

Chemical and microbiological safety of black soldier fly larvae (*Hermetia illucens*) reared on sewage and industrial sludges

Food safety in our future circular society

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Research objective



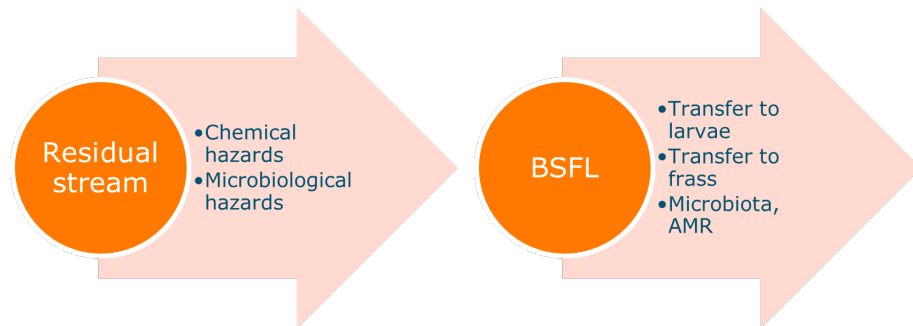
Be prepared for future food safety issues in our circular society

SURVEY in sludges

Monitor the presence of safety hazards in different types of sludge

FATE study

Study behavior of selected food safety hazards and their effects in case studies consisting of a selection of circular systems



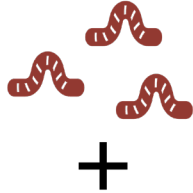
Experimental design



25.000 BSFL

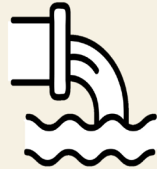
10 kg start
substrate

BSFL, 5-DOL, 7 days



Sludges from
food industry or
STPs:

- Potato processing factory
- Dairy factory
- Sugar factory
- STP-city
- STP-island
- STP-rural
- Control



Collected samples

Start
substrate
(t=0)



BSFL (t=0
and t=7)



Frass



Microbiological analyses

Food pathogenic
bacteria:

- *Salmonella*,
Campylobacter spp.,
Listeria
monocytogenes and
Bacillus cereus (PCR
after enrichment)

Antimicrobial resistance:

- ESBLs and
carbapenem resistant
bacteria

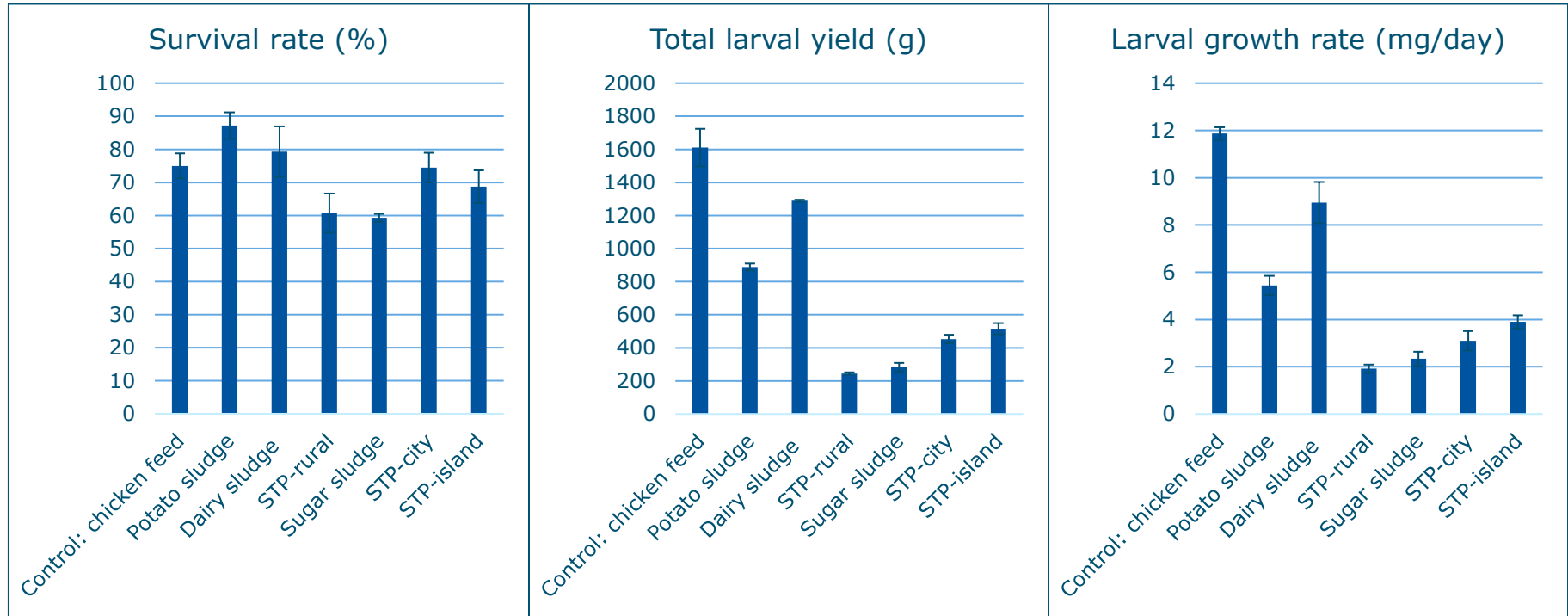
Chemical analyses

Heavy metals:

- Pb, As, Hg, Cd

Dioxins and PCBs

Larval survival and yield



Results: Microbiological safety analyses



Start		BSFL	Chicken Feed	Potato sludge	Dairy sludge	STP-rural*	Sugar sludge	STP-city*	STP-island*
	Salmonella	ND	ND	ND	ND	Detected	ND	Detected	ND
	Campylobacter	ND	Detected	Detected	Detected	Detected	Detected	Detected	Detected
	Listeria	ND	ND	ND	ND	ND	ND	ND	ND
	Bacillus	ND	Detected	Detected	Detected	Detected	Detected	Detected	Detected
Larvae			Chicken feed	Potato sludge	Dairy sludge	STP-rural	Sugar sludge	STP-city	STP-island
	Salmonella		ND	ND	ND	ND	ND	ND	ND
	Campylobacter		ND	Detected	Detected	Detected	Detected	Detected	Detected
	Listeria		ND	ND	ND	ND	ND	ND	ND
	Bacillus		ND	Detected	Detected	Detected	Detected	Detected	Detected
Frass			Chicken feed	Potato sludge	Dairy sludge	STP-rural	Sugar sludge	STP-city	STP-island
	Salmonella		ND	ND	ND	ND	ND	ND	ND
	Campylobacter		Detected	Detected	Detected	Detected	Detected	Detected	Detected
	Listeria		ND	ND	ND	ND	ND	ND	ND
	Bacillus		Detected	Detected	Detected	Detected	Detected	Detected	Detected

Results: Antimicrobial resistance by ESBL-producing and Carbapenem resistant bacteria



- Carbapenem resistant bacteria only detected in STP-rural sludge.
- ESBL genes were found in the substrate, BSFL and frass of control (chicken feed) and STP-city
 - ESBLs found in control substrate were not related to ESBLs found in BSFL and frass
 - ESBL match found between BSFL reared on STP-city sludge and frass

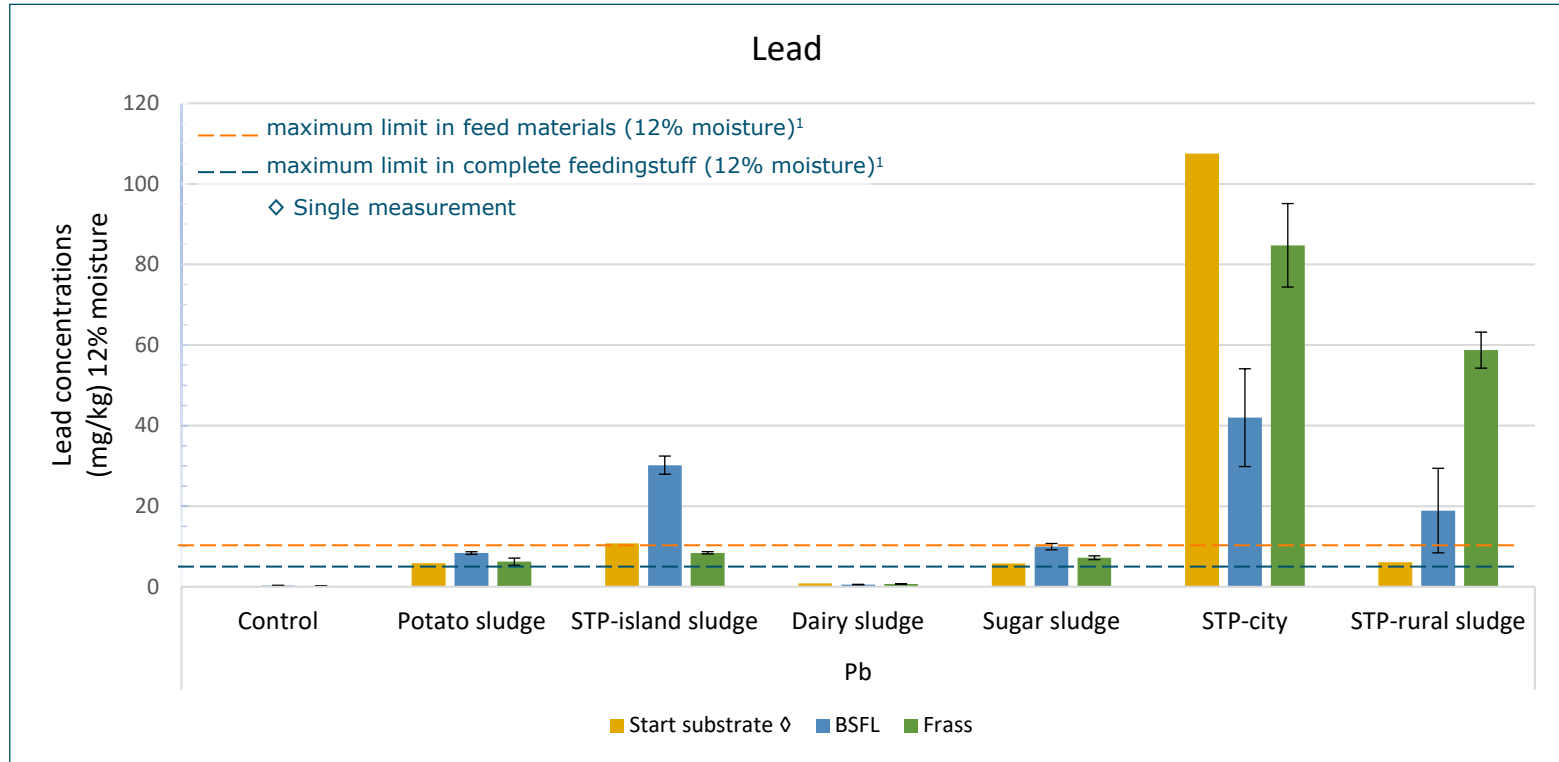
Results: Chemical safety analyses - Heavy metals



- Persistent in the environment
- Mn. Fe. Co. Ni. Cu. Zn. **As**. Se. Mo.
Cd. Hg. Ti. Pb and U

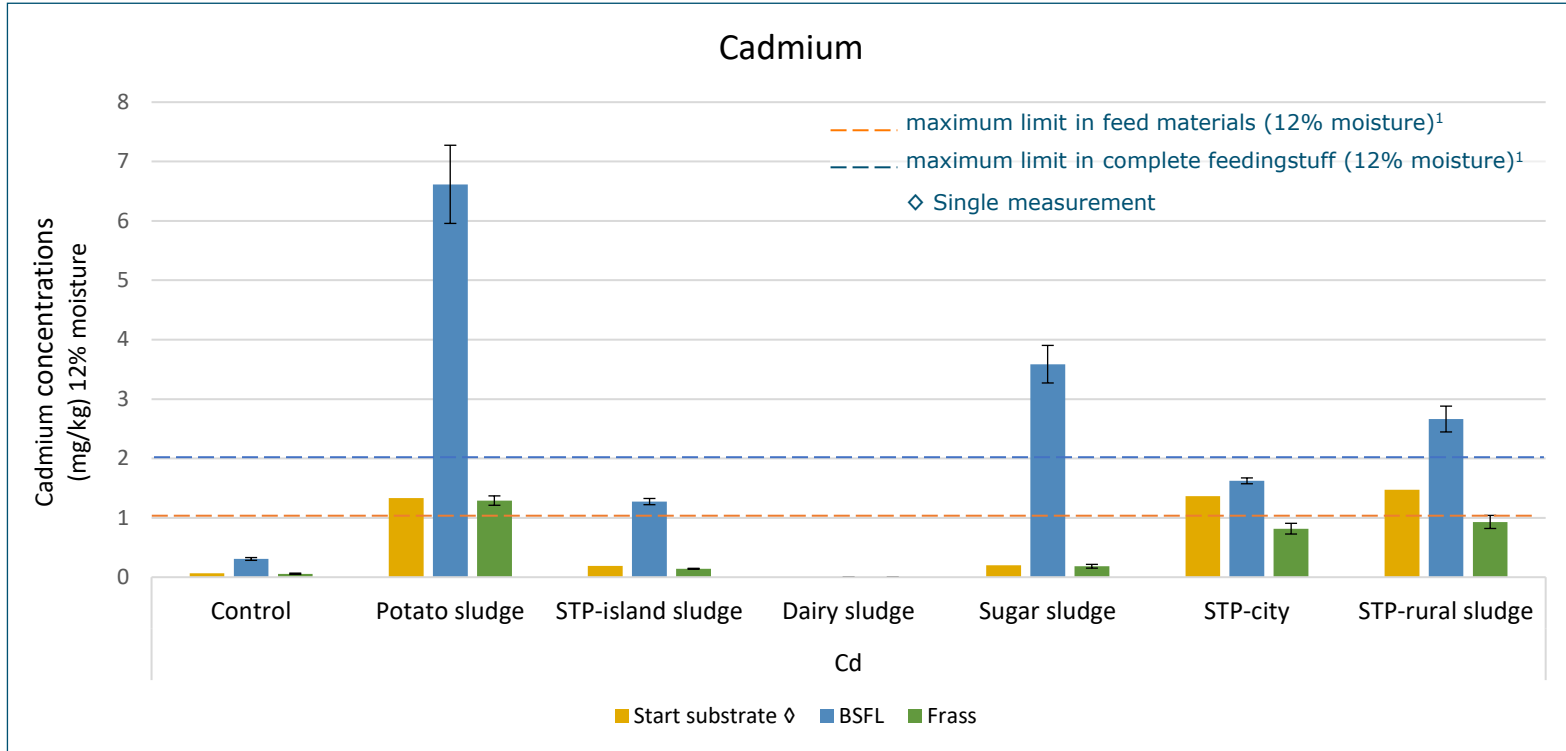
Heavy metal	Treatment	BAF
Pb	Control	-
	Potato	1.43
	STP-island	2.80
	Dairy	0.66
	Sugar	1.73
	STP-city	0.39
	STP-rural	3.09
As	Control	-
	Potato	0.95
	STP-island	1.77
	Dairy	-
	Sugar	1.25
	STP-city	0.50
	STP-rural	0.58
Hg	Control	-
	Potato	-
	STP-island	-
	Dairy	-
	Sugar	-
	STP-city	0.38
	STP-rural	0.27
Cd	Control	4.76
	Potato	4.97
	STP-island	6.65
	Dairy	-
	Sugar	17.90
	STP-city	1.18
	STP-rural	1.81

Results: Chemical safety analyses - Lead



¹Directive 2002/32/EC CL2002L0032EN0220010.0001_cp 1..1 (europa.eu)

Results: Chemical safety analyses - Cadmium



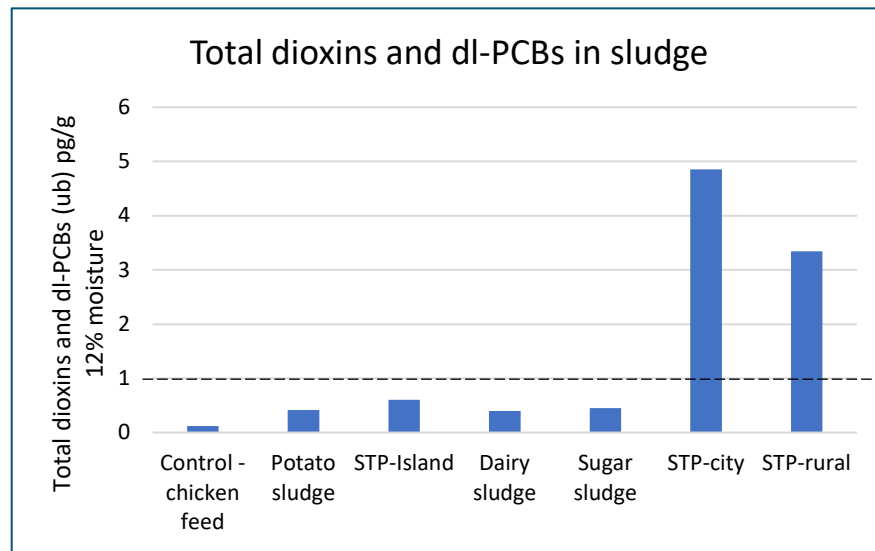
¹Directive 2002/32/EC CL2002L0032EN0220010.0001_cp 1..1 (europa.eu)

Results: Chemical safety analyses – Dioxins & PCBs



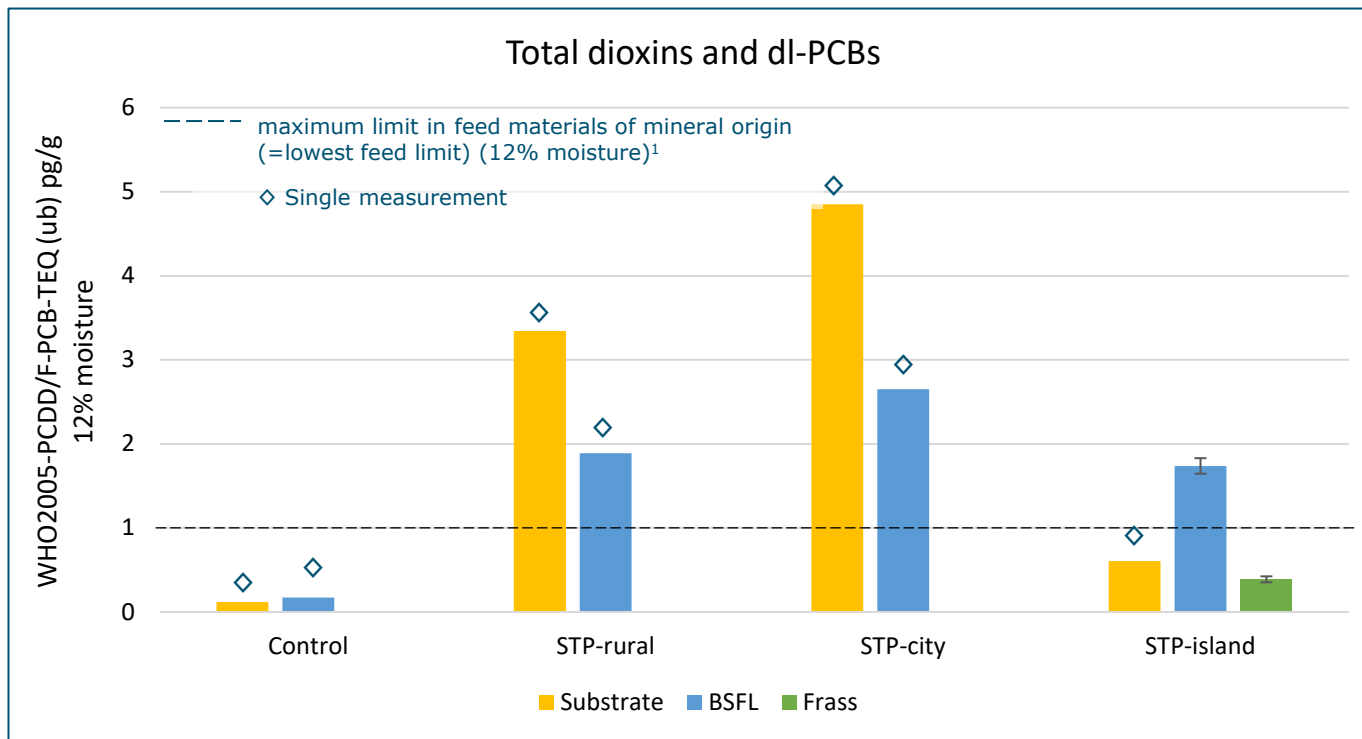
- Persistent organic pollutants (POPs)
- Total dioxins and dl-PCBs were higher in STP sludges compared to food industry sludges
- Accumulation in fat

	Treatment	Larval fat content (g/kg)	BAF
WHO2005-PCDD/F-PCB-TEQ (ub) pg/g product	Control	169.21	1.42
	STP-island	66.13	2.85
	STP-city	36.60	0.55
	STP-rural	28.54	0.57



--- maximum limit in feed materials of mineral origin
(=lowest feed limit) (12% moisture)¹

Results: Chemical safety analyses – Dioxins & PCBs



¹Directive 2002/32/EC CL2002L0032EN0220010.0001_cp 1..1 (europa.eu)

Discussion and conclusions



- Some food pathogenic bacteria seem to transfer to BSFL.
- The possible presence of more/other antimicrobial resistance genes remains inconclusive. Metagenomics sequencing useful.
- Exposure of BSFL to other chemical hazards in sludges is evident and needs to be studied. Additional food safety analyses on short-chain PFAS.
- Domestic sewage sludges and food industrial sludges can possibly be valorized as BSFL feed. However, food/feed safety precautions are required.

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