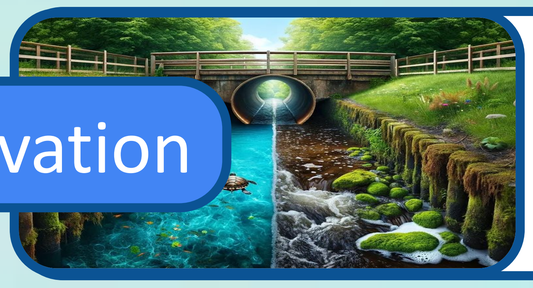
SIWI
Stockholm *Junior* Water Prize

Immobilized Microalgae Bioremediation
A Sustainable Solution for Contaminated Water

Valentina Fontenla

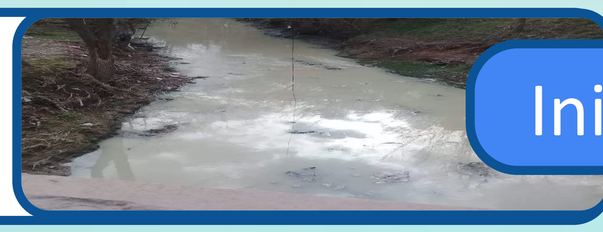
Motivation



Motivated by the severe degradation of a local stream once known for its clarity and biodiversity, this project aims to tackle the influx of waste and pollution that has marred its waters over the past three decades. Committed to restoring the stream's health and beauty, I am dedicated to applying innovative remediation techniques to rejuvenate this vital community resource.

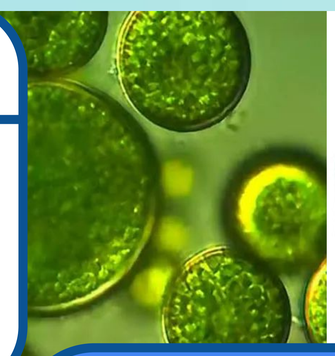
Initial Stage

The project began with analyzing water from a local stream affected by industrial discharges, revealing significant contamination with heavy metals like chromium and copper.

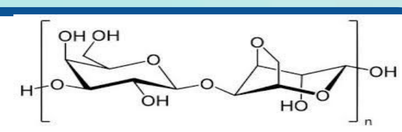


Chlorella vulgaris

It is a single-celled green microalgae found in freshwater and other aquatic habitats. It is known for its high growth rate and its ability to photosynthesize efficiently, which makes it an organism of interest in various fields, including bioremediation..



Agar Agar



I believe that using agar-agar to contain Chlorella vulgaris improves the effectiveness of the treatment by keeping the algae in direct contact with the contaminants, without dispersing. Furthermore, being biodegradable and non-toxic, agar-agar ensures an environmentally safe and sustainable process.

Experimental bioreactor

1 / Container

This project uses a bioreactor with affordable techniques, employing spheres of Chlorella vulgaris in agar to purify the El Clavel stream. A 2-liter transparent tank with aeration and agitation systems supports photosynthesis and monitors algae growth. After a 6-day trial, the technique's effectiveness for small-scale water treatment was evaluated, offering a sustainable option for resource-limited communities.

2 / Aeration

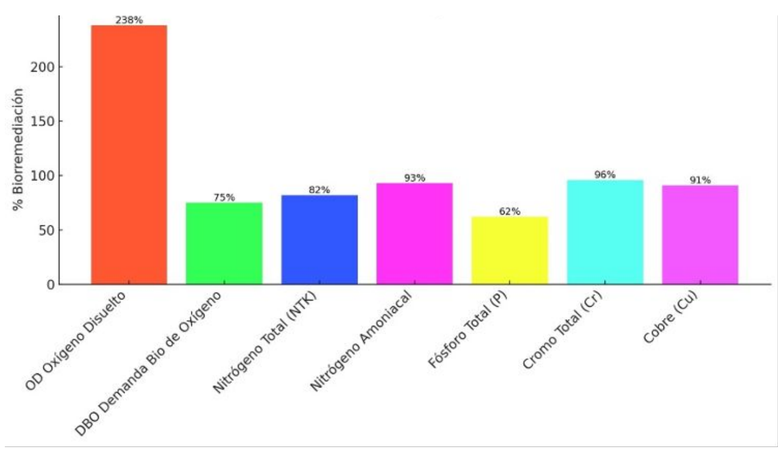
This bioreactor simulates stirred tank fermenters with an adjustable air pump regulating oxygen and CO2 flow for up to 20 liters per hour. It ensures optimal oxygenation and keeps algae in suspension for photosynthesis, with a pump diffuser that evenly distributes nutrients and light. Strategic placement of the pump and diffusers prevented microalgae stress and maintains effective agitation, crucial for bioremediation.

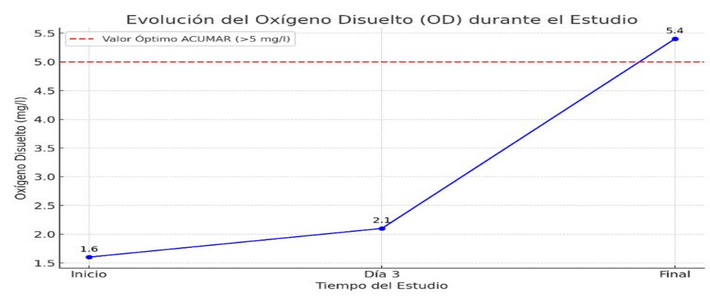
3 / Ph

Experiments in bioreactors controlled pH and temperature (pH 6.5-8.5, 20-30°C) to optimize Chlorella vulgaris growth and photosynthesis. Optimal metal biosorption occurred at pH 7.5. Adjustments, typically with sodium bicarbonate or citric acid, and continuous monitoring, are crucial for effective bioremediation.

4 / Temperature

A thermometer keeps the temperature stable at 24 ± 2°C, ideal for Chlorella Vulgaris growth. Although a thermal blanket was available, it was unnecessary due to consistent temperatures. Thermal blankets are useful for maintaining or increasing temperatures above ambient levels when needed.





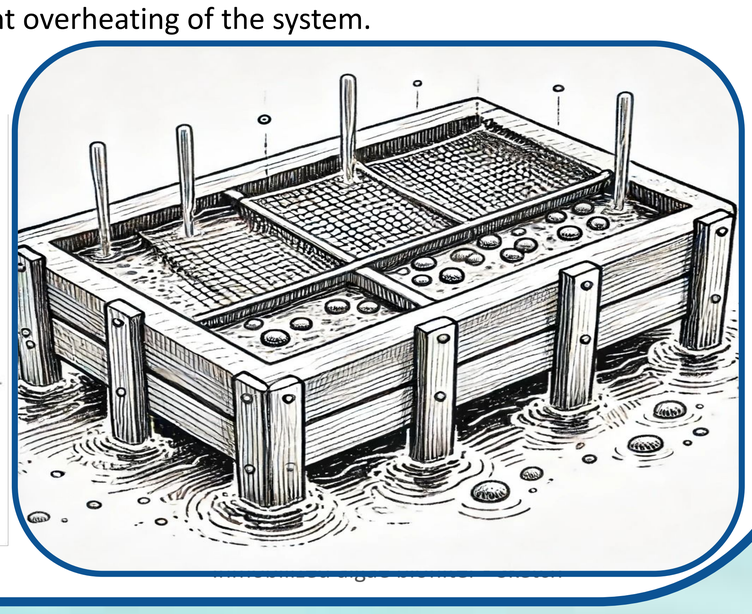
5 / Lightning

To achieve photosynthesis, it was illuminated with low intensity LED lights.

It was decided to maintain lighting for 16 hours with 8 hours of darkness.

6 / Evaporation

A transparent cover was used for the bioreactor that allowed light to pass through but reduced evaporation. We made sure the cover had some openings to allow gas exchange and prevent overheating of the system.



Results

This study assessed the efficacy of Chlorella Vulgaris, immobilized in agar-agar, for bioremediating water from the El Clavel stream contaminated with industrial discharges. A specialized bioreactor was used, and results were observed over six days.

Parameter	Unit	1.a	1.b	Lab Results M1	Lab Results M2
Dissolved Oxygen (DO)	Mg/l	>5	>5	1.6	5.4
Biochemical Oxygen Demand	Mg/l	<5	<5	19.70	4.90
Total nitrogen (NTK)	Mg/l	S/D	S/D	14.98	2.73
Ammoniacal nitrogen	Mg/l	<0.6	<0.6	11.70	0.79
Total Phosphorus (P)	Mg/l	<0.01	<0.01	1.63	0.62
Total Chromium (Cr)	Mg/l	<0.02	<0.02	0.25	0.01
Copper (Cu)	Mg/l	<0.09	<0.09	0.10	<0.01
Temperature	°C	<35	<35	18.5	24
pH	UpH	6.5-9	6.5-9	8.5	7.5

Resolution 283/2019 (Annex A) ACUMAR (Authority of the basin Matanza Riachuelo) is an autonomous, self-governing, inter-jurisdictional entity formed by the Nation, the Province of Buenos Aires, and the City of Buenos Aires.

Growth of Chlorella Vulgaris: 40% biomass increase.
Dissolved Oxygen (DO): The initial level of 1.6 mg/l DO, increased to 2.1 5.4 mg/l at the end of the study.
Water pH: The initial pH of 8.5, was adjusted and maintained at 7.5, decreasing the water's alkalinity.
Biochemical Oxygen Demand reduction of 75%.
Nitrogen, ammoniacal removal reached 93%.
Total nitrogen approximate reduction of 82%.
Total phosphorus decreased by 62%.
Copper 90% reduction.
Chromium 96% of reduction.
Nitrite Levels: Showed no significant changes. The technique used to measure these levels was colorimetry, which did not allow detection of slight variations due to the method's resolution.