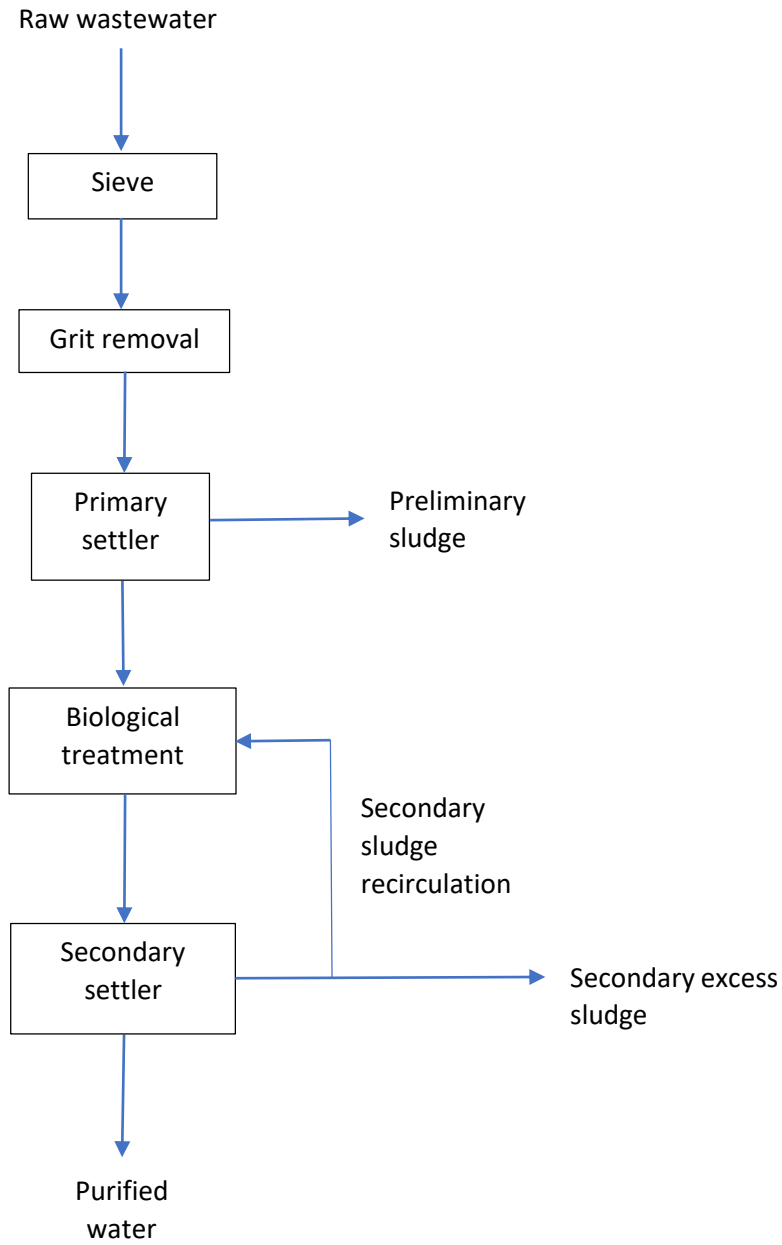
5.05.2022, I.FAST 1st Annual Meeting

Marcin Sudlitz, INCT

Sewage sludge

- A waste obtained in the wastewater purification process
- Contains soluble and insoluble organic compounds
- These compound are valuable due to their nutricious properties
- However sewage sludges can also produce odours and thus are not suitable for long term storage
- Also huge quatities of these wastes produced every year are a matter of concern – some innovative forms of utilisation are rquired
- Sewage sludges may contain toxic compound and heavy metals and almost always contains pathogenic organizms including helminths eggs, even in high developed countries



Biological threats in sewage sludge

- Pathogenic bacteria (*Salmonella spp., Clostridium perfrigens, Escherichia Coli*…)
- Helminths eggs (*Toxocara spp., Trichuris spp., Ascaris spp, Taenia spp….)*
- Viruses
- Fungi

Occurence of pathogens in sewage sludge in Poland

- 92 WWTPs tested from 16 regions of Poland – in 91 sludge samples ATT eggs were detected

(Zdybel, J. Karamon, J. Dąbrowska, M. Różycki, E. Bilska – Zając, T. Kłapeć, T. Cencek, Parasitological contamination with eggs Ascaris spp., Trichuris spp. and Toxocara spp. of dehydrated municipal sewage sludge in Poland. *Env Pol*, 2019, *248,* 621 – 626)

- 17 WWTPs from 7 regions of Poland - raw sewage (ATT in 46% samples), sludge from grit removal(11%), preliminary sludge(76%), secondary sludge (44%), digestate (100%) and thickened sludge (82%)

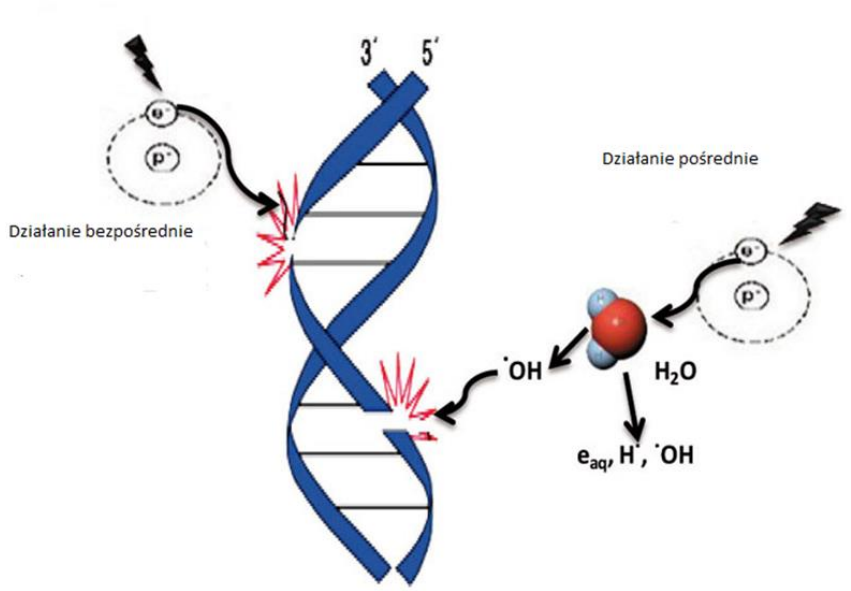
(Zdybel, J.; Cencek, T.; Karamon, J.; Kłapeć, T. Effectiveness of selected stages of wastewater treatment in elimination of eggs of intestinal parasites. *Bull Vet Inst Pulawy* 2015 *59*, 51-57)

Methods of hygienization

- Addition of lime
- Pasteurization
- Biological treatment (aerobic treatment, anaerobic digestion, composting)
- **Irradiation**

Sludge hygienization using EB

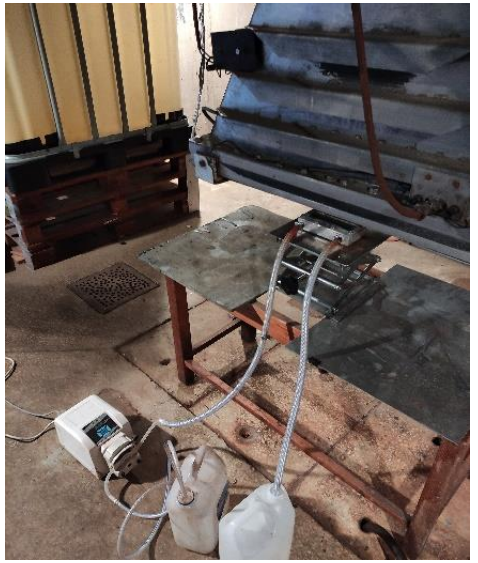
- Ionising radiation is lethal – causes DN^ damage directly, by interacting with DNA or indirectly via water radiolysis products
- Many research confirmed effectivenes of irradiation proces for pathogens removal
- EB can be cosidered as a reliable, safe and efficient source of radiation for sludge treatment



Irradiation systems

- Polyethylene bags filled with slduge + 10MeV accelerator

- Flow irradiation system + 1,7 MeV accelerator



Dosimmetry:

- alanine pellets (Aerial, France) with EPR spectrometer,
- 0,2 M alanine solution with conductivity measurements after irradiation

Sludges and pathogens

Sludges used for the experiments

- Preliminary sludge (4% TS)
- Postflotation sludge (2,5 % TS)
- Mixed thickened sludge (10% TS)

Tested pathogens

- Bacteria: *Salmonella spp., Escherichia Coli, Clostridium perfrigens*
- Helminths*: Ascaris spp., Trichuris spp., Toxocara spp.*

Results - bacteria

Dose (kGy)	Detected Species	Result (CFU)
0	*Escherichia coli,*	6.2×10^4
	Salmonella spp.	9.2×10^2
	Clostridium perfringens	1.1×10^2
2	*Escherichia coli,*	9.8×10^3
	Salmonella spp.	1.3×10^2
	Clostridium perfringens	0.9×10^2
3	*Escherichia coli,*	1.4×10^2
	Salmonella spp.	0.4×10^2
	Clostridium perfringens	ca.0.2×10^2
4	*Escherichia coli,*	none detected
	Salmonella spp.	none detected
	Clostridium perfringens	none detected
5	*Escherichia coli,*	none detected
	Salmonella spp.	none detected
	Clostridium perfringens	none detected

Preliminary sludge

Dose (kGy)	Detected Species	Result (CFU)
0	*Escherichia coli,*	4.9×10^4
	Salmonella spp.	7.1×10^2
	Clostridium perfringens	0.6×10^2
2	*Escherichia coli,*	9.8×10^3
	Salmonella spp.	0.8×10^2
	Clostridium perfringens	0.2×10^2
3	*Escherichia coli,*	0.4×10^2
	Salmonella spp.	ca.0.1×10^2
	Clostridium perfringens	none detected
4	*Escherichia coli,*	none detected
	Salmonella spp.	none detected
	Clostridium perfringens	none detected
5	*Escherichia coli,*	none detected
	Salmonella spp.	none detected
	Clostridium perfringens	none detected

Postflotation sludge

Sudlitz, M., Chmielewski, A., G., A method for WWTP sludge valorization through hygienization by electron beam treatment, Fermentation, 2021,7,302, doi.org/10.3390/fermentation7040302

Results - bacteria

Dose (kGy)	Detected Species	Result (CFU)
0	*Escherichia coli*,	6.1×10^4
	Salmonella spp.	4.2×10^3
	Clostridium perfringens	0.9×10^2
1.8	*Escherichia coli*,	6.4×10^3
	Salmonella spp.	0.3×10^3
	Clostridium perfringens	0.1×10^2
3.7	*Escherichia coli*,	0.2×10^3
	Salmonella spp.	$<0.1 \times 10^2$
	Clostridium perfringens	none detected
5.5	*Escherichia coli*,	none detected
	Salmonella spp.	none detected
	Clostridium perfringens	none detected
7.5	*Escherichia coli*,	none detected
	Salmonella spp.	none detected
	Clostridium perfringens	none detected
9	*Escherichia coli*,	none detected
	Salmonella spp.	none detected
	Clostridium perfringens	none detected

Mixed thickened sludge

Sudlitz, M., Chmielewski, A., G., A method for WWTP sludge valorization through hygienization by electron beam treatment, Fermentation, 2021,7,302, doi.org/10.3390/fermentation7040302

Results - helminths

Dose (kGy)	Detected Species	Result (Number of Living Eggs)
0	*Ascaris* spp.	21
	Trichuris spp.	9
	Toxocara spp.	3
2	*Ascaris* spp.	16
	Trichuris spp.	4
	Toxocara spp.	1
3	*Ascaris* spp.	4
	Trichuris spp.	none detected
	Toxocara spp.	none detected
4	*Ascaris* spp.	none detected
	Trichuris spp.	none detected
	Toxocara spp.	none detected
5	*Ascaris* spp.	none detected
	Trichuris spp.	none detected
	Toxocara spp.	none detected

Preliminary sludge

Dose (kGy)	Detected Species	Result (Number of Living Eggs)
0	*Ascaris* spp.	17
	Trichuris spp.	4
	Toxocara spp.	2
2	*Ascaris* spp.	11
	Trichuris spp.	1
	Toxocara spp.	none detected
3	*Ascaris* spp.	3
	Trichuris spp.	none detected
	Toxocara spp.	none detected
4	*Ascaris* spp.	none detected
	Trichuris spp.	none detected
	Toxocara spp.	none detected
5	*Ascaris* spp.	none detected
	Trichuris spp.	none detected
	Toxocara spp.	none detected

Postflotation sludge

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Results - helminths

Dose (kGy)	Detected Species	Result (CFU)
0	*Ascaris* spp.	27
	Trichuris spp.	9
	Toxocara spp.	4
1.8	*Ascaris* spp.	16
	Trichuris spp.	6
	Toxocara spp.	1
3.7	*Ascaris* spp.	7
	Trichuris spp.	2
	Toxocara spp.	none detected
5.5	*Ascaris* spp.	none detected
	Trichuris spp.	none detected
	Toxocara spp.	none detected
7.5	*Ascaris* spp.	none detected
	Trichuris spp.	none detected
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Mixed thickened sludge

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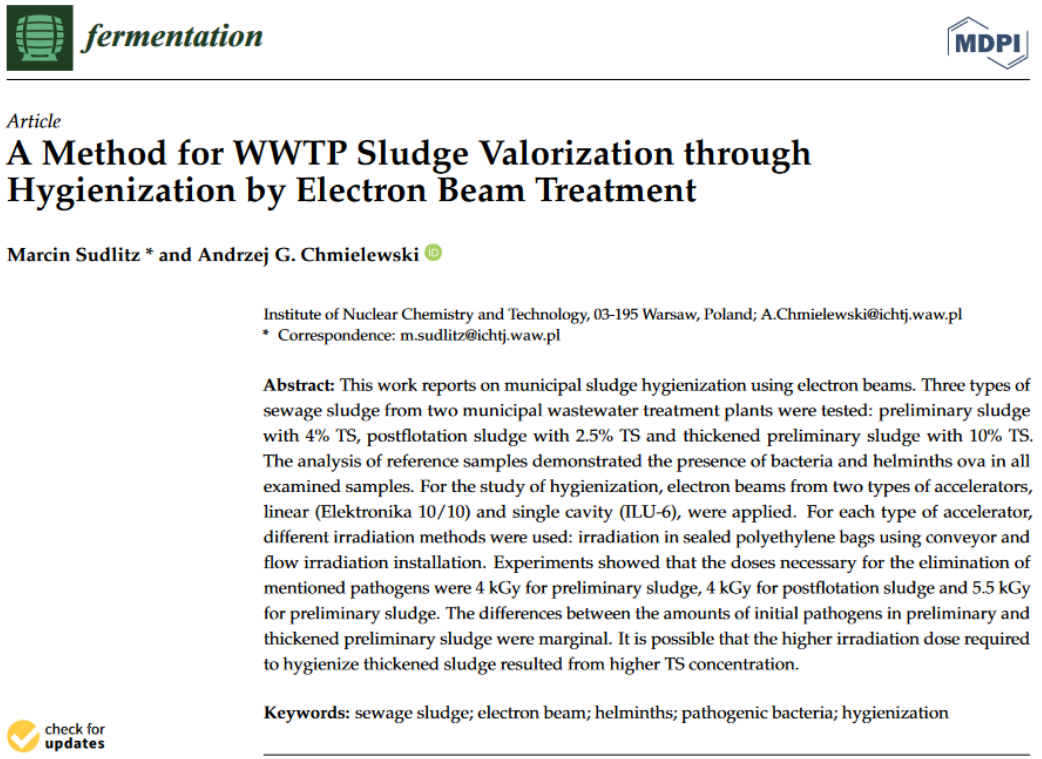
Coclusion

- Occurence of pathogenic bacteria and helmiths eggs in sewage sludges is still a problem
- 4 kGy dose is enough to remove all pathogens from two tested sludges: preliminary sludge with 4 % TS and postflotation sludge with 2,5% TS
- For mixed thickened sludge with 10% TS a dose necessary to remove all pathogens was 5,5 kGy possibly due to higher TS content

Acknowledgement

- All data obtained in the frame of IAEA CRP Radiation Inactivation of Bio-Hazards Using High-Powered Electron Beam Accelerators (F23033) and Ministry of Science and Higher Education: A method of hygienization of sewage sludge based on electron accelerator application.



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Article

A Method for WWTP Sludge Valorization through Hygienization by Electron Beam Treatment

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Abstract: This work reports on municipal sludge hygienization using electron beams. Three types of sewage sludge from two municipal wastewater treatment plants were tested: preliminary sludge with 4% TS, postflotation sludge with 2.5% TS and thickened preliminary sludge with 10% TS. The analysis of reference samples demonstrated the presence of bacteria and helminths ova in all examined samples. For the study of hygienization, electron beams from two types of accelerators, linear (Elektronika 10/10) and single cavity (ILU-6), were applied. For each type of accelerator, different irradiation methods were used: irradiation in sealed polyethylene bags using conveyor and flow irradiation installation. Experiments showed that the doses necessary for the elimination of mentioned pathogens were 4 kGy for preliminary sludge, 4 kGy for postflotation sludge and 5.5 kGy for preliminary sludge. The differences between the amounts of initial pathogens in preliminary and thickened preliminary sludge were marginal. It is possible that the higher irradiation dose required to hygienize thickened sludge resulted from higher TS concentration.

Keywords: sewage sludge; electron beam; helminths; pathogenic bacteria; hygienization

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Thank You for your attention

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA No 101004730.