Aerobic granular sludge as a regenerative system for nutrient removal and metal recovery from landfill leachate

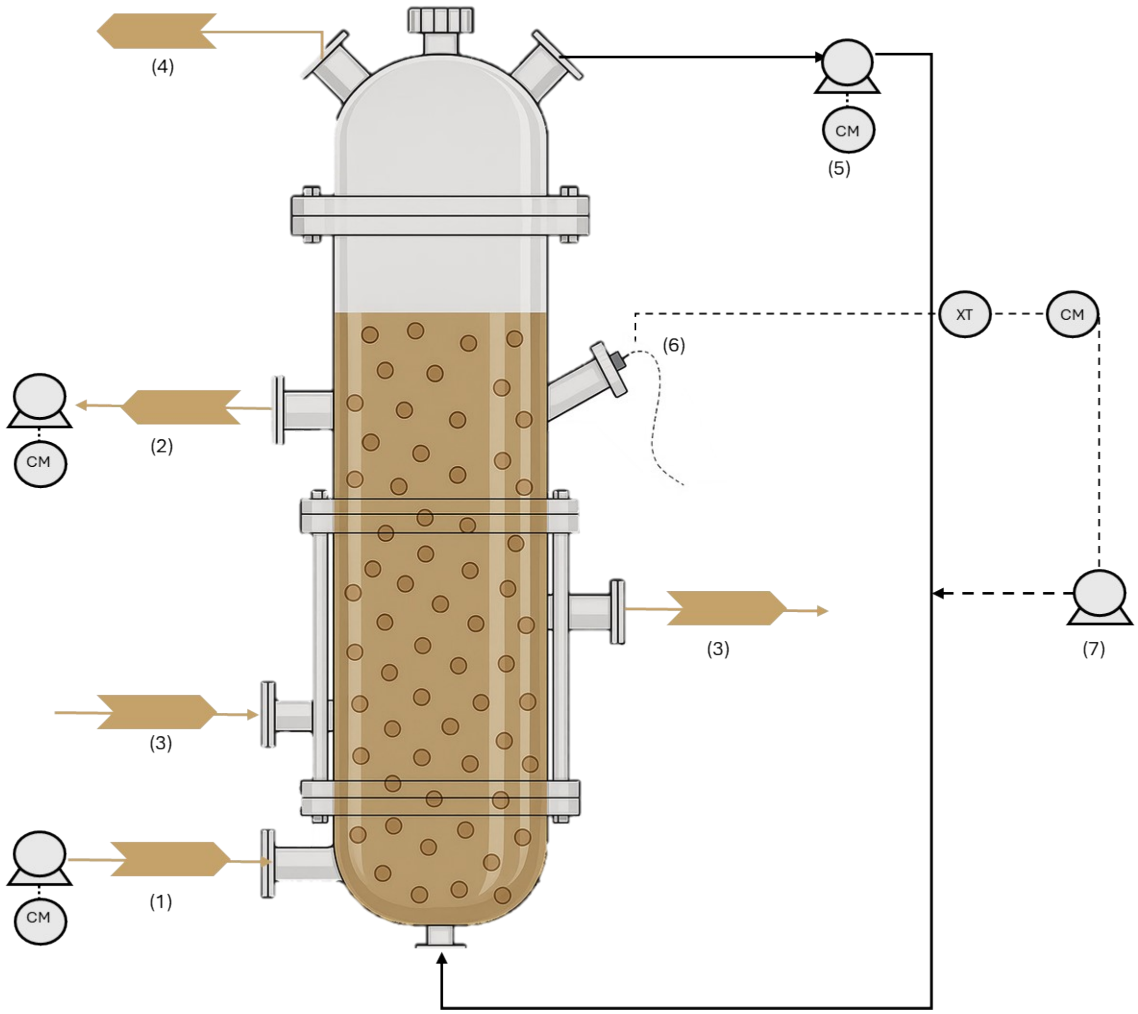

Figure S1. Scheme of the aerobic granular sludge (AGS) reactor used for landfill leachate treatment. Numbers indicate: (1) raw landfill leachate influent; (2) AGS reactor effluent; (3) heating-water system; (4) gas overpressure outlet; (5) gas-recirculation loop; (6) dissolved oxygen (DO) monitoring zone / DO probe; (7) air-injection control node supplying air to the gas-recirculation line. (CM) control module; (XT) DO transmitter.

A) B)

Figure S2. Experimental setup and biomass characteristics of the aerobic granular sludge (AGS) system used in this study. (A) Aerobic granular sludge reactor operated as a bubble column reactor (BCR) under sequencing batch reactor (SBR) mode. (B) Representative sample of the mature aerobic granular sludge collected from the reactor.

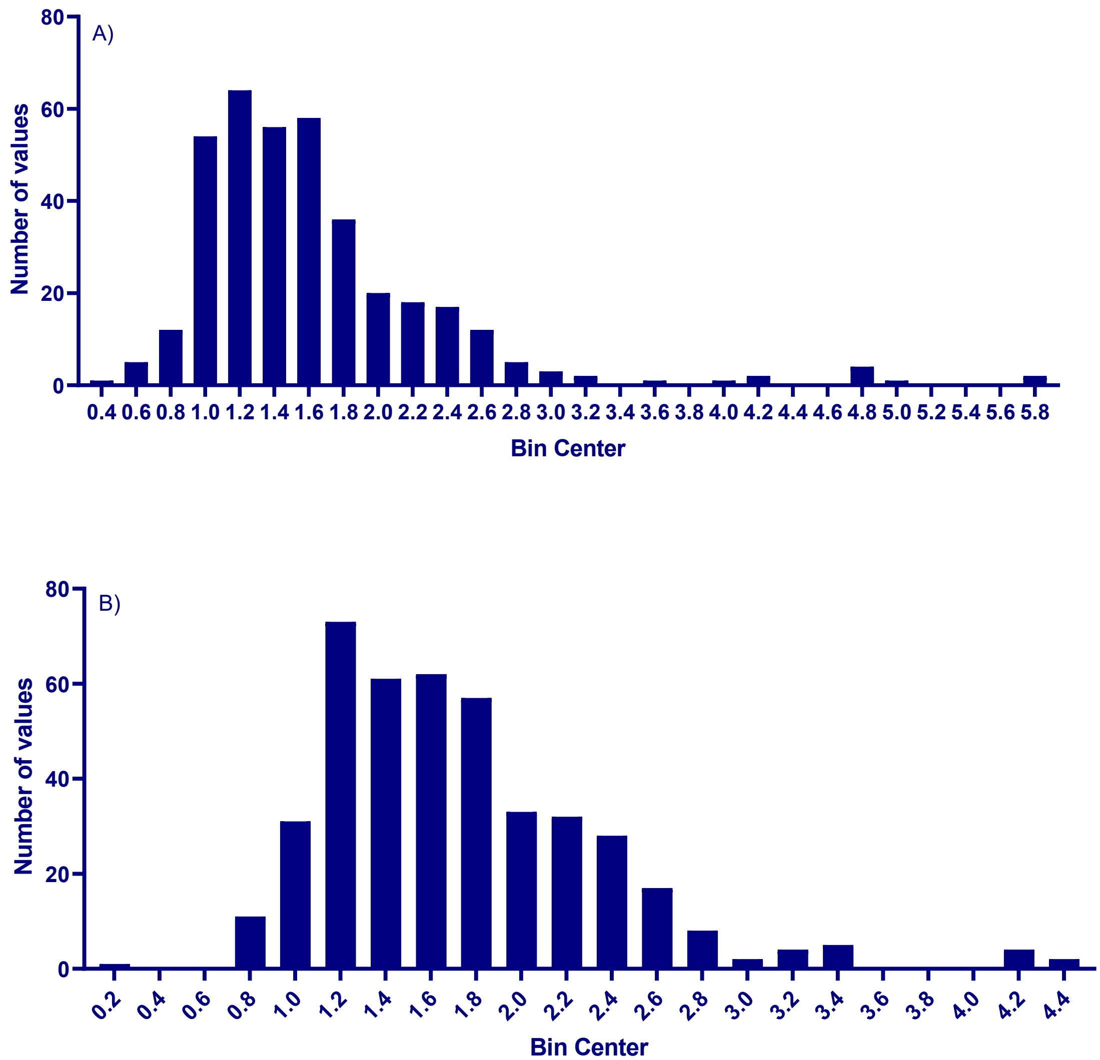

Figure S3. Histogram of diameter distribution of AGS. A) Without treatment. B) with treatment of NaCl (0.1 M).

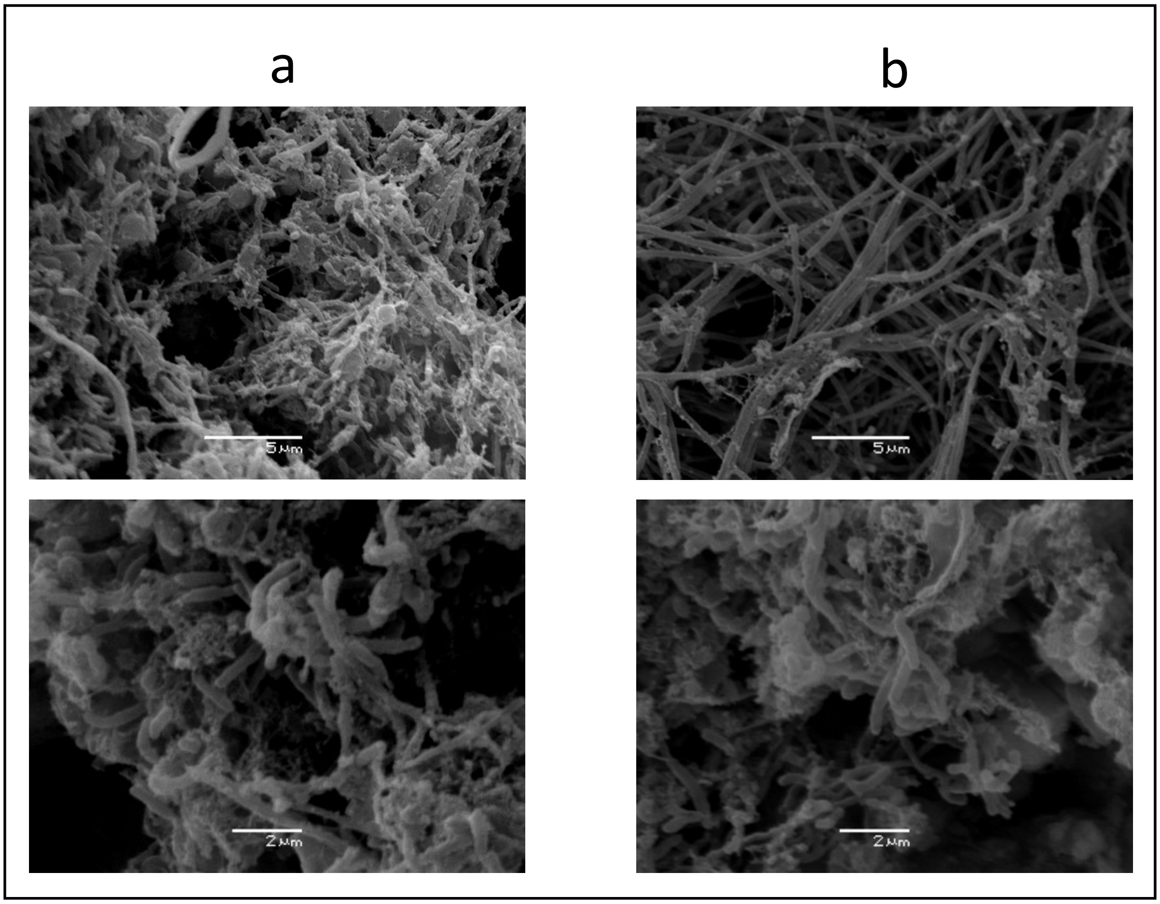

Figure S4. SEM images of aerobic granular sludge (AGS) surface morphology: (a) Without treatment; (b) with treatment of NaCl (0.1 M).

Table S1. Comparative overview of advanced leachate treatment technologies

Technology	COD Removal (%)	Energy demand (kWh/m3)	Estimated Cost (€/m3)	Reference
AGS	87%	0.17	0.091	[1,2]
Membrane bioreactor	92-95%	0.2-0.4	0.39 – 0.49	[3–5]
Electrochemical oxidation	80-93%	20 - 90	5.5 - 14	[6]

Table S2. Quantification of polyvalent cation assimilation by aerobic granular sludge through biosorption (NaCl desorption) and bioaccumulation (acid digestion) expressed in mg g^{-1} TS.

Cation	**Biosorption (mg g^{-1} TS)**	**Bioaccumulation (mg g^{-1} TS)**
Manganese	0.08 ± 0.04	0.54 ± 0.02
Chromium	0.08 ± 0.00	0.01 ± 0.00
Magnesium	4.37 ± 0.10	0.36 ± 0.01
Calcium	4.67 ± 0.67	9.80 ± 0.29
Iron	0.80 ± 0.06	0.79 ± 0.06
Zinc	0.08 ± 0.01	0.03 ± 0.01
Copper	0.13 ± 0.02	0.01 ± 0.00
Lead	0.03 ± 0.00	0.00 ± 0.00

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