APPLICATION OF BIOCHAR FOR THE REMOVAL OF THE PHARMACEUTICAL ZIDOVUDINE FROM WASTEWATER

HANA POSAVČIĆ, DOMAGOJ NAKIĆ,
KATARINA LICHT, ANĐELA PRKAČIN

FACULTY OF CIVIL ENGINEERING
UNIVERSITY OF ZAGREB, CROATIA

WMHE 2026

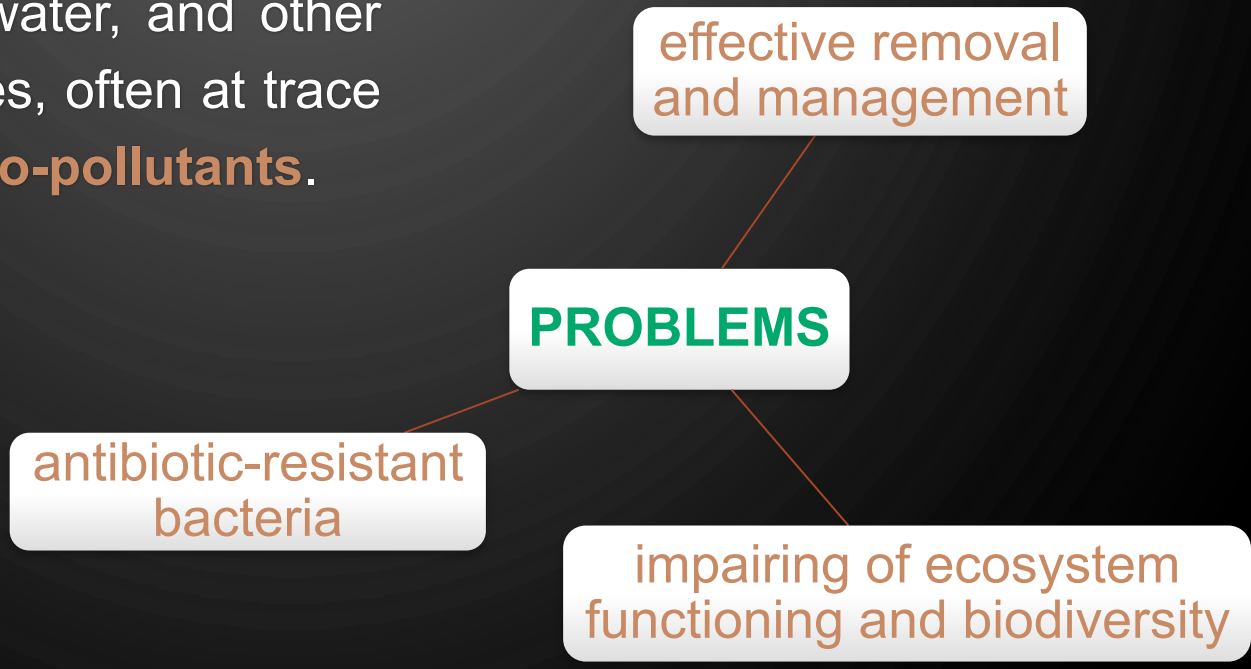
AdSorB

HrZZ

PHARMACEUTICALS

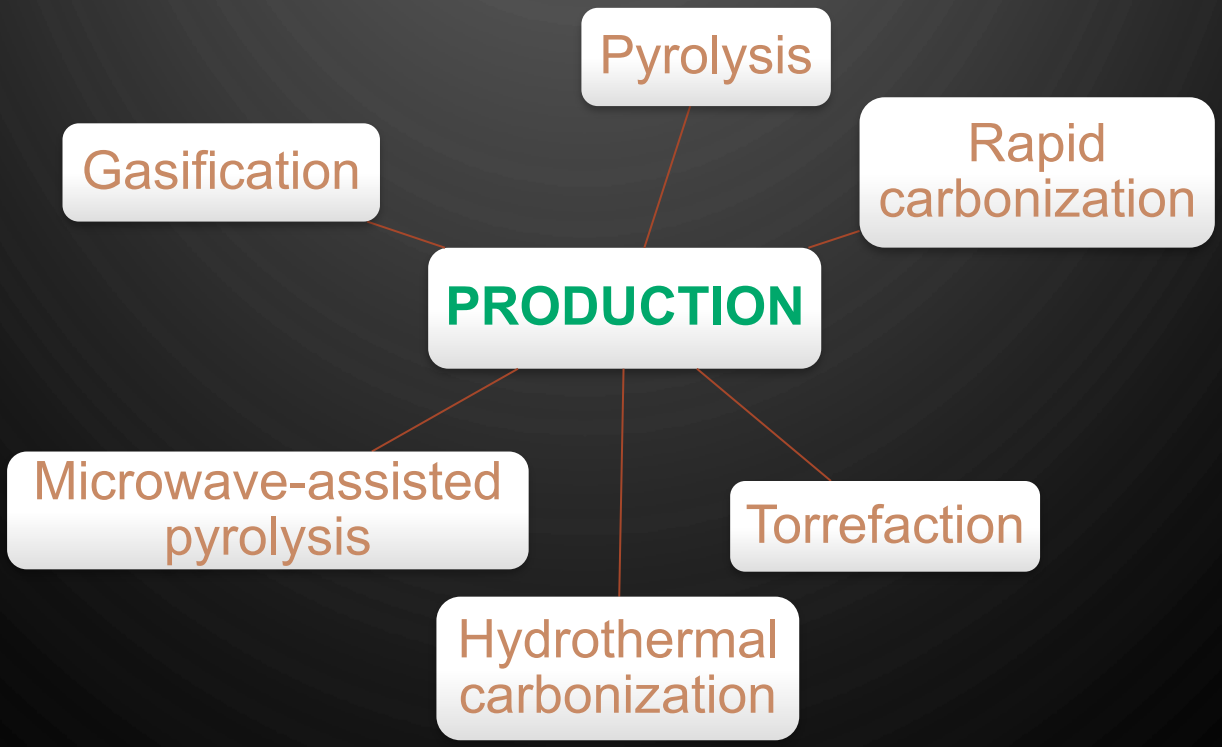
- Biologically active substances encompassing a wide range of commonly used medical products.

- Numerous studies have reported the presence of pharmaceutical residues in surface water, groundwater, treated and untreated wastewater, and other environmental matrices, often at trace concentrations – **micro-pollutants**.



BIOCHAR

- porous, carbon-rich material produced through the thermochemical conversion of organic biomass under limited or oxygen-free conditions.
- The feedstocks used for production: organic waste materials (agricultural residues, forestry by-products, wood chips, algae, sewage sludge, paper and pulp mill sludge, and municipal solid waste).



MATERIALS AND METHODS

Stabilized and dehydrated sludge (Karlovac WWTP) → Drying (105 °C) → Gasification → **BIOCHAR**

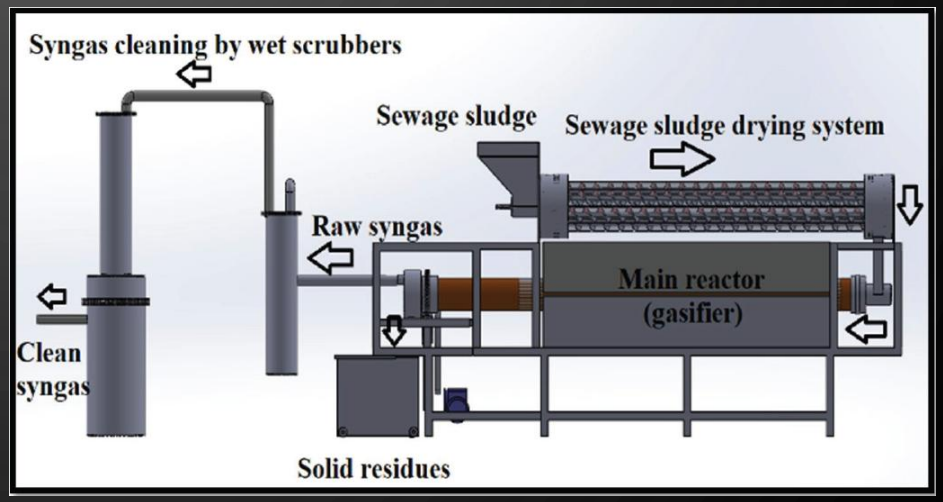


Fig. 1. The Gasification pilot plant (Looper)

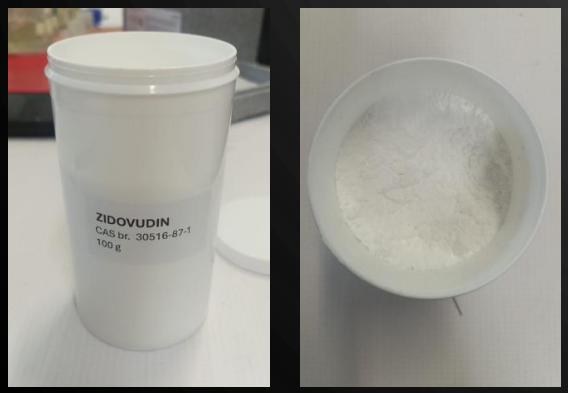


Fig. 2. The pharmaceutical zidovudine – pure active substance

ADSORPTION EXPERIMENTS

Tab. 1. Ranges of parameters

Parameter	Range		
A) Initial zidovudine concentration [mg/L]	1	10	20
(B) pH	3	7	9
(C) Biochar mass [g/200 mL]	0.1	0.5	1
(D) Time [h]	1	6	24

Fig. 3. Rotary mixer

RESULTS AND DISCUSSION

Tab. 2. Experimental matrix

Run	(A) C_{in} [mg/L]	(B) pH	(C) m [g/200 mL]	(D) t [h]	RE [%]	q_e [mg/g]
1	1	7	0.5	6	16	0.06
2	20	7	1	24	21.5	0.86
3	1	9	0.1	1	0	0
4	1	3	1	1	47	0.09
5	10	3	1	6	48.3	0.97
6	1	9	1	1	0	0
7	10	9	0.5	24	9	0.36
8	20	3	0.5	1	14	1.12
9	20	7	0.1	24	4.05	1.62
10	1	3	0.5	6	40	0.16
11	20	7	1	1	17.7	0.71
12	1	7	0.5	6	19	0.08
13	10	7	0.5	1	9	0.36
14	10	3	0.1	24	14.7	2.94
15	1	3	1	24	65	0.13
16	20	3	0.5	24	29	2.32
17	20	7	0.1	6	3	1.2
18	10	3	0.1	6	9.5	1.9
19	1	7	0.1	24	4	0.08
20	20	9	0.5	6	17	1.36
21	1	7	0.5	6	13	0.05
22	10	7	0.5	1	13	1.72
23	10	3	1	6	43	2

Removal efficiency:

$$RE\ [\%] = \frac{C_{in} - C_e}{C_{in}} \times 100$$

Adsorption capacity:

$$q_e = \frac{(C_{in} - C_e) \times V}{m}$$

RESULTS AND DISCUSSION

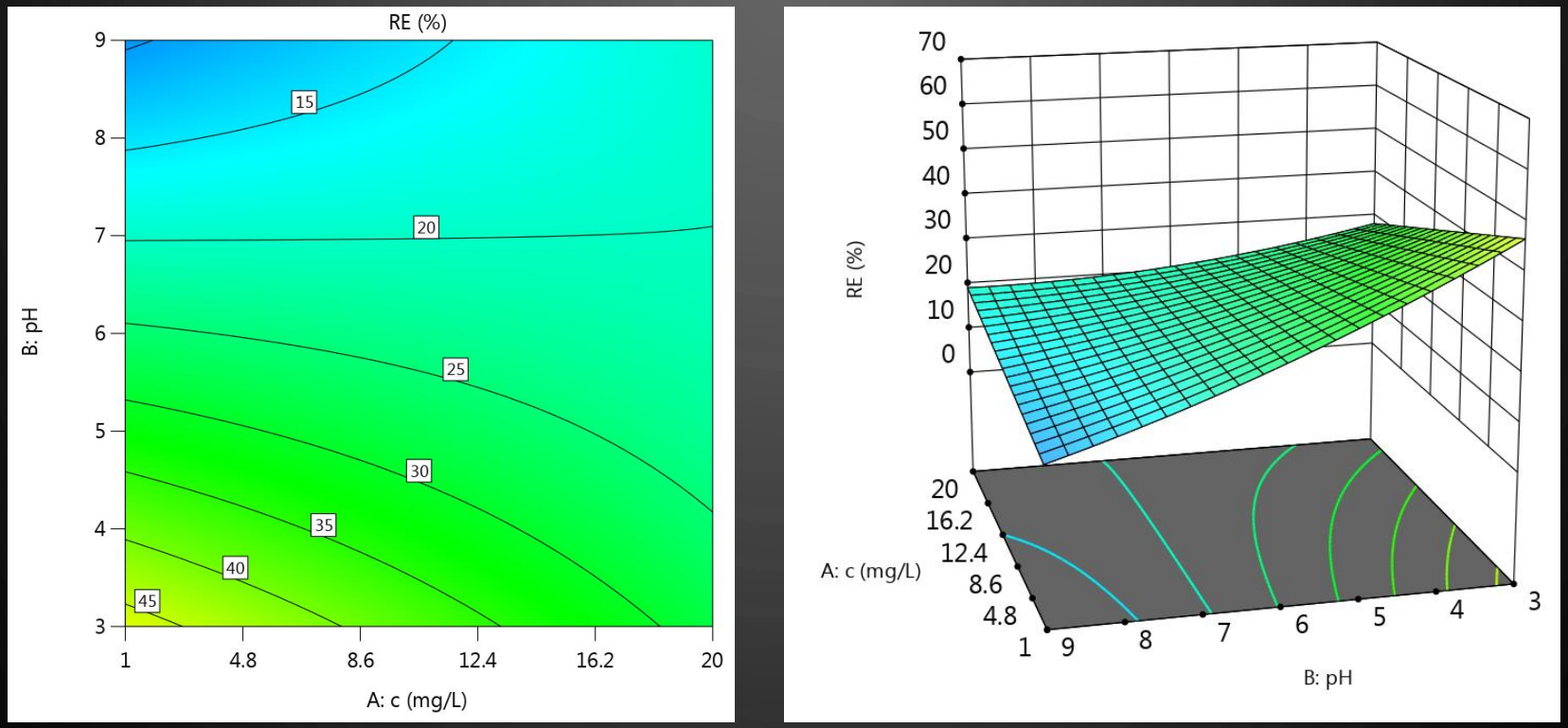


Fig. 4. Contour plot (left) and 3D response surface (right) for combined effect of initial concentration and pH on zidovudine removal

RESULTS AND DISCUSSION

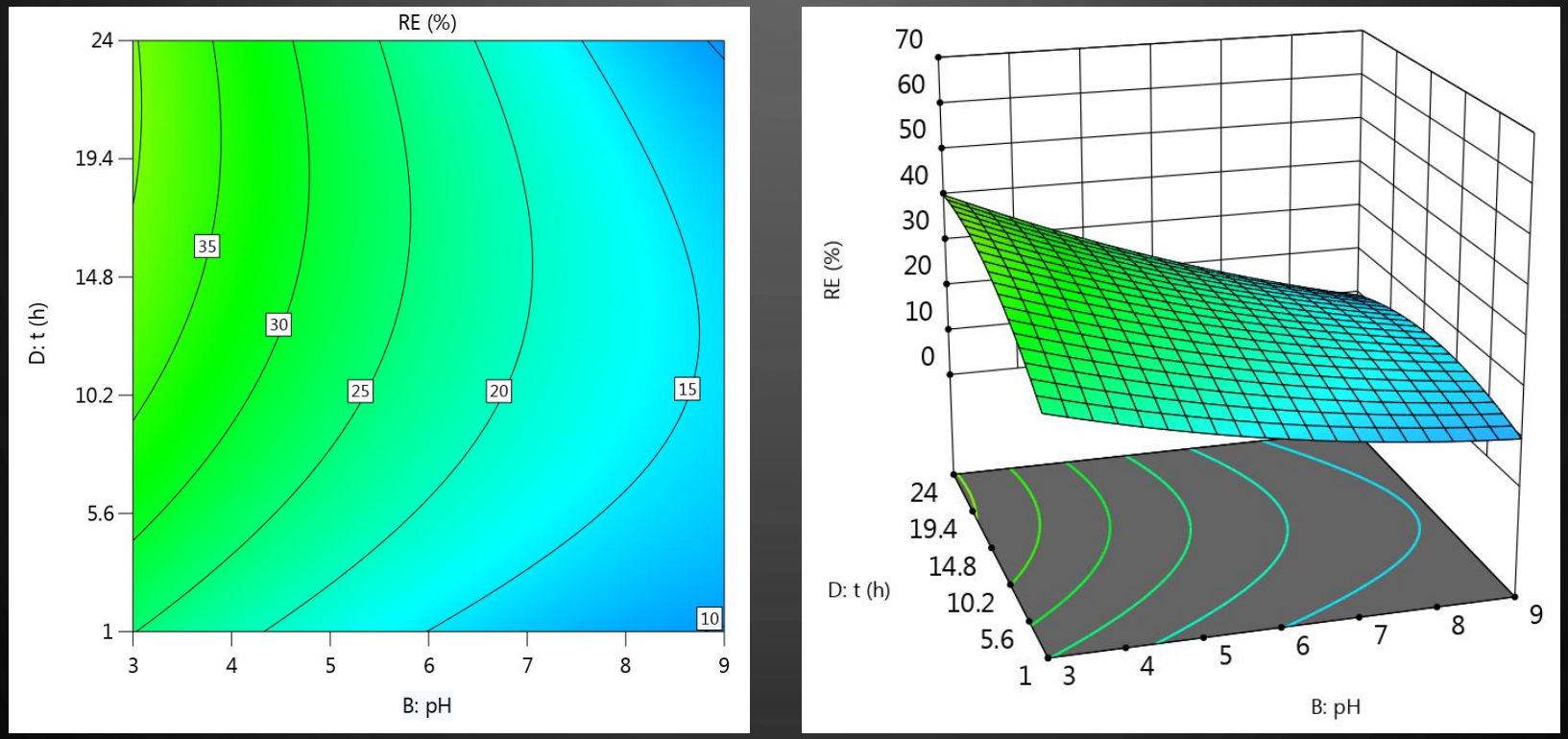


Fig. 5. Contour plot (left) and 3D response surface (right) for combined effect of time and pH on zidovudine removal

RESULTS AND DISCUSSION

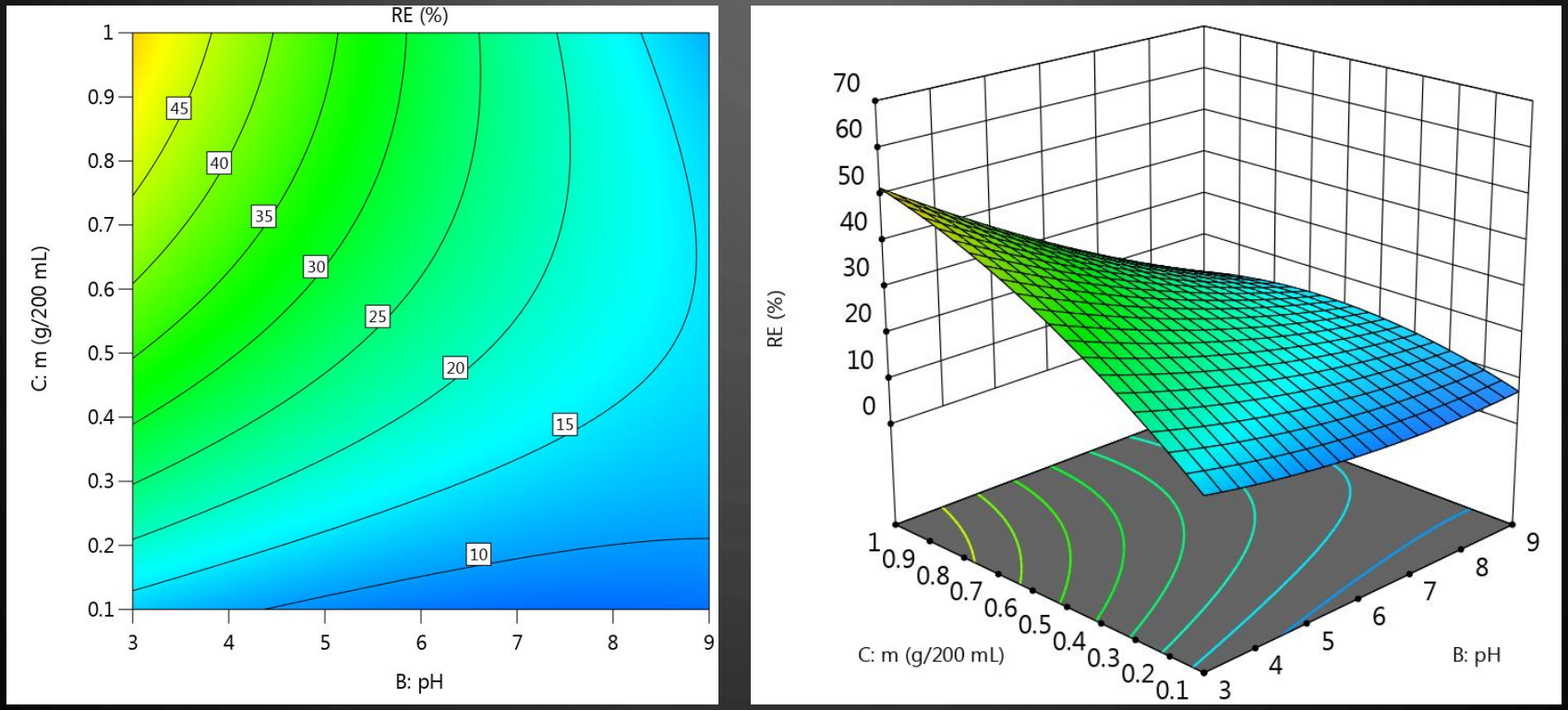


Fig. 6. Contour plot (left) and 3D response surface (right) for combined effect of biochar mass and pH on zidovudine removal

RESULTS AND DISCUSSION

Tab. 2. Experimental matrix

Run	(A) C_{in} [mg/L]	(B) pH	(C) m [g/200 mL]	(D) t [h]	RE [%]	q_e [mg/g]
1	1	7	0.5	6	16	0.06
2	20	7	1	24	21.5	0.86
3	1	9	0.1	1	0	0
4	1	3	1	1	47	0.09
5	10	3	1	6	48.3	0.97
6	1	9	1	1	0	0
7	10	9	0.5	24	9	0.36
8	20	3	0.5	1	14	1.12
9	20	7	0.1	24	4.05	1.62
10	1	3	0.5	6	40	0.16
11	20	7	1	1	17.7	0.71
12	1	7	0.5	6	19	0.08
13	10	7	0.5	1	9	0.36
14	10	3	0.1	24	14.7	2.94
15	1	3	1	24	65	0.13
16	20	3	0.5	24	29	2.32
17	20	7	0.1	6	3	1.2
18	10	3	0.1	6	9.5	1.9
19	1	7	0.1	24	4	0.08
20	20	9	0.5	6	17	1.36
21	1	7	0.5	6	13	0.05
22	10	7	0.5	1	13	1.72
23	10	3	1	6	43	2

Adsorption capacity

Removal efficiency

CONCLUSION

- Optimal removal: low pH values (3 – 4), higher biochar dosages, and longer contact times (RE = 65%, q_e = 2.94 mg/g).
- These results demonstrate that biochar derived from sewage sludge gasification can serve as an effective and environmentally sustainable adsorbent for zidovudine, while simultaneously contributing to sustainable waste management in line with circular economy principles.

- Limitations:
  - controlled laboratory conditions,
  - synthetic solutions,
  - kinetic or isotherm modelling – not conducted,
  - biochar regeneration, long-term stability, and continuous-operation performance – not addressed.

FUTURE RESEARCH

This work was supported by the Croatian Science Foundation under the project number [HRZZ-UIP-2025-02-9907]: AdSorb – “Advanced Wastewater Treatment by Repurposing Sewage Sludge Derived Biochar”.

THANK YOU FOR YOUR ATTENTION!