

Influence of earthworms on the behavior of micropollutants in sewage sludge

Ales Hanc^{a*}, Bayu Dume^a, Pavel Michal^a, Vojtech Pospisil^a, Alena Grasserova^{b,c}, Tomas Cajthaml^{b,c}



^a*Czech University of Life Sciences, Faculty of Agrobiological Sciences, Department of Agro-Environmental Chemistry and Plant Nutrition, Kamýcka 129, Prague 16500, Czech Republic. *hanc@af.czu.cz*

^b*Institute of Microbiology, Academy of Sciences of the Czech Republic, Prague, Czech Republic*

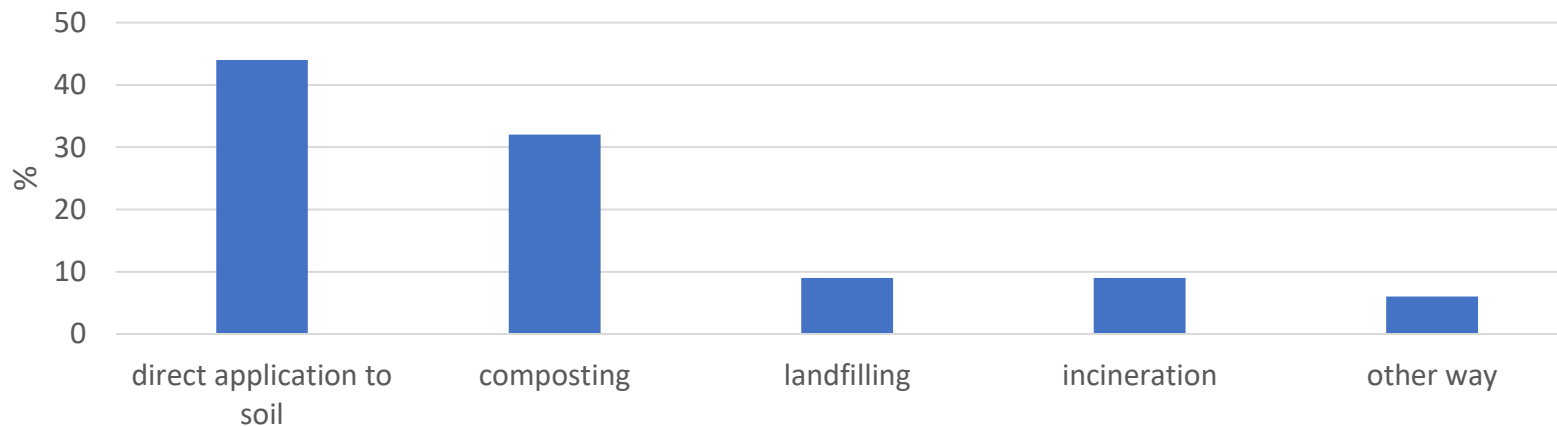
^c*Institute for Environmental Studies, Faculty of Science, Charles University in Prague, Czech Republic*

Sewage sludge

- Sewage sludge is a byproduct of wastewater treatment and is produced worldwide
- There are many strategies to reuse sewage sludge but also many restrictions on the use of the given management method



Current handling with sewage sludge in the Czech Republic



Use of dewatered sewage sludge in agriculture

- **Strengths**

- Organic matter (34 – 62 % in dry matter)
- Macronutrients - 4% N, 0.8% P, 0.2% K, 0.6% Mg, 4.5% Ca, ... and micronutrients

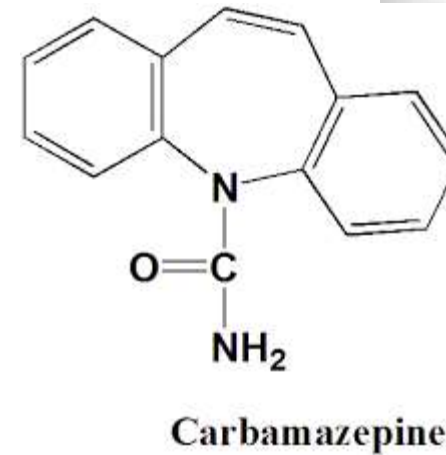
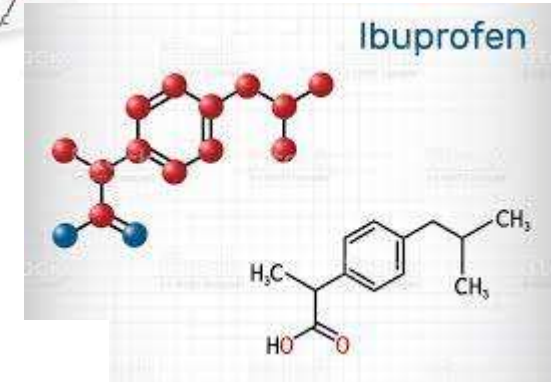
- **Weaknesses**

- Risk elements
- Organic pollutants
- Pathogenic microorganisms
- Micropollutants (pharmaceutical and personal care products (PPCPs))



Pharmaceuticals

- veterinary and human antibiotics
- analgesics and anti-inflammatory drugs
- antidepressants
- fat regulators
- beta blockers
- contrast media for X-rays
- steroids and hormones



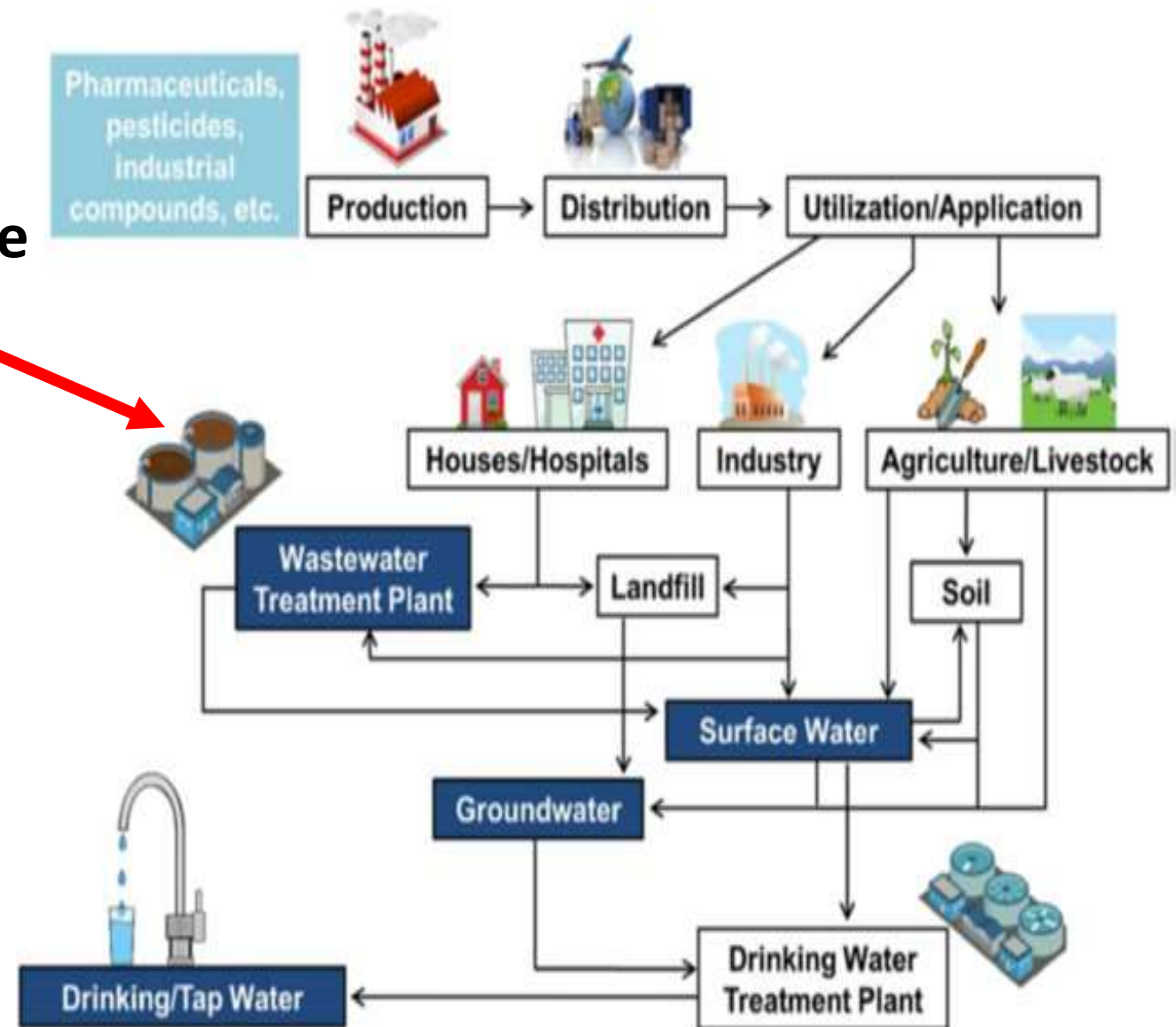
Personal care products

- scents
- UV filters
- insect repellents
- surfactants (surface-active substances)
- antiseptics

Pollutants pathways into the sewage sludge

Pharmaceuticals	rate of removal from wastewater (%)
atenolol	21
ofloxacin	57
hydrochlorothiazide	44
furosemide	15
ciprofloxacin	63
ranitidine	72
ibuprofen	55
sulfamethoxazole	24
bezafibrate	30
enalapril	69
clarithromycin	0
carbamazepine	0
erythromycin	0

Sewage sludge



Legislation

- Management with sewage sludge is regulated in many countries around the world
- However, it is not known that the occurrence of pharmaceuticals and personal care products in sludge is regulated by legislation

Aim of the study

- to determine the influence of earthworms (vermicomposting) on changes of the contents of selected 48 micropollutants (pharmaceuticals, personal care products and endocrine disruptors) during vermicomposting



Material and methods

Vermicomposting with one time feeding

var.	repetition	composition	Vol. of substrate with earthworms in every tray
1	a	sludge 100 weight % (9 kg)	3 l of subs. with earthw. from the side
1	b temperature	sludge 100 weight % (9 kg)	without substrate
1	c	sludge 100 weight % (9 kg)	3 l of subs. with earthw. from the side
2	a	sludge 75 weight % (6.75 kg) + pellets 25 weight % (2.25 kg)	3 l of subs. with earthw. from the side
2	b temperature	sludge 75 weight % (6.75 kg) + pellets 25 weight % (2.25 kg)	without substrate
2	c	sludge 75 weight % (6.75 kg) + pellets 25 weight % (2.25 kg)	3 l of subs. with earthw. from the side
3	a	sludge 50 weight % (4.5 kg) + pellets 50 weight % (4.5 kg)	3 l of subs. with earthw. from the side
3	b temperature	sludge 50 weight % (4.5 kg) + pellets 50 weight % (4.5 kg)	without substrate
3	c	sludge 50 weight % (4.5 kg) + pellets 50 weight % (4.5 kg)	3 l of subs. with earthw. from the side
4	a	sludge 25 % weight % (2.25 kg) + pellets 75 weight % (6.75 kg)	3 l of subs. with earthw. from the side
4	b temperature	sludge 25 % weight % (2.25 kg) + pellets 75 weight % (6.75 kg)	without substrate
4	c	sludge 25 % weight % (2.25 kg) + pellets 75 weight % (6.75 kg)	3 l of subs. with earthw. from the side
5	a	pellets 100 weight % (9 kg)	3 l of subs. with earthw. from the side
5	b temperature	pellets 100 weight % (9 kg)	without substrate
5	c	pellets 100 weight % (9 kg)	3 l of subs. with earthw. from the side



Sampling

- Beginning of the experiment
- 1st month
- 4th month





Dionex ASE 200 extractor (extraction under increased pressure and temperature)



6475 Triple Quadrupole LC/MS



Results and discussion

Sewage sludge:

of the 48 substances determined, 32 micropollutants were detected, the most for telmisartan (10,161 +/- 391 ng/g), triclosan (543 +/- 62 ng/g) and citalopram (440 +/- 5 ng/g)



Straw pellets:

5 substances detected (caffeine, mirtazapine, sulfapyridine, telmisartan, venlafaxine)



Evaluation parameters were created to verify the influence of earthworms on degradation

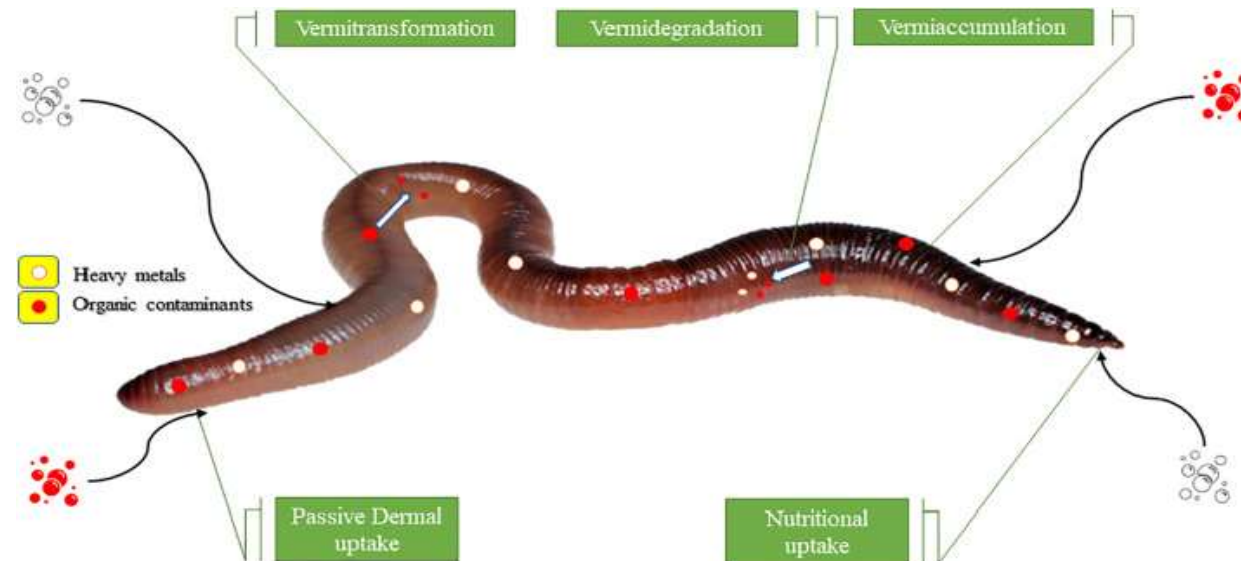
- **Vermidegradation** – calculated as Earthworm effect = (degradation rate V+) – (degradation rate V-) [in %]

degradation rate V+ = 1- (VK vermis+)/ (input raw material or input mix)

degradation rate V- = 1- (VK vermis-) / (input raw material or input mix)

The effect value indicates by how much percentage the reduction of the micropollutant concentration was more significant with the use of earthworms compared to the variant without earthworms

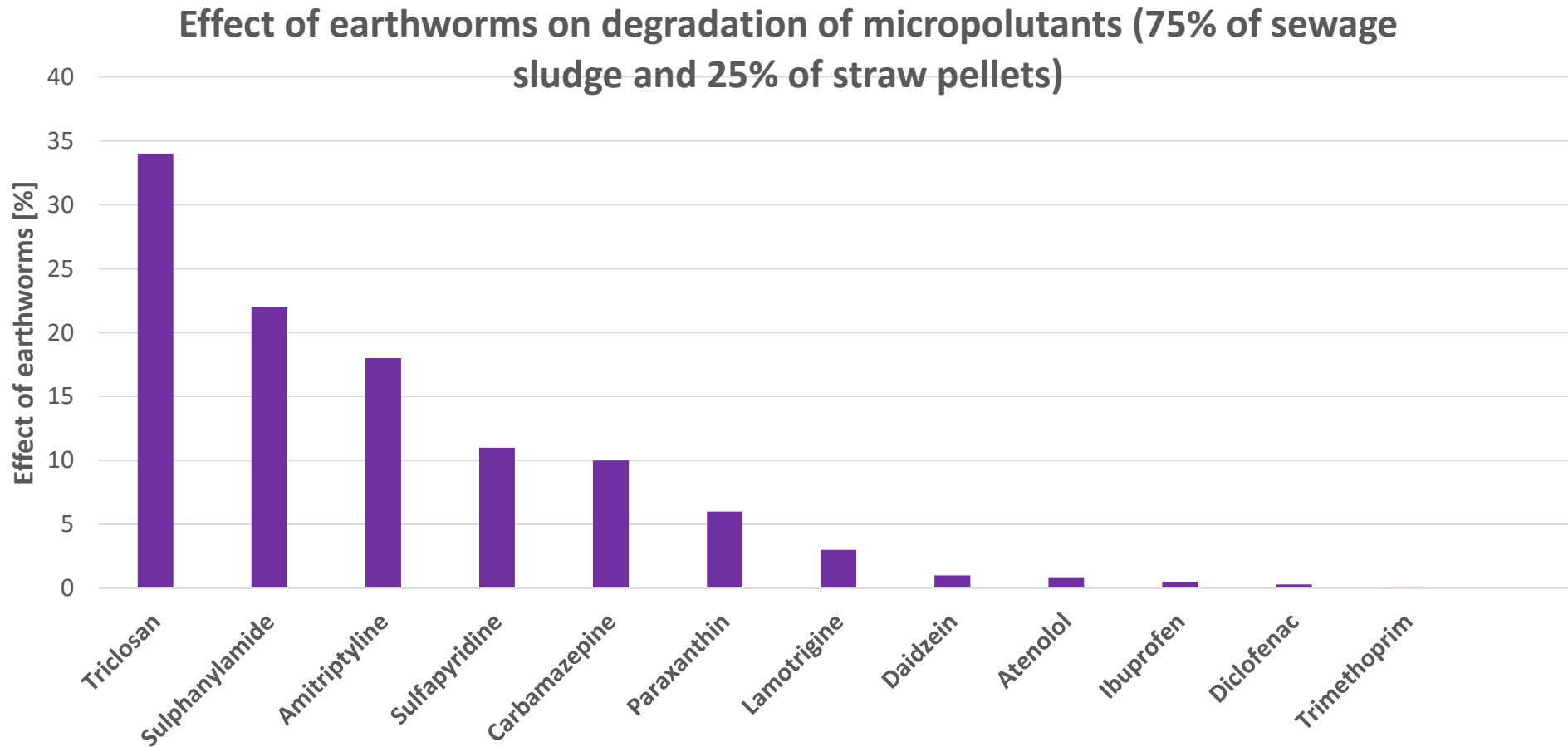
- **Vermiaccumulation** – calculated as Bioconcentration factor = average concentration in earthworm / average concentration in vermicomposted material (at the end of vermicomposting)



Vermidegradation

Summary evaluation of the rate of degradation of micropollutants

Variants [portion in %]		Content [ng/g]			Rate [%]		
Sludge	Straw	Σ input raw material or input mix	Σ VK vermis+	Σ VK vermis-	Degradation rate V+	Degradation rate V-	Effect of earthworms (in %)
100	0	12687	9554	10351	25	18	6.3
75	25	8281	11037	9565	-33	-16	-18
50	50	4891	6154	6404	-26	-31	5.1
25	75	2203	5277	3567	-140	-62	-77.5
0	100	19	36	32	-89	-68	-21.5



Triclosan – antibacterial agent, used in shampoos, toothpaste, deodorants

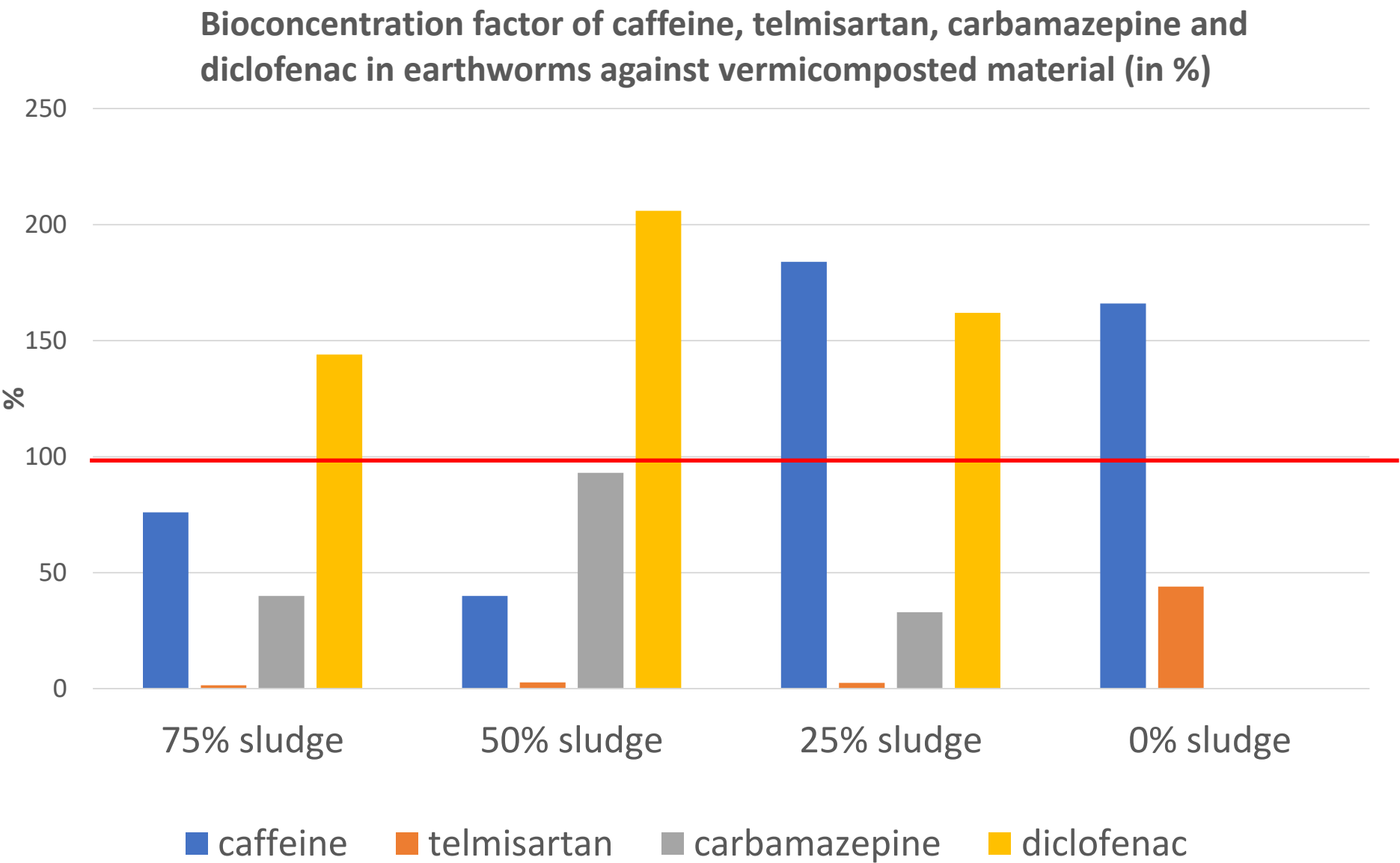
Sulphanylamide – antibacterial drug especially against yeast infections

Amitriptyline – antidepressant

Sulfapyridine – antibacterial drug used in veterinary medicine

Carbamazepine - an active substance for the treatment of epilepsy, neuropathic pain, schizophrenia and bipolar disorder

Vermiaccumulation



Conclusion

- The most significant effect of earthworms was determined with triclosan (by 30 – 43% lower content than the earthworm-free variant), sulfanilamide (by 3 – 37%), amitriptyline (by 15 – 19%) and carbamazepine (by 10 – 42%)
- Vermiacumulation was most significant for caffeine (40 – 184% of the micropollutant content in the earthworm in relation to the content in vermicomposted material), diclofenac (144 – 207%)
- Telmisartan has the highest content within all monitored micropollutants in earthworms
- Vermicomposting of sewage sludge can definitely be recommended for further investigation in relation to the removal of PPCPs and endocrine disruptors
- In the future, this technology represents a very promising and cost-effective solution to the issue of pollutants in sewage sludge applied to soils

Thank you for your attention!



Acknowledgment

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