Leachate treatment study using mixed granular microalgae – bacteria biomass

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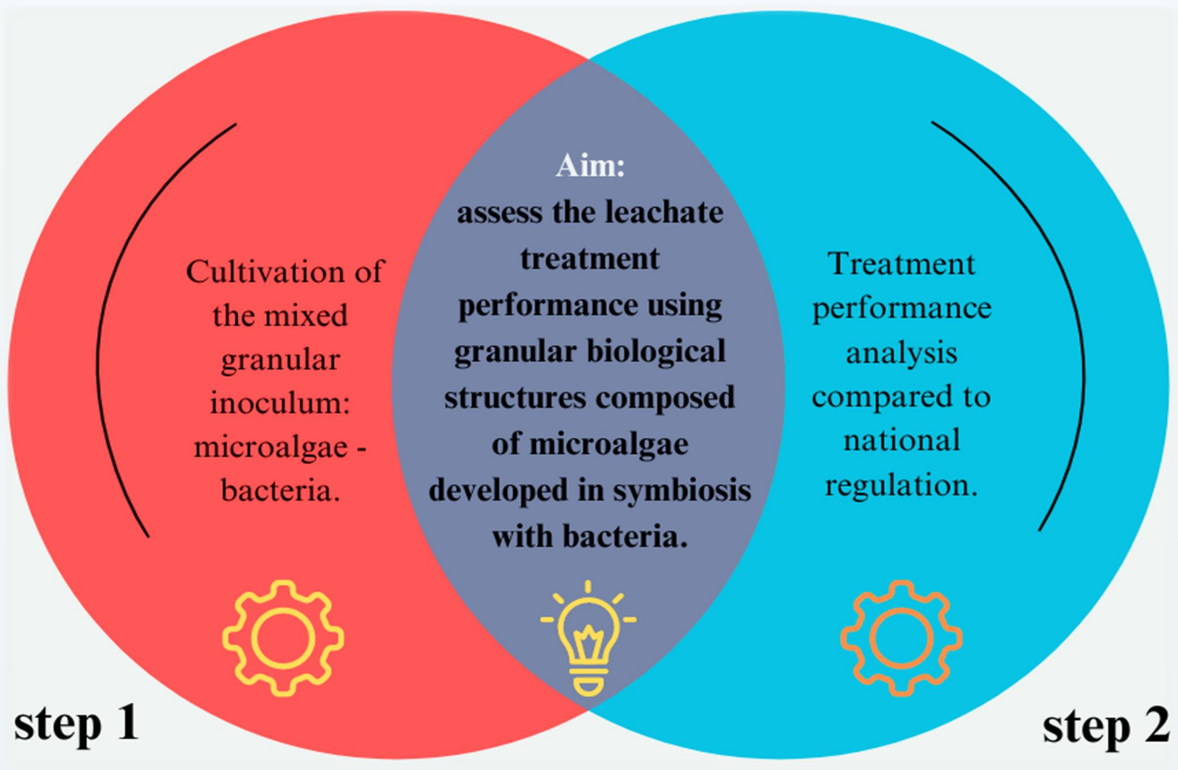
Introduction

Microalgae can grow in different environments, *e.g.* wastewater, assimilating macronutrients, trace minerals (*e.g.* metals), or other important pollutants. Considering their metabolic properties, recent investigations have shown the potential to use microalgae biomass for leachate treatment.



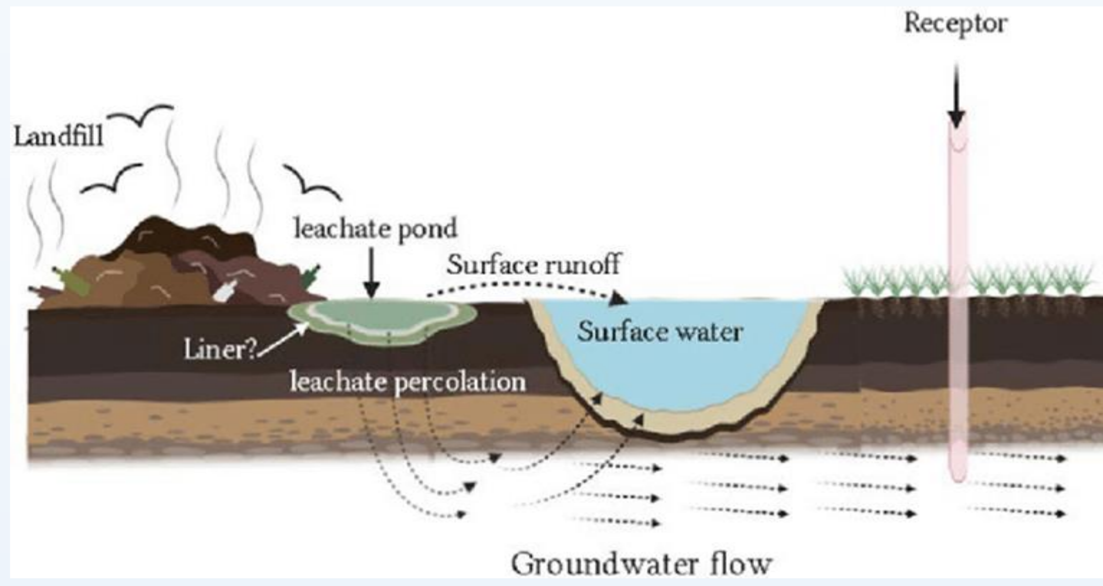
Compared to wastewater, leachate represents an effluent rich in organic and inorganic substances resulting from municipal waste decomposition, including rainwater leaking from the listed deposits.

Leachate presents certain particularities that make difficult its direct treatment:

- COD up to tens of thousands mg O_2/L
- low biodegradability (BOD_5/COD)
- high content of nutrients (*e.g.* ammonium nitrogen, total phosphorus)
- high turbidity, mainly determined by complex dark-brown colour compounds (*e.g.* humic acids).

Applied conventional methods for leachate treatment

leachate transfer	recirculation and combined treatment with municipal wastewater
physico-chemical	includes adsorption process and membrane-based technologies
biological	aerated lagoon systems, SBR systems, biofilm

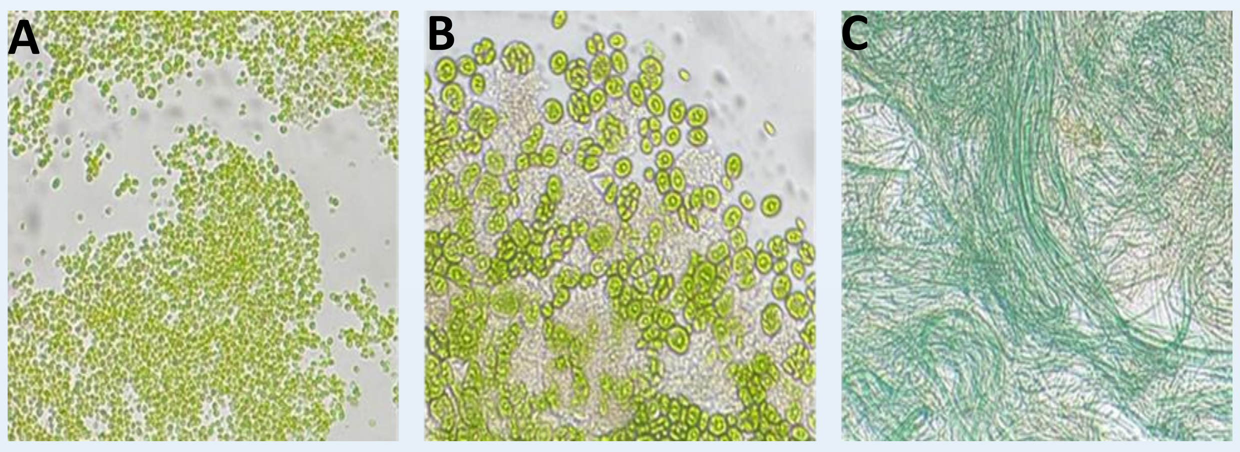


*Example of landfill leachate**

*Parvin, F., & Tareq, S. M. (2021). Impact of landfill leachate contamination on surface and groundwater of Bangladesh: a systematic review and possible public health risks assessment. Applied Water Science, 11, 1–17

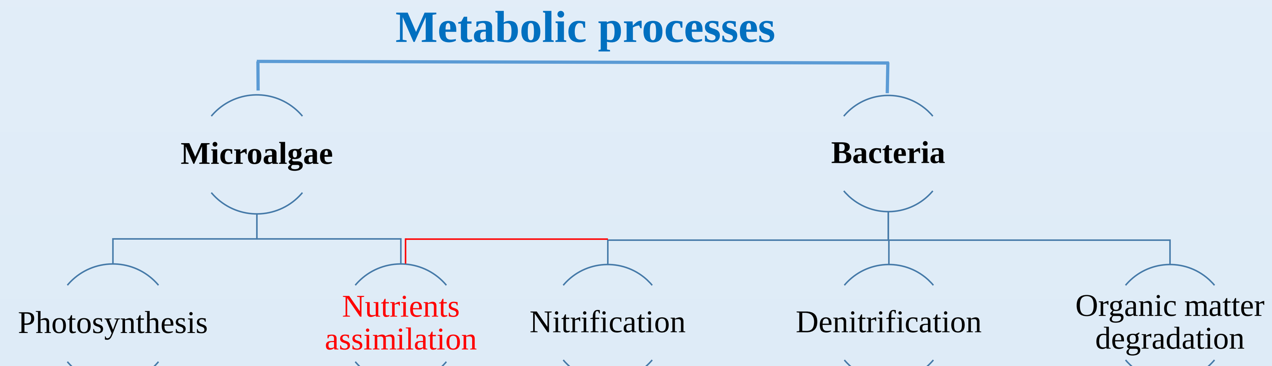
Materials and methods

step 1. Cultivation stage ➤ Photobioreactor ◄ **Treatment stage. step 2**



Chlorella sp. (A), *Lobochlamys segnis* (B) and *Phormidium* sp. (C)

During the first 14 days, the microalgae were cultivated in a synthetic standardized municipal wastewater, in the absence of the addition of organic substrate. Conventional activated sludge was inoculated on day 15 to promote the development of symbiotic microalgae-bacteria biomass and the occurrence of overall metabolic reactions found in the activated sludge process.



Particularity of the biomass – **mixed *granular-like* biological structures**

Sartorius Stedim Biotech (Germany)

Operation conditions

Temperature: 12-25 °C	HRT: 23h 35min
Agitation: 150 rpm	Reaction volume: 1.5 L
Photoperiodicity: 12h light – 12h dark	Light intensity: 467 µmol/m²/s

Considering the high concentration of organic matter in the leachate, a **2%** dilution was carried out in synthetic standardized municipal wastewater.

Quality indicators	Values recorded for gross leachate	Recorded values for influent resulting from leachate dilution in synthetic municipal wastewater	Limits (influent)
Biochemical oxygen demand (BOD_5)	75 mg O_2/dm^3	500.5 mg O_2/dm^3	300 mg O_2/dm^3
Chemical oxygen demand (COD)	4048 mg O_2/dm^3 * →	430.2 -569.9 mg O_2/dm^3 *	500 mg O_2/dm^3
	3872 mg O_2/dm^3 **	336.2 – 439.6 mg O_2/dm^3 **	
Ammonium (NH_4^+)	1515.8 mg/dm³	**59.7** mg/dm³	30 mg/dm³
Nitrates (NO_3^-)	24.9 mg/dm³	0.5 mg/dm³	-
Nitrites (NO_2^-)	2.1 mg/dm³	< 0.1 mg/dm³	-
Phosphate (PO_4^{3-})	28 mg/dm³	15.3 mg/dm³	-
Total phosphorus (TP)	15.2 mg/dm³	5.2 mg/dm³	5 mg/dm³
Magnesium (Mg_2+)	139 mg/dm³	37.1 mg/dm³	-
Calcium (Ca_2+)	270.8 mg/dm³	15.2 mg/dm³	-

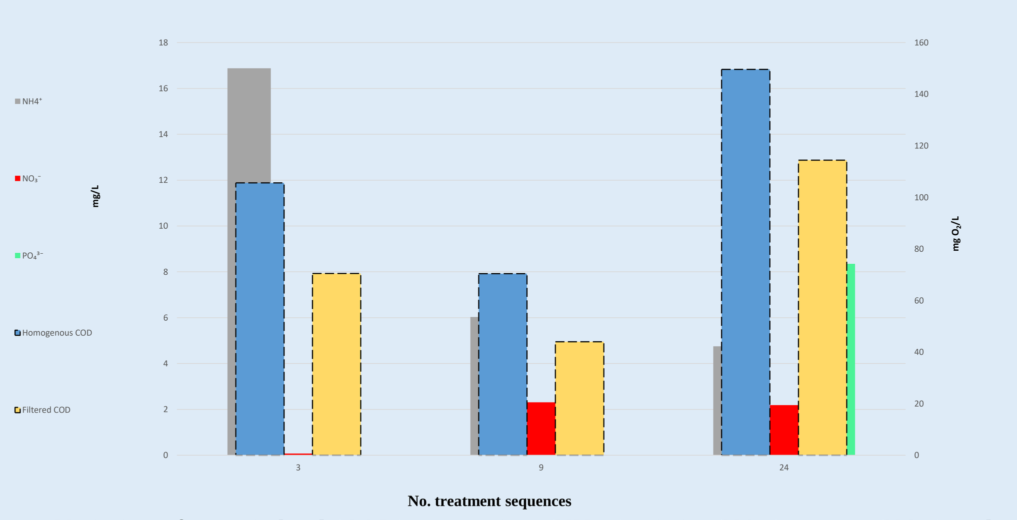
*homogenous sample **filtered sample

To assess the impact on the biomass and treatment performance, the following parameters were monitored:

- biomass concentration (dry matter/volatile dry matter),
- chlorophyll *a* (mg/L) (biomass/effluent)
- nutrient concentration (mg/L)
- color index (CN) (influent/effluent),

and microscopy observations of the biomass were carried out.

Results



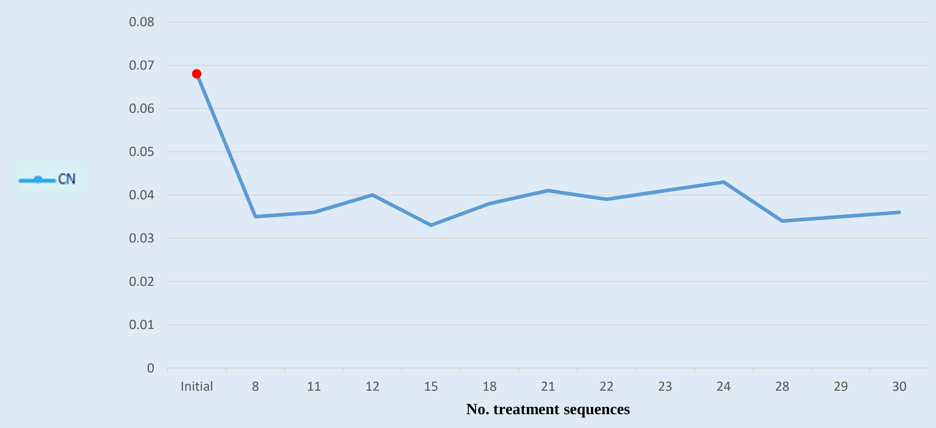
Variation of organic load (COD), ammonium (NH_4+), nitrite (NO_2^-), nitrate (NO_3^-) and phosphate (PO_4^{3-}) concentrations recorded in effluents during the leachate treatment process

Overall nutrient efficiency:

COD < 88 %	NH_4^+ < 92 %
BOD_5 < 95 %	PO_4^{3-} < 45 %
NT < 40 %	*NO_2^- < 0.1 mg/L
PT < 72 %	* NO_3^- < 3 mg/L

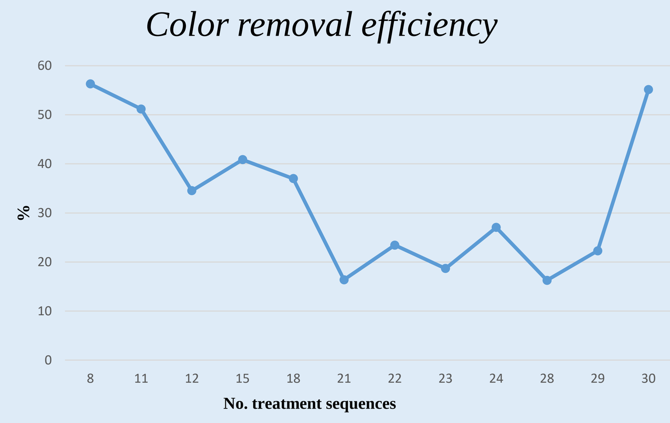
*detected concentrations in effluents

Color index variation – CN



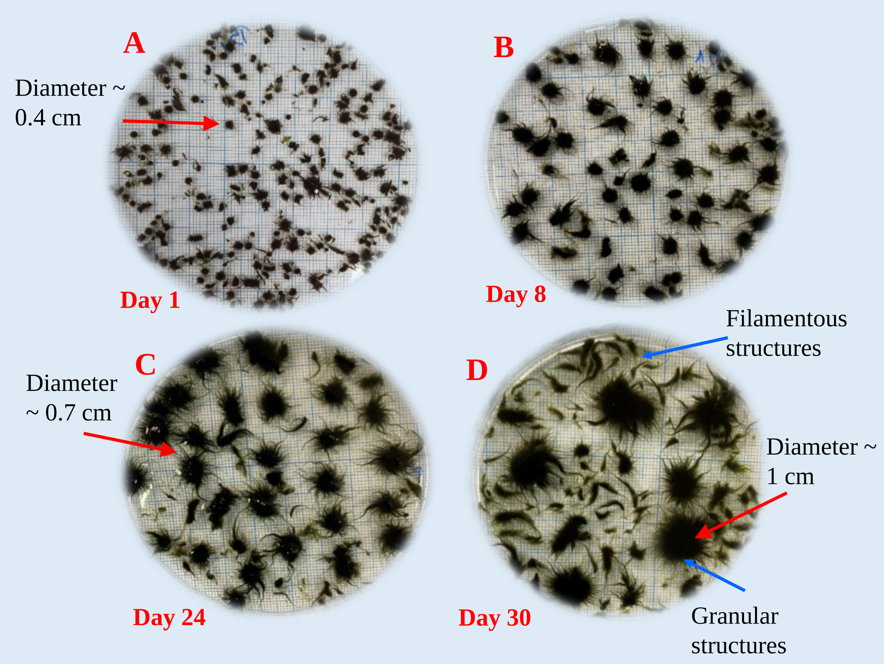
The final CN ranged between 0.03 and 0.045 values (0.066 ± 0.003 influent).

Color removal efficiency



The resulting color removal efficiency ranged between 16 and 56%.
The effluents were characterized by a brown color emphasizing still remaining non-biodegradable organic compounds.

Morphological evolution of granules



An increase in the diameter size of the granular entities and a defragmentation of the outside filaments were recorded, resulting two structures: *granular vs. filamentous*.

Conclusions

❑The parameters ensured below the allowed limits imposed by national norms:

- COD and BOD_5
- Nitrites and nitrates
- Phosphate and total phosphorus

❑Removed nutrient with a high efficiency (> 90 %):

- Ammonium

❑ Removed nutrient with a low efficiency (< 40%):

- Total nitrogen

❑ Challenges:

1. High color index with low color intensity removal efficiency (< 56%)
2. Requirements for increasing removal efficiency of total nitrogen

➤ Compared to activated sludge processes, in the aerobic stage (*supported only by the natural process of photosynthesis*), tested method limited the increase of nitrate concentration in the effluents.

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