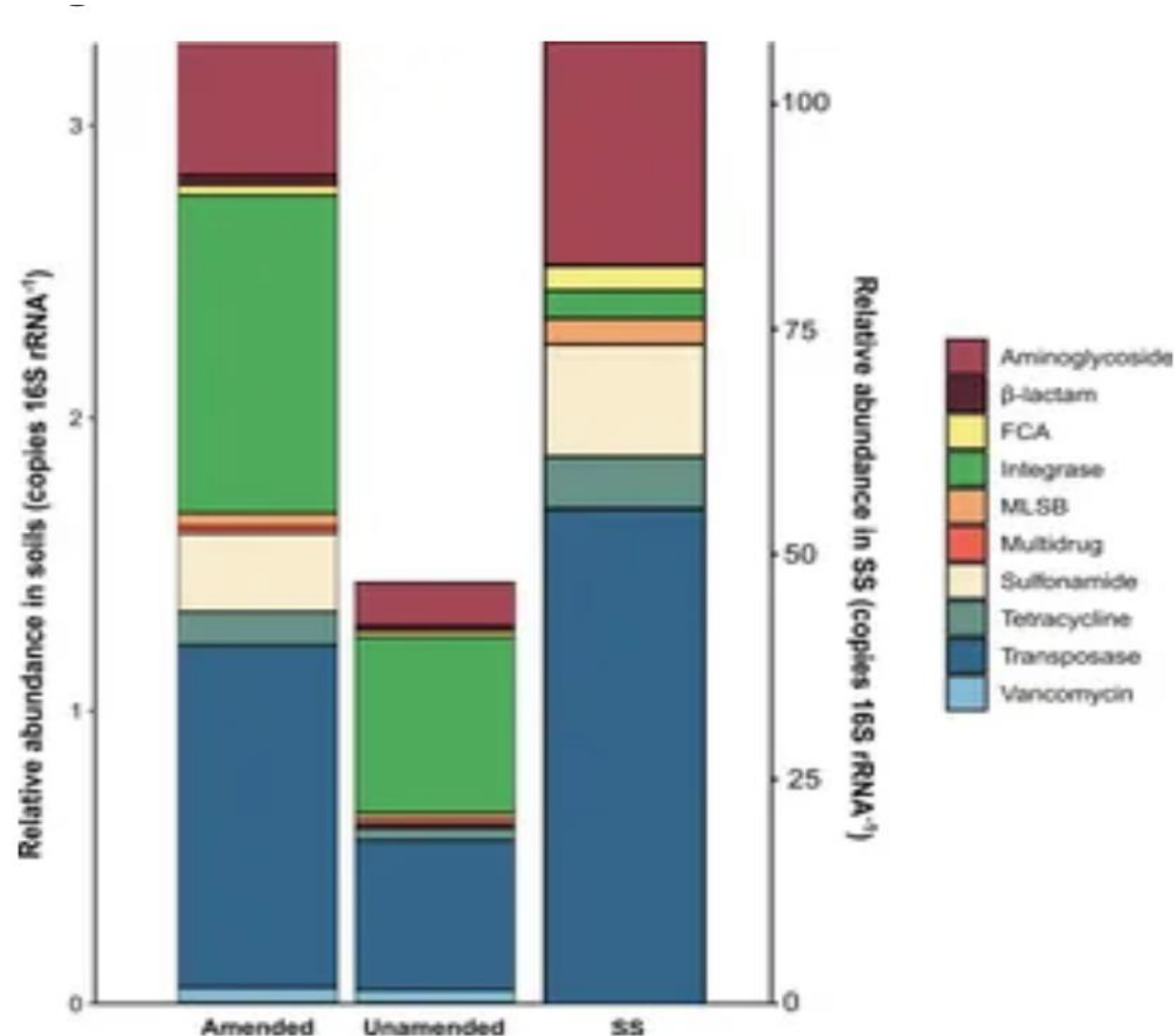
Sludge Chemistry

- ⊙ pH/ pKa
- ⊙ Organic matter
- ⊙ Cation concentration

PPCPs and Industrial Chemicals in Biosolids



Relative Abundances of ARGs and MGE-genes in Sludge Amended Soils, Unamended Soils and Sludge



Jauregi et al (2021) Frontiers in Microbiology

Land Application of Biosolids

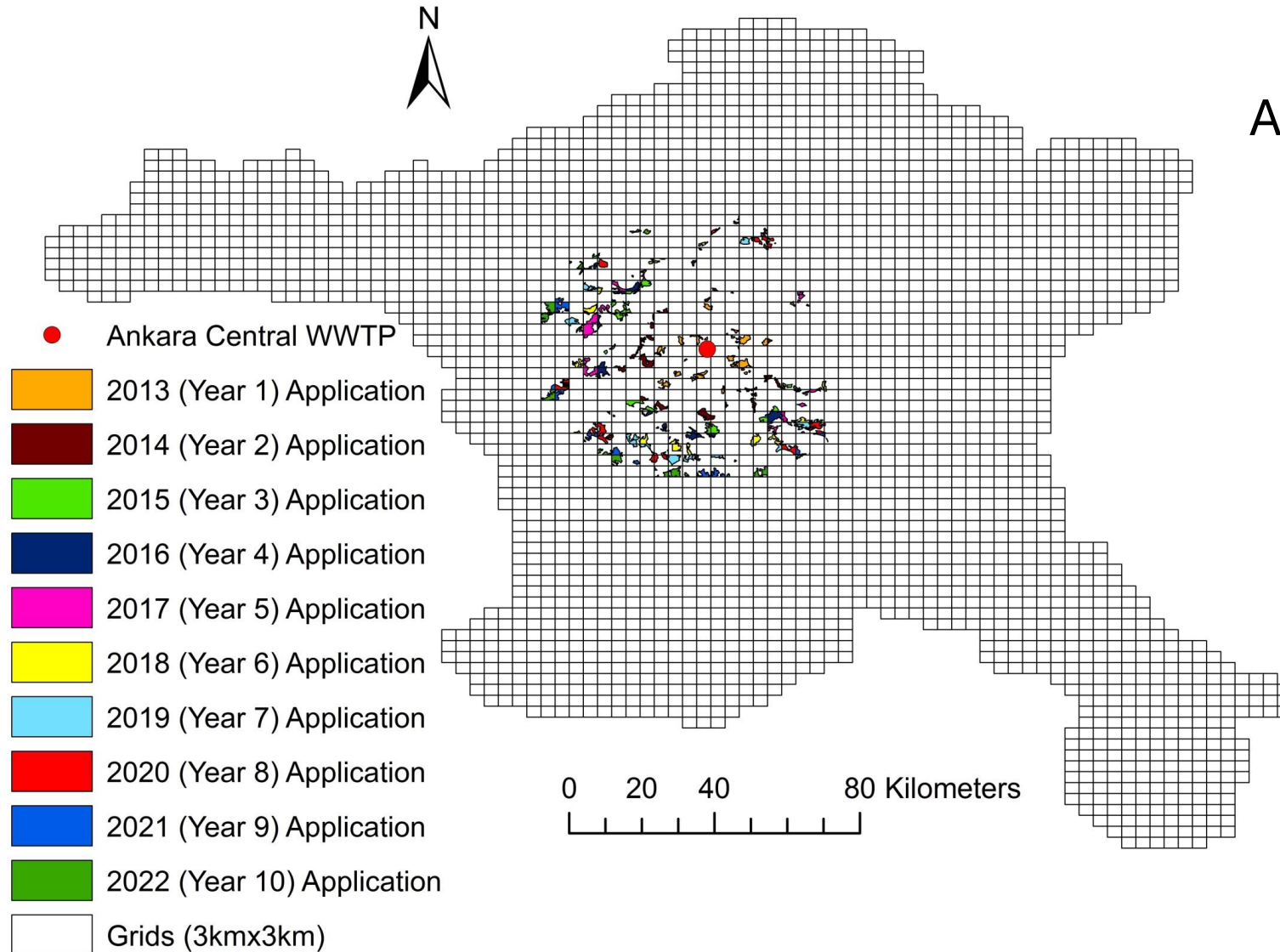
- ⊙ Circular economy perspective necessitates land application of biosolids
- ⊙ Opportunities: Macro and micro-nutrients, organics content, ...
- ⊙ Concerns
 - ⊙ Heavy Metals
 - ⊙ Emerging Contaminants
 - ⊙ Pathogens and/or antibiotic resistance genes
- ⊙ Concern due to missing risk assessment studies
- ⊙ Concern about repeated application to the same area/land
- ⊙ Concern about persistence and bioaccumulative characteristics of most organic contaminants

Ankara Land Application Optimization Study



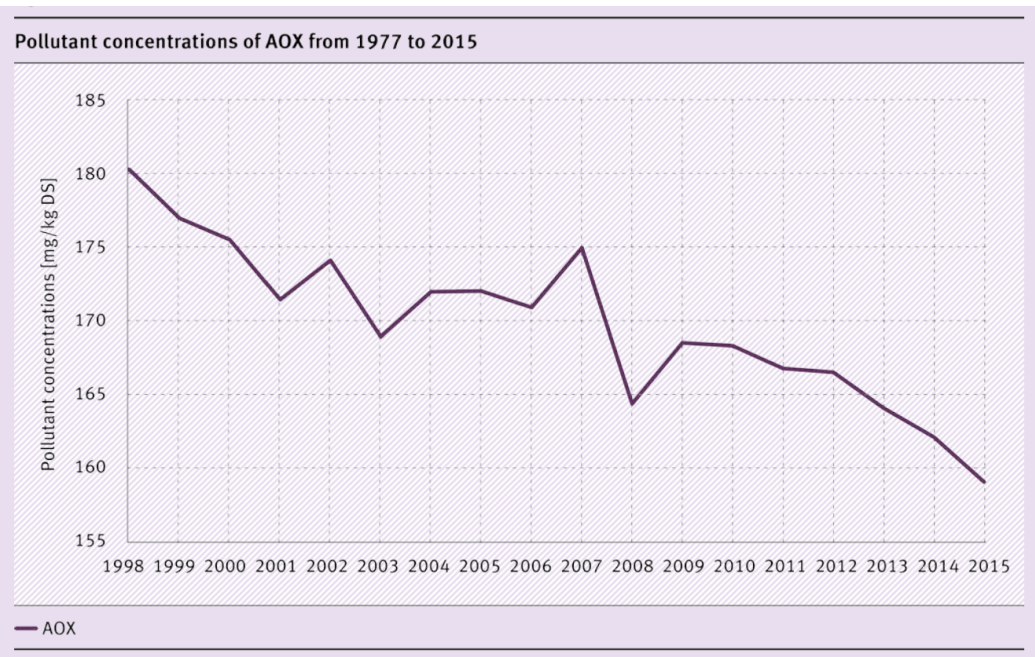
Application Rate= 1 dry ton/yr

According to the optimization model, 17.1% of the total non-irrigated arable lands suitable for application received sewage sludge in 10 years without having to go to the same application site.

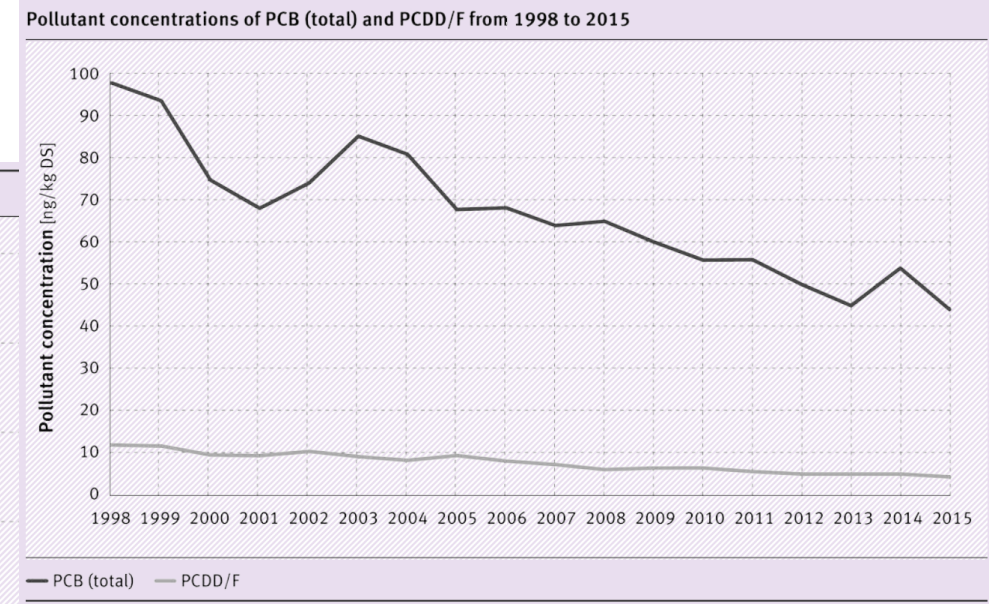
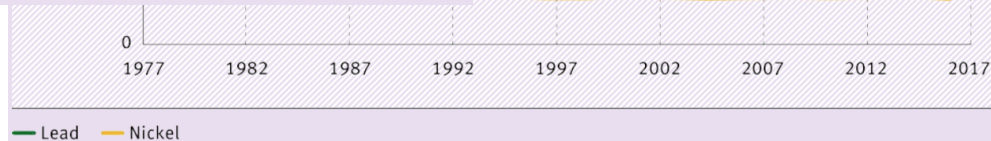


What Can be Done to Reduce CECs in Biosolids?

- Effective legislation on source control
 - Reduce the sludge generated at WWTPs
 - Reduce/prevent the contaminants entry to WWTPs to start with



1977 to 2016



What Can be Done to Reduce the Risk of CECs in Biosolids?

- ⊙ Effective legislation on land application of biosolids and monitoring
 - ⊙ Heavy Metals ==> Cd, Cu, Hg, Ni, Pb and Zn, As, Se, etc.
 - ⊙ In sludge
 - ⊙ In soils
 - ⊙ Emerging Contaminants ==> AOX, DEHP, LAS, NPE, PAH, PCB, PCDD/F, PFAS, etc.
 - ⊙ Pathogens and/or Indicators ==> Fecal Coliforms, E Coli, Enterococci, Thermotolerant Coliforms, Clostridium perfringens, Helminth eggs, etc.
 - ⊙ Risk assessment studies

What Can be Done to Reduce CECs in Biosolids?

- ◎ Use of more effective technologies in wastewater treatment
- ◎ Selection of the right processes to reduce CECs
 - ◎ Requires some knowledge of the contaminant chemistry/biochemistry and properties
 - ◎ Requires some manipulation of the conventional treatment system
 - ◎ Requires the use of advanced treatment techniques
- ◎ Generally it may not be possible to eliminate these compounds by single treatment system. Use of combined or hybrid processes may be necessary.

What Can be Done to Reduce CECs in Biosolids?

- ◎ Use of more effective technologies in sludge treatment
 - ◎ Effective stabilization – necessary for chemical contaminants and pathogens
 - ◎ Pretreatment methods such as thermal hydrolysis in connection with anaerobic digestion may decrease the CECs as well as pathogens
 - ◎ Combination of aerobic and anaerobic processes may help reduce CECs
 - ◎ Integrating processes to reduce these compounds into sludge treatment lines



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THANK YOU



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