

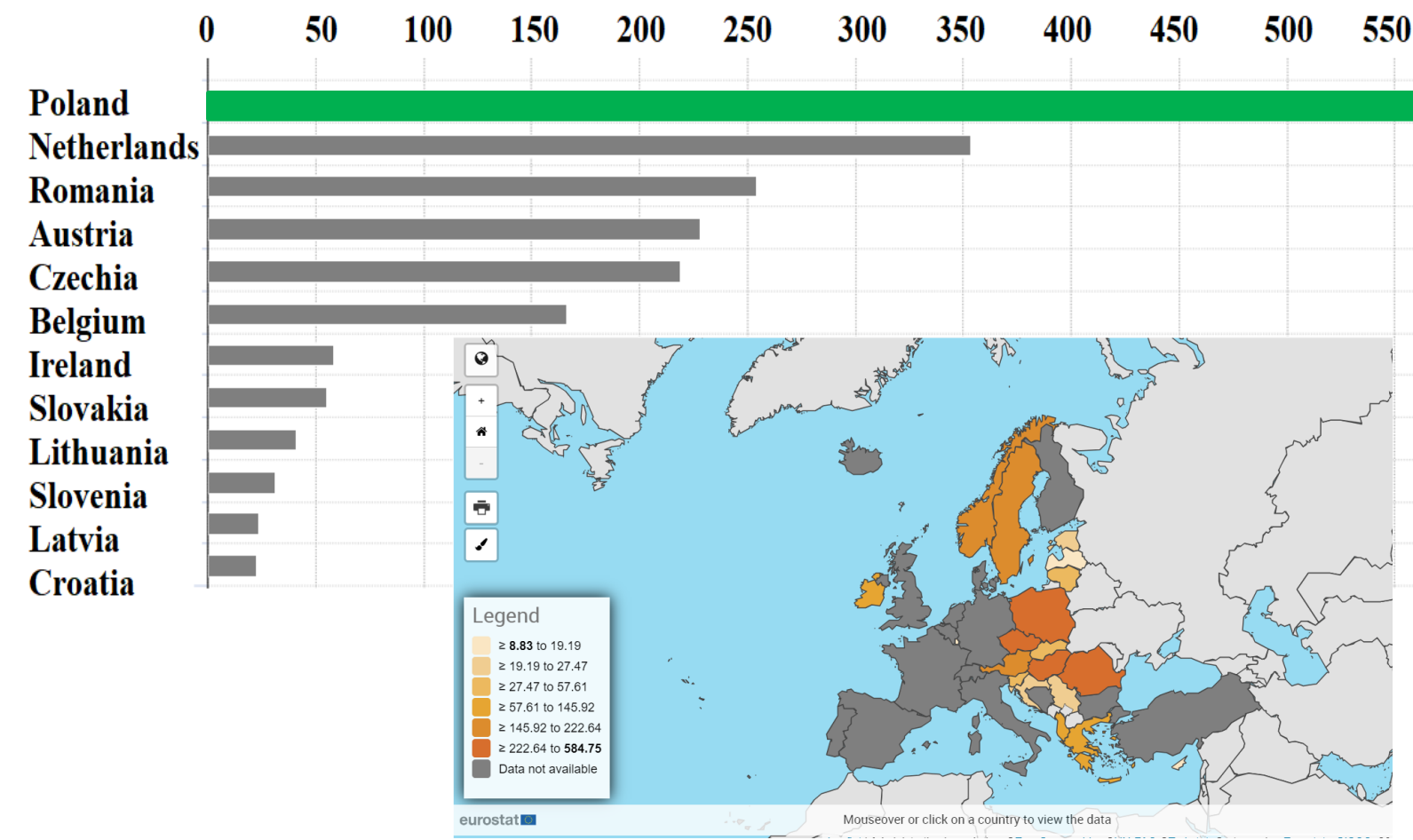
Toxicity of Hydrochars Derived from The Hydrothermal Carbonization of Sewage Sludge

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MOTIVATION

SEWAGE SLUDGE FROM URBAN WASTEWATER

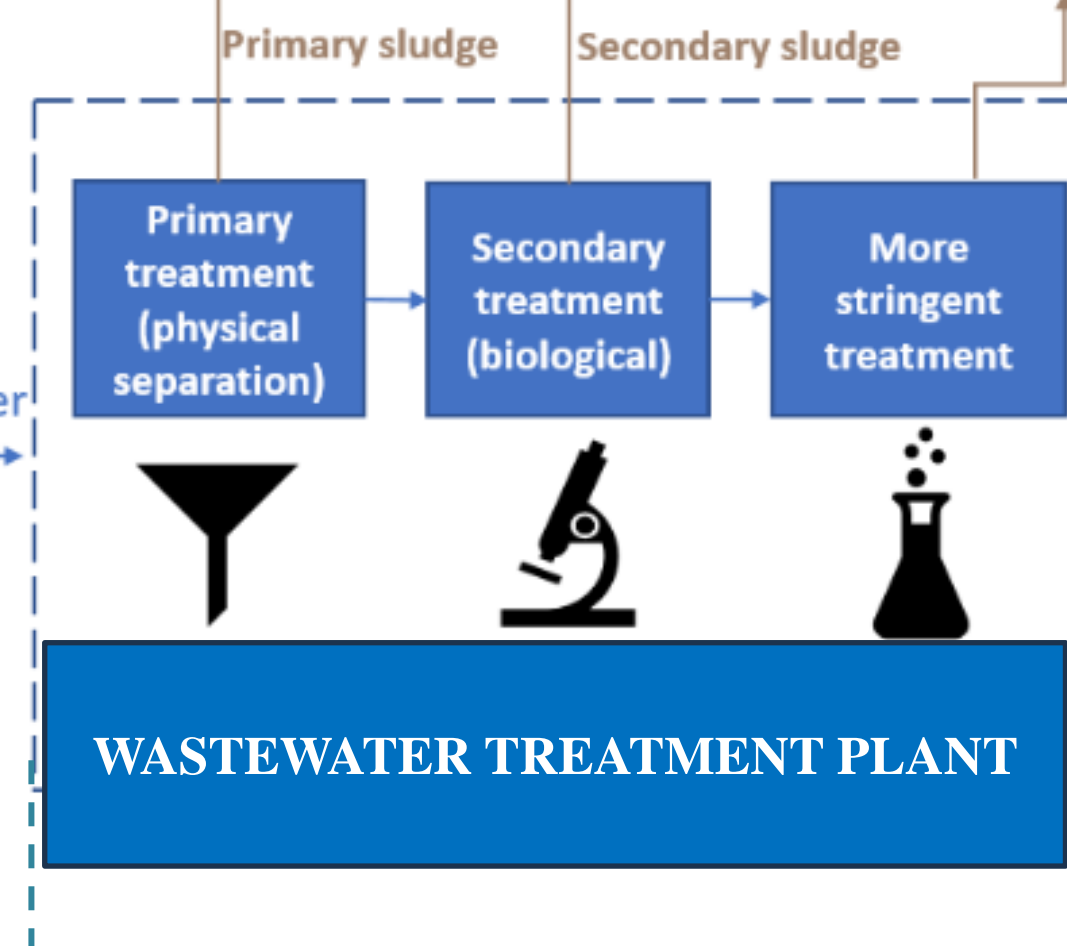
PRODUCTION



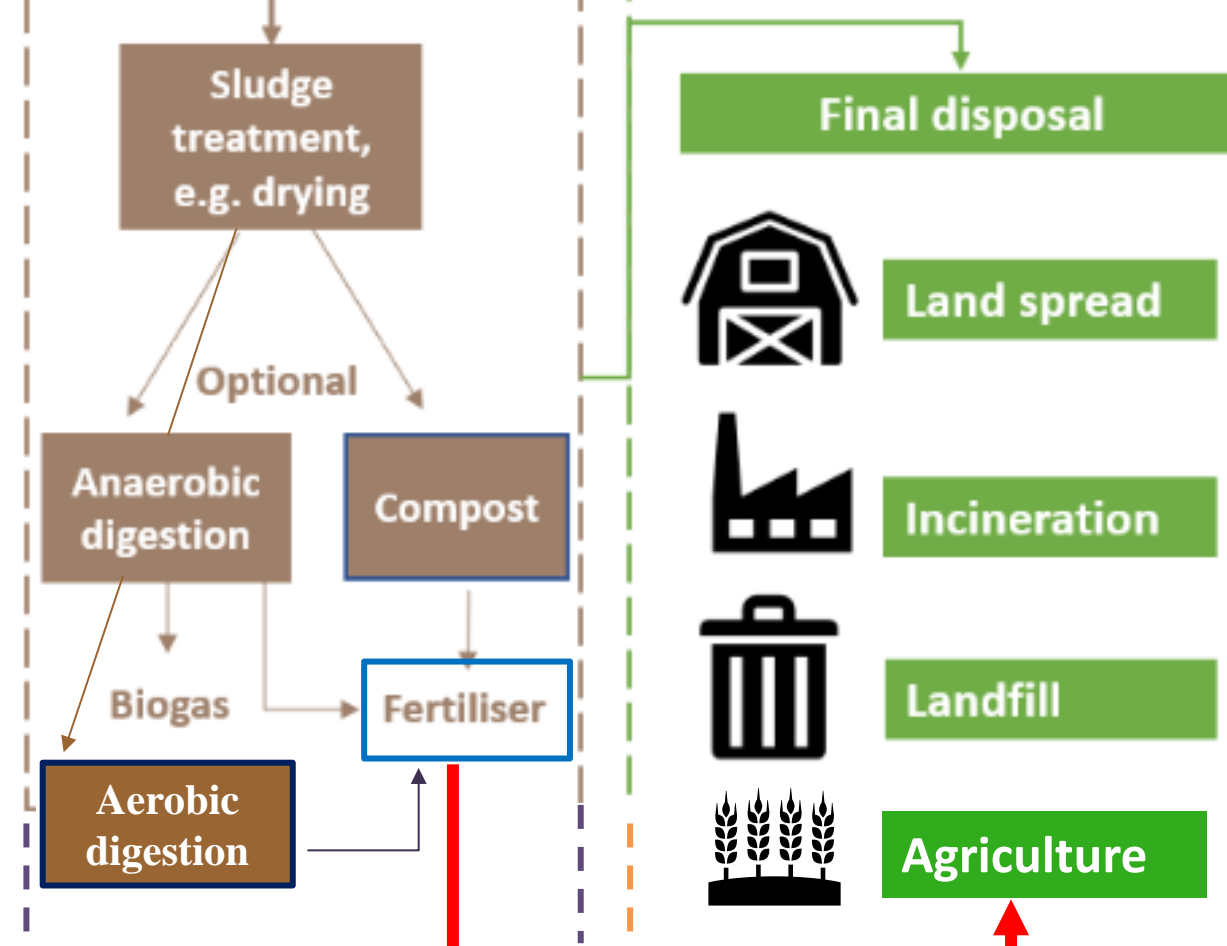
Eurostat 2021

European Environment Agency 2021

GENERATION



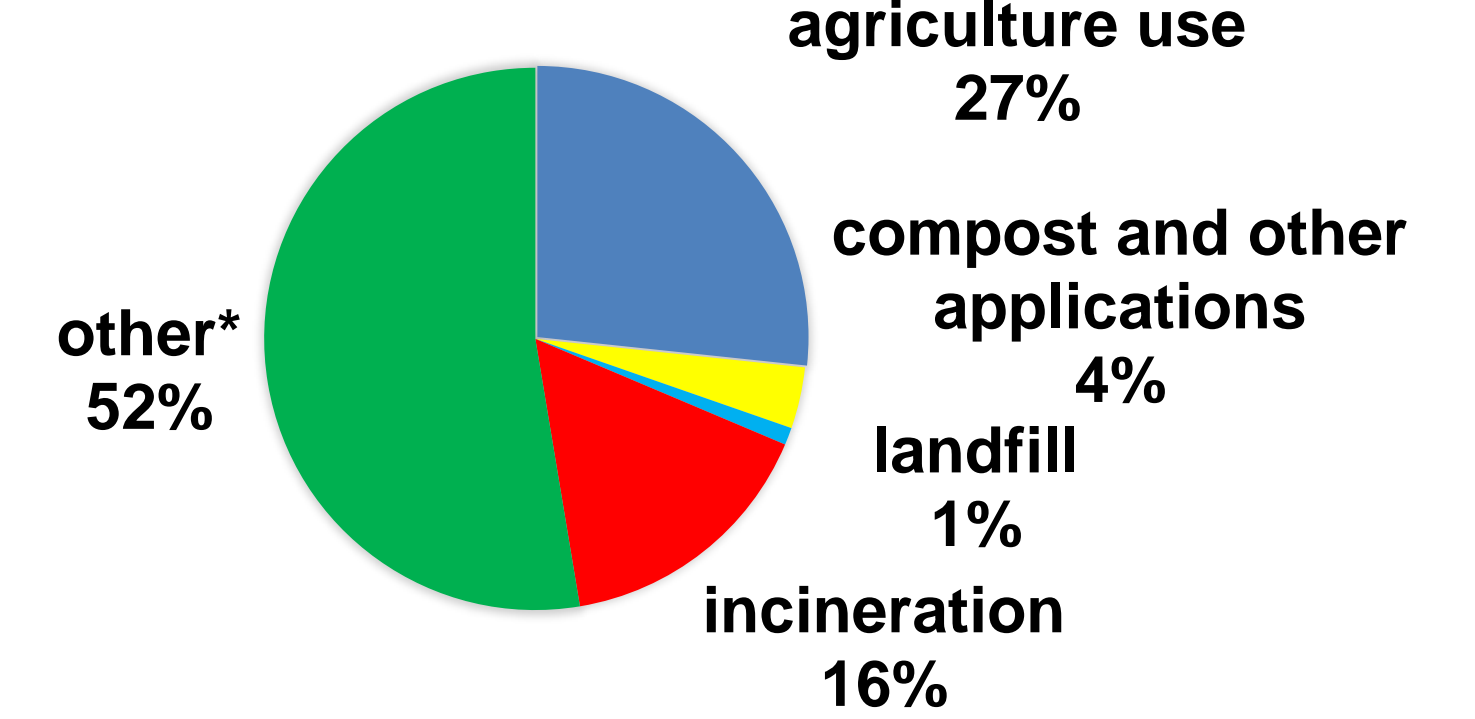
TREATMENT



END-OF-LIFE



DISPOSAL



* Land reclamation for agriculture and temporarily stored (Przydatek & Wota, 2020)

Statistics Poland 2021

INTRODUCTION

AIM

SEWAGE SLUDGE PROBLEMS

- High content of moisture
- Insufficient dewaterability
- High volume of waste
- Organic content - biodegradable
- Bacteria, viruses, pathogens
- Pharmaceuticals, microplastics
- Heavy metals
- Odour

REQUIRED PRETREATMENT

HYDROTHERMAL CARBONIZATION PROCESS

IMPROVED PROPERTIES

- Dewaterability
- Disinfection
- Reduction of waste volume
- Biodegradability
- Microplastic removal
- Pharmaceutical removal
- Heavy metals

HYDROCHAR

- carbonaceous
- hydrophobic
- brittle
- stabilised heavy metals

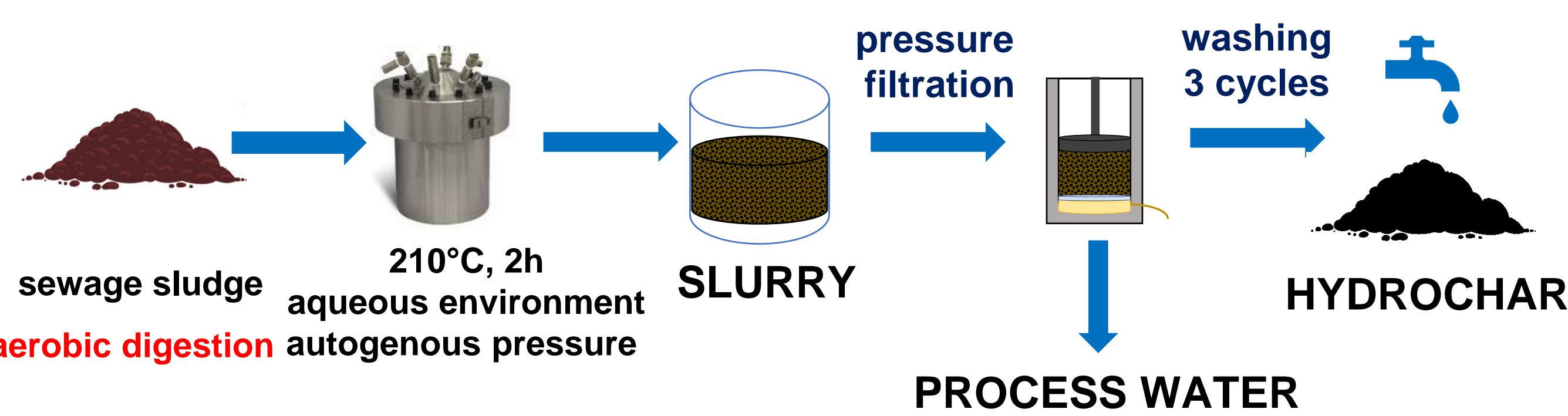
TOXICITY TEST
FERTILISER

AGRICULTURE DISPOSAL

MATERIAL

METHODS

HYDROTHERMAL CARBONIZATION

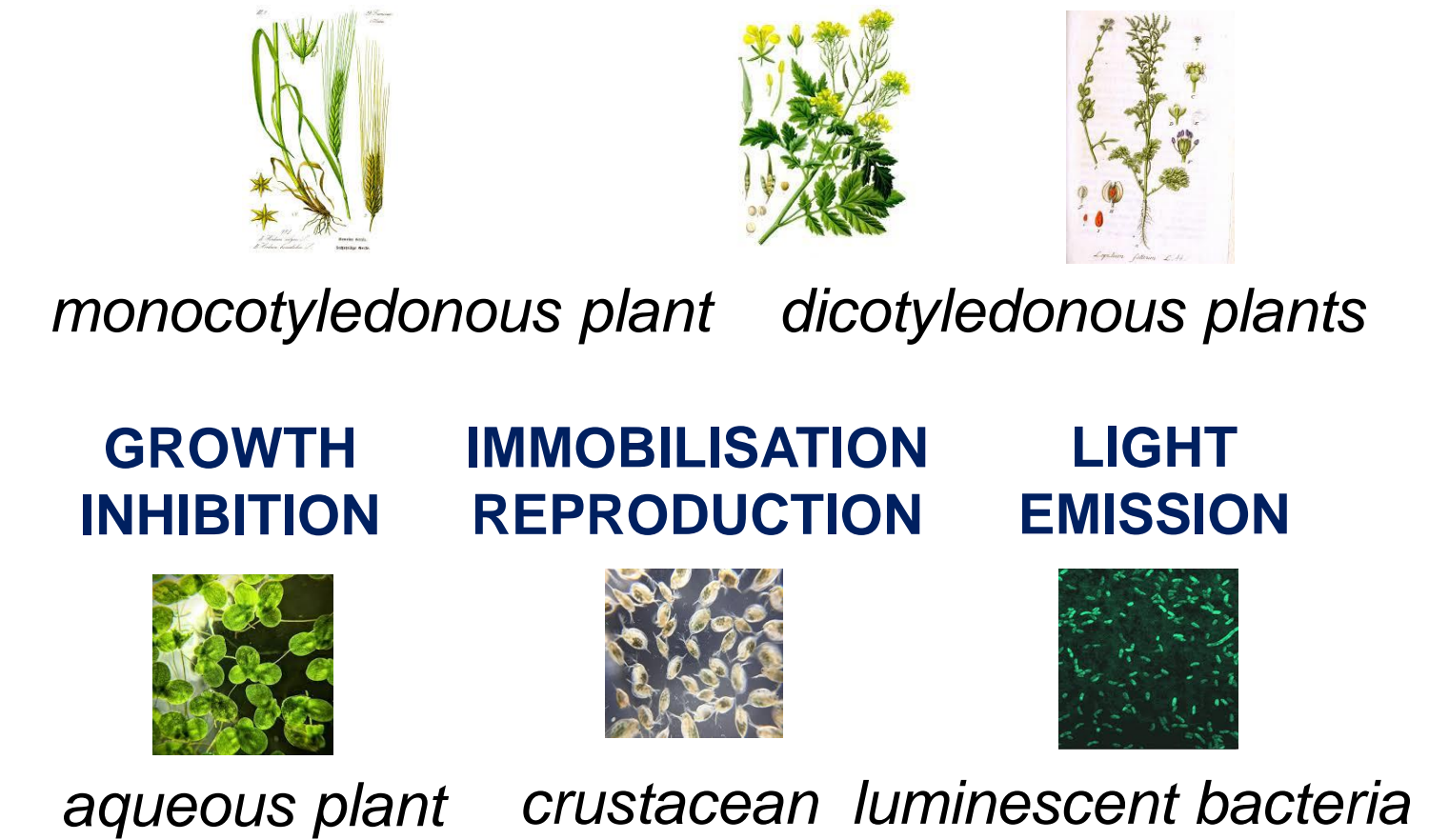


TOXICITY TESTS

H1, H10, H100
1, 10, 100% concentration of hydrochar (H) in synthetic soil

AEI, AEII, AEIII
aqueous extracts

GERMINATION TEST and EARLY GROWTH of PLANT



RESULTS

CONCLUSIONS

Toxicity towards aqueous organisms for the aqueous extracts

Hazard classification system for waste discharged into the aquatic environment

TU	Toxicity	Class
< 0.4	no acute toxicity	I
0.1 – 1	slight acute toxicity	II
1 – 10	acute toxicity	III
10 – 100	high acute toxicity	IV
> 100	very high acute toxicity	V

$TU = \frac{1}{EC_{50}} \cdot 100\%$ – toxicity unit, EC_{50} or IC_{50}
 EC_{50} – medial immobilization concentration, mg/L
 IC_{50} – medial inhibitory concentration, mg/L

Toxicity towards aqueous organisms

Aquatic extracts	Inhibition of undiluted sample %	Standard deviation	EC/IC ₅₀ %	TU
<i>Daphnia magna</i> - freshwater crustacean, OECD 202 (2004)				
AEI	100.0	0	28.1	3.6
AEII	100.0	0	27.7	3.6
AEIII	100.0	0	24.5	4.1
<i>Vibrio fischeri</i> - luminescent bacteria, ISO 11348-3:2007				
AEI	87.3	0.6	30.0	3.3
AEII	83.0	1.0	35.0	2.9
AEIII	73.7	2.3	47.0	2.1
<i>Lemna minor</i> - aqueous plant, OECD 221 (2006)				
AEI	-70.5	7.4	-	-
AEII	-40.6	9.2	-	-
AEIII	-29.9	7.3	-	-

Toxicity towards plants for the aqueous extracts

EC/IC₅₀, for aqueous extracts

Sample	Control	AEI	AEII	AEIII
<i>Hordeum vulgare</i> - monocotyledonous plant, EN ISO 18763:2020-10				
Medial root length, cm	6.1 ± 1.1	5.4 ± 1.6	6.6 ± 0.7	6.6 ± 1.0
Medial shoot length, cm	0.9 ± 0.6	1.2 ± 0.9	1.6 ± 0.9	1.4 ± 0.9
Shoot growth inhibition, %	-	11.5	-8.2	-8.2
Root growth inhibition, %	-	-33.3.6	-77.8	-55.6
<i>Sinapis alba</i> - dicotyledonous plants, EN ISO 18763:2020-10				
Medial root length, cm	2.1 ± 1.6	2.2 ± 1.1	2.6 ± 1.5	3.1 ± 1.3
Medial shoot length, cm	2.0 ± 1.2	2.6 ± 1.5	3.4 ± 0.9	3.0 ± 1.1
Shoot growth inhibition, %	-	0	-2.3	2.3
Root growth inhibition, %	-	-30.0	-70.0	-50.0
<i>Lepidium sativum</i> - dicotyledonous plants, EN ISO 18763:2020-10				
Medial root length, cm	4.4 ± 1.1	4.4 ± 1.6	4.5 ± 0.7	4.3 ± 1.0
Medial shoot length, cm	3.8 ± 0.4	3.7 ± 0.4	3.7 ± 0.7	3.8 ± 0.7
Shoot growth inhibition, %	-	0	-2.3	2.3
Root growth inhibition, %	-	2.6	2.6	0

Toxicity towards plants for the hydrochar

EC/IC₅₀ values for hydrochar

Sample	Control	H1	H10	H100
<i>Hordeum vulgare</i> - monocotyledonous plant, EN ISO 18763:2020-10				
Medial root length, cm	6.1 ± 1.1	5.8 ± 1.5	3.1 ± 1.2	3.2 ± 1.3
Medial shoot length, cm	0.9 ± 0.6	0.8 ± 0.4	0.1 ± 0.3	0.1 ± 0.2
Shoot growth inhibition, %	-	4.9	49.2	47.5
Root growth inhibition, %	-	11.1	88.9	88.9
<i>Sinapis alba</i> - dicotyledonous plants, EN ISO 18763:2020-10				
Medial root length, cm	2.1 ± 1.6	2.6 ± 1.3	2.7 ± 0.7	1.3 ± 0.8
Medial shoot length, cm	2.0 ± 1.2	1.9 ± 1.0	2.1 ± 0.7	0.6 ± 0.4
Shoot growth inhibition, %	-	-23.8	-28.6	38.1
Root growth inhibition, %	-	5.0	-5.0	70.0
<i>Lepidium sativum</i> - dicotyledonous plants, EN ISO 18763:2020-10				
Medial root length, cm	4.4 ± 1.1	6.0 ± 1.2	4.5 ± 2.1	2.8 ± 1.4
Medial shoot length, cm	3.8 ± 0.4	4.0 ± 1.2	2.2 ± 1.1	1.4 ± 0.9
Shoot growth inhibition, %	-	-36.4	-2.3	36.4
Root growth inhibition, %	-	-5.3	42.1	63.2

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