Poster Ingeniería Ambiental

Curso: Anteproyecto de Investigación

Docentes: Andrea Tamayo Londoño y Carlos Fidel Granda

Programa: Ingeniería Ambiental

Muestra de los estudiantes de Ingeniería Ambiental, matriculados en el curso de Anteproyecto de Investigación. En esta oportunidad, presentan el avance de resultados de sus proyectos de investigación.

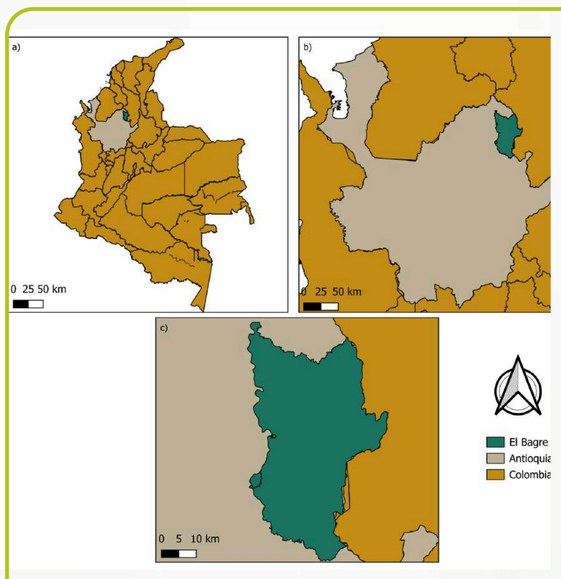
XXIV SEMANA DE LA FACULTAD ARQUITECTURA E INGENIERÍA

EVALUATION OF RISKS TO HUMAN HEALTH AND THE ENVIRONMENT ASSOCIATED WITH ENVIRONMENTAL LIABILITIES FROM GOLD MINING (PAMA) FOR THEIR CATEGORIZATION AND PRIORITIZATION IN SOME MUNICIPALITIES OF THE BAJO CAUCA AREA, ANTIOQUIA.

Researchers: Esteban Vélez Colorado - Sebastián Collazo Perea

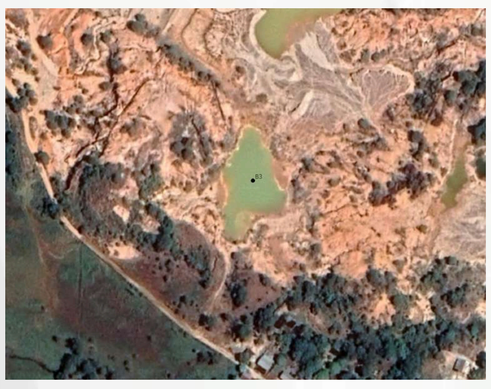
Adviser: Julián Esteban López Correa, Course teacher: Andrea Tamaño Londoño

Introduction



Gold mining is an activity that generates environmental liabilities, including tailings dams. Tailings contain potentially toxic elements (PTEs) like As, Cd, Pb, and Cr. They represent a significant risk to the environment and human health, as contaminants can move through water, wind, and soil, affecting ecosystems and nearby communities. Given the lack of clear regulations for the management of these liabilities.

This study seeks to evaluate and prioritize the risks associated with PAMAs in the municipalities of Nechí, El Bagre, and Zaragoza, with emphasis on tailings dams and their potential influence on environmental quality.



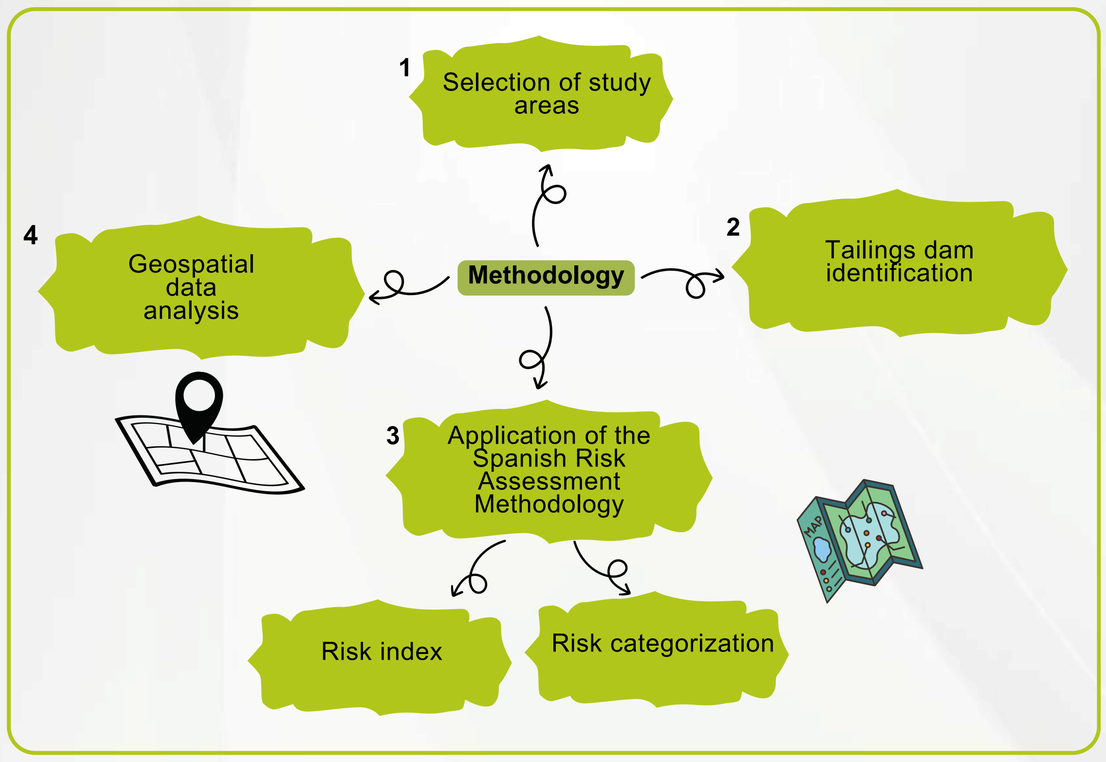
General Objective

To assess the risks to human health and the environment associated with gold mining environmental liabilities (PAMA) in the municipalities of Nechí, El Bagre, and Zaragoza, located in Antioquia.

Specific Objectives

To characterize the level of environmental and human health risk in tailings dams associated with PAMAs in some municipalities of the Bajo Cauca area, Antioquia.

To spatialize the results of the characterization and prioritization of environmental and human health risk associated with PAMAs through the use of geographic information systems.



Partial results

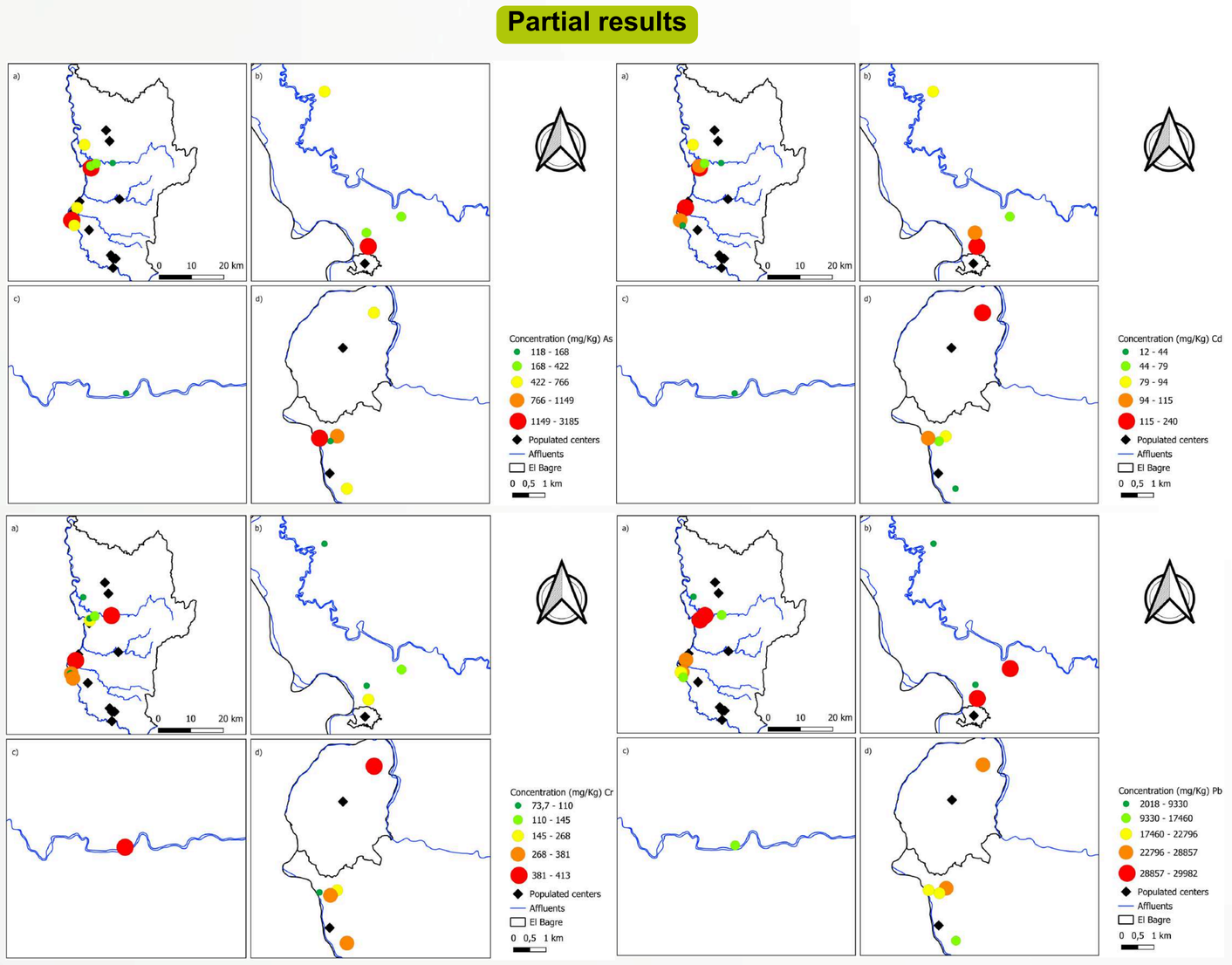


Fig. 1 Metal distribution and concentrations. El Bagre.

The higher concentration of PTEs in the municipality of El Bagre could be related to the high density of mining areas. This municipality is considered the main gold producer in Antioquia. However, it is crucial to highlight that illegal mining is also practiced in the region, which aggravates environmental problems by increasing the concentrations of PTEs and the lack of adequate regulation can cause kidney and bone diseases, cancer, and skin damage.

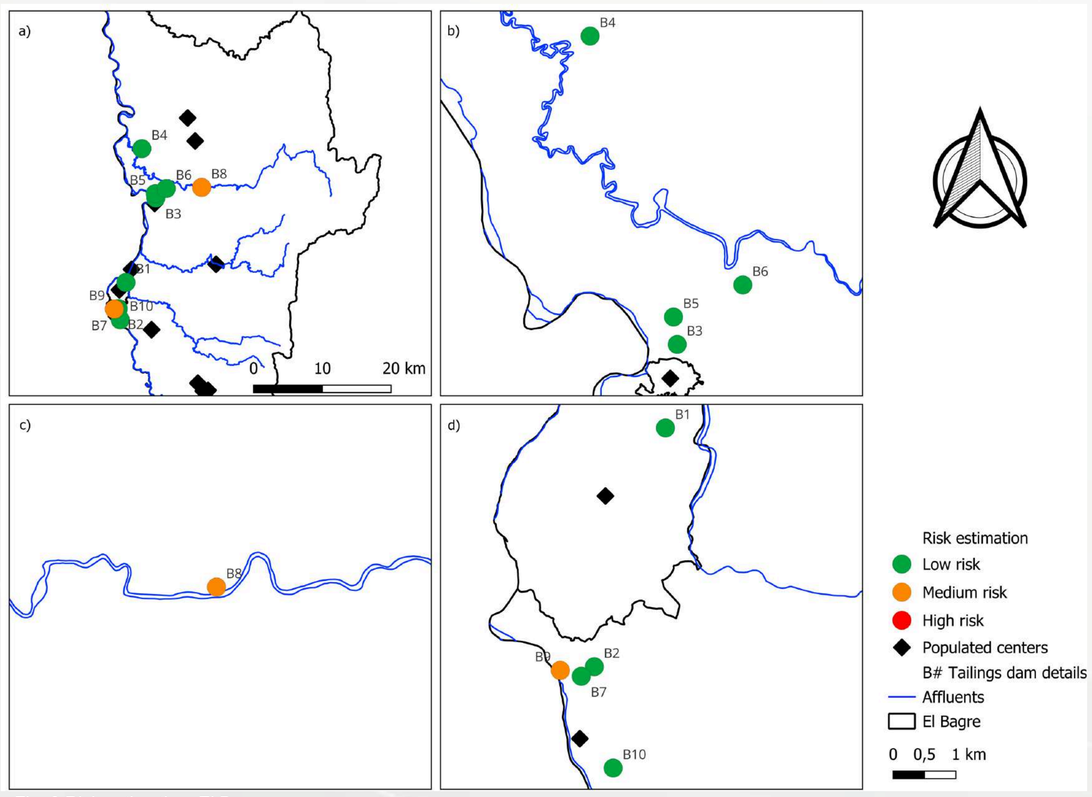


Fig. 2 Risk estimation. El Bagre.

In El Bagre, a risk assessment was carried out on 10 tailings dams, which revealed that 80% are low risk, while 20% were classified as medium risk. No dams in the area were found to present a high risk. Therefore, it is essential to implement mitigation and regulation actions in the medium risk dams by the environmental authority in order to protect the local community and nearby water bodies, such as the Amacerí and Tigüí rivers.

Bibliography

XXIV SEMANA DE LA FACULTAD ARQUITECTURA E INGENIERÍA

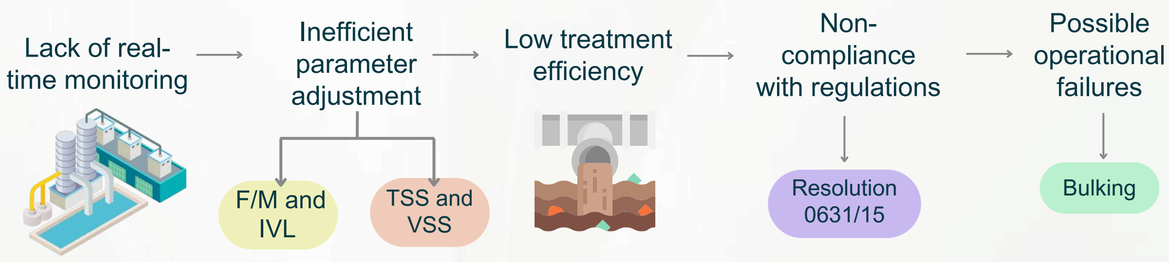
Design and evaluation of a real-time data acquisition system for decision making in an activated sludge reactor.

Sara Castrillon Montoya - Daniela Otalvaro Aguirre
Thematic advisor: Msc. Juan David Correa Estrada
Methodological advisor: Ph.D Carlos Fidel Granda

PROBLEM

Wastewater treatment using activated sludge is inefficient due to the lack of real-time data. Without continuous monitoring of physicochemical parameters, operators are unable to adjust operating parameters, resulting in:

- Inefficiency in removing contaminants.
- Non-compliance with environmental standards.
- Risk of bulking and other operational failures.



THEORETICAL

Biological wastewater treatment using activated sludge is an important strategy for reusing and improving water resource management. This approach not only contributes to the elimination of pollutants, but is also aligned with goal **6.3** of the **2030 Agenda**, which seeks to improve water quality globally [1], [2]. This project presents an easy-to-build prototype that allows indirect measurement of total suspended solids (TSS) in an activated sludge reactor in real time, using IoT technology, facilitating decision-making and the issuance of early warnings under critical operating conditions, thus optimizing treatment efficiency and ensuring compliance with regulations such as Resolution 0631 of 2015 [3] - [6].

GOALS

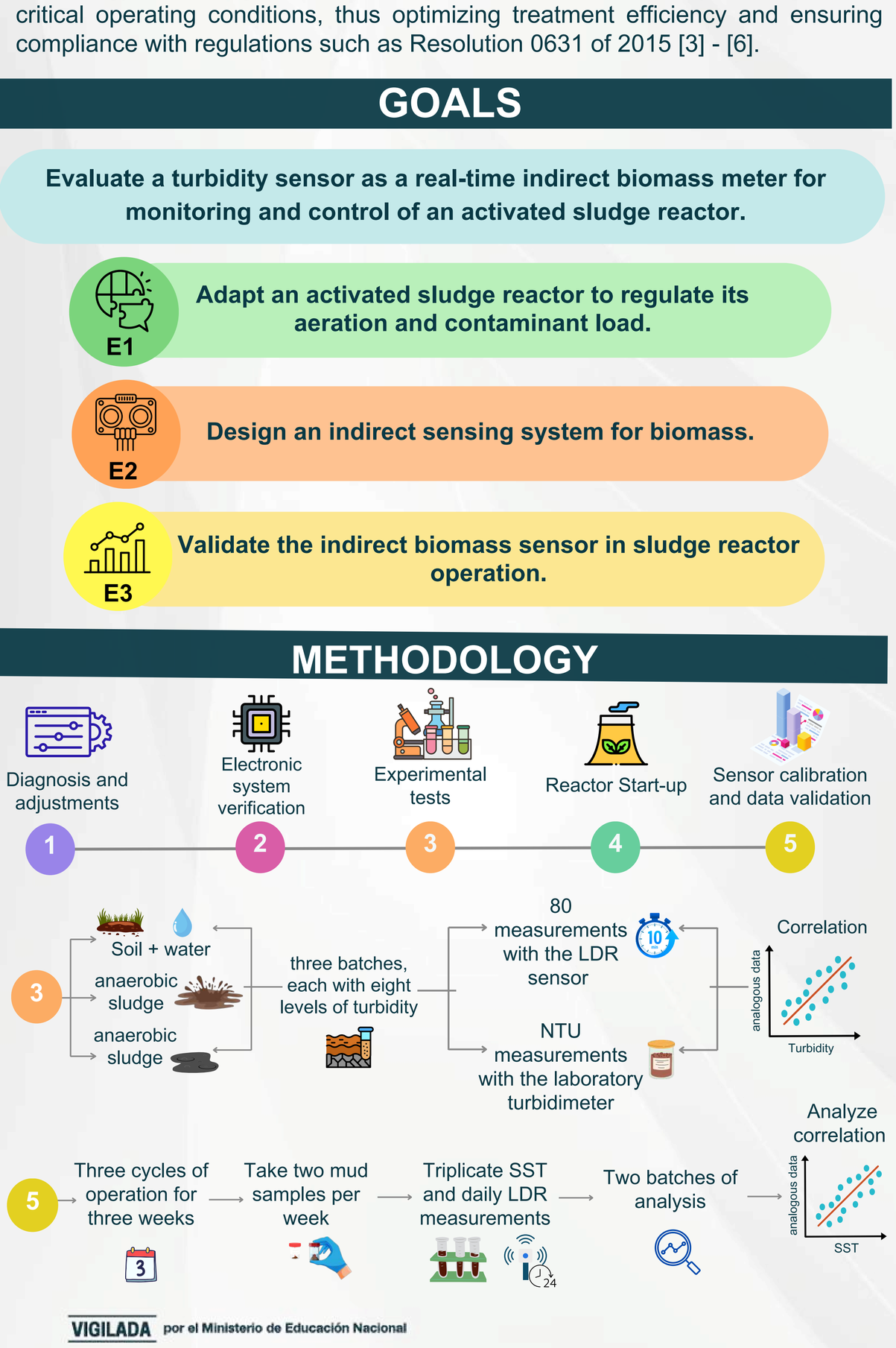
Evaluate a turbidity sensor as a real-time indirect biomass meter for monitoring and control of an activated sludge reactor.

E1 — **Adapt an activated sludge reactor to regulate its aeration and contaminant load.**

E2 — **Design an indirect sensing system for biomass.**

E3 — **Validate the indirect biomass sensor in sludge reactor operation.**

METHODOLOGY



VIGILADA por el Ministerio de Educación Nacional

RESULTS

The activated sludge reactor was improved by redesigning the control box and optimizing the feed system. The mixing system was modified with an Arduino-controlled motor, improving efficiency and avoiding bulges when sealing gates as seen in Figure 1A.

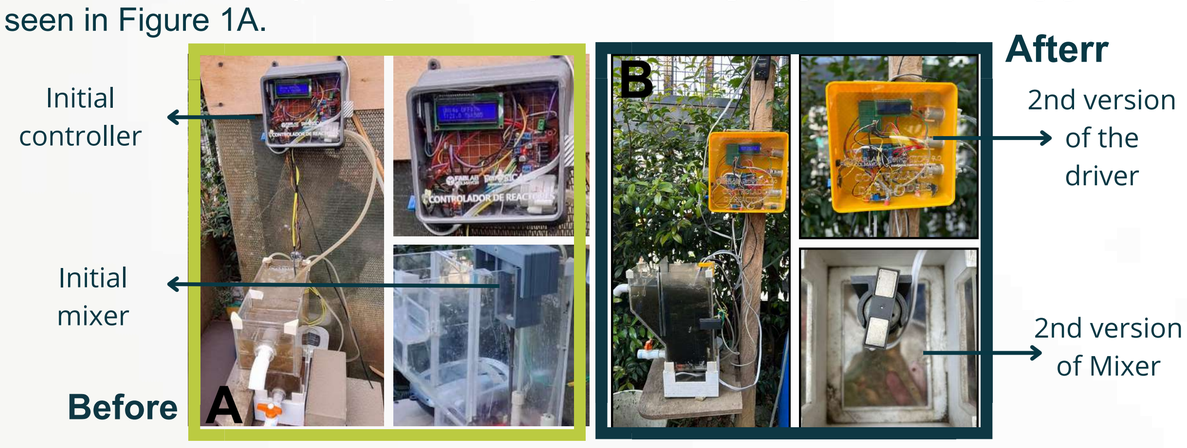


Figure 1. (A) Initial reactor with initial version of controller box and mixer. (B) Reactor with second version of controller box and mixer.

Subsequently, a functional prototype was built with serial data capture (Figure 2). Correlations of 0.905 were found for soil, and 0.963 for aerobic sludge (Figure 3). Anaerobic sludge did not present significant correlations, possibly due to the continuous granulation of floc. It is expected that in the next few months, the correlations will be carried out in a continuous activated sludge reactor.

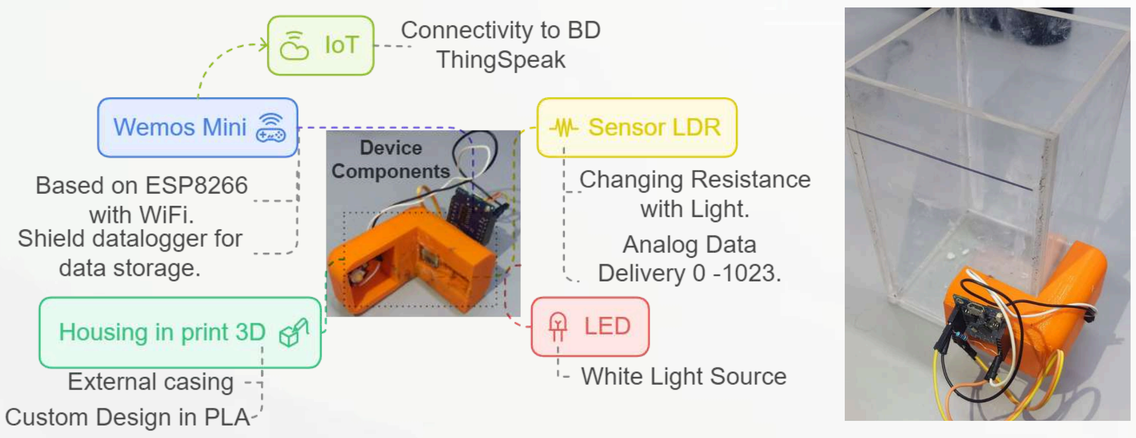


Figure 2. Initial prototype of indirect SST sensor

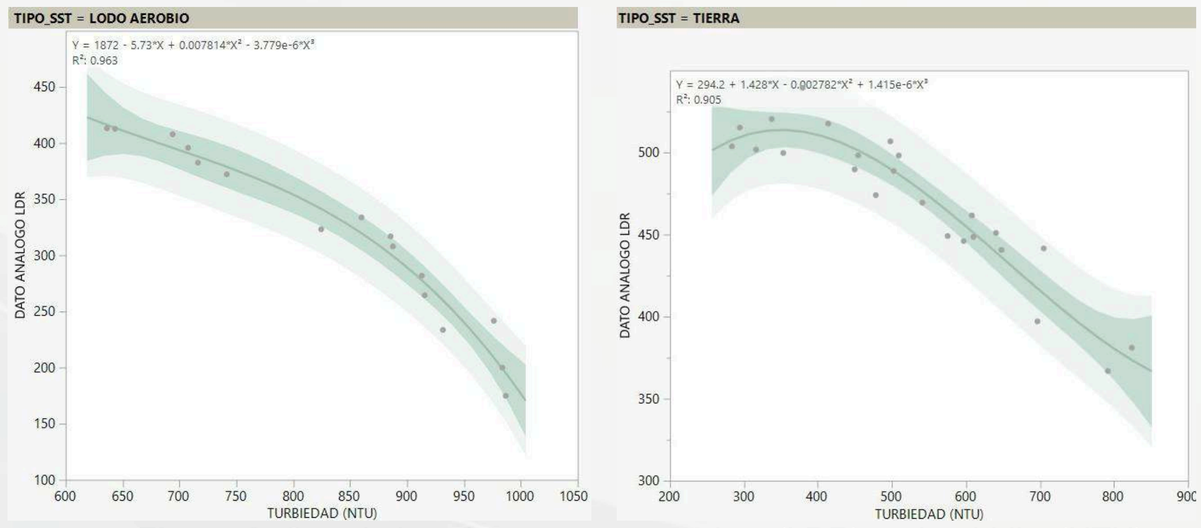


Figure 3. Correlations between sensor data (LDR) and turbidity (NTU) in soil and aerobic sludge.

CONCLUSIONS

The performance of the low-cost sensor in aerobic sludge for real-time measurement of TSS is promising, allowing for more agile calculation of IVL and other parameters to make control decisions in the process.

REFERENCES

INSTITUCIÓN UNIVERSITARIA COLEGIO MAYOR DE ANTIOQUIA® Acreditados en ALTA CALIDAD

Alcaldía de Medellín Distrito de Ciencia, Tecnología e Innovación

XXIV SEMANA DE LA FACULTAD ARQUITECTURA E INGENIERÍA

ANALYSIS OF THE WATER SECURITY OF PERI-URBAN COMMUNITIES, OF COMMUNE ONE (1), OF THE DISTRICT OF MEDELLÍN, AS SOURCES OF SELF-SUFFICIENCY

Diana Lucia Oliveros & Katerine Serna
Thematic advisor: Joan Amir Arroyave - María Elena González Duque - Carlos Arturo Hoyos– Methodological advisor: Andrea Tamayo

INTRODUCTIÓN

Access to safe drinking water is a fundamental right that impacts public health and economic development. However, only 3% of the world's water is suitable for human consumption. Diseases related to unsafe water, such as diarrhea, are a leading cause of child mortality. The United Nations Sustainable Development Goals (SDGs) aim to ensure safe drinking water and sanitation for all by 2030. In Colombia, drinking water coverage as of last year was 44.5%, while access to sanitation services reached 41.6%. Water quality is also a concern in parts of Colombia, where studies have detected *E. coli* and found non-compliance with drinking water standards. This study, conducted in Commune 1 of Medellín, aims to analyze the quality of untreated water used by its inhabitants, evaluating physicochemical and microbiological parameters to identify health risks and promote community management.

OBJECTIVES

To analyze water security in peri-urban communities in Commune one(1) of the Medellín District that rely on self-supply sources.

OBJECTIVE 1

To identify the water sources used for self-supply by peri-urban communities in Commune 1, Medellín District.

OBJECTIVE 2

To characterize the physicochemical and microbiological quality of water sources used for self-supply by peri-urban communities in Commune 1, Medellín District.

OBJECTIVE 3

To propose alternatives for the management and use of the water sources analyzed in Commune 1 of the Medellín District.

METHODOLOGY

1. Identification and georeferencing of water source.
2. Selection of sources to be studied.
3. Sampling
4. Laboratory analysis.
5. Jar test to determine the optimal coagulant dose.
6. Comparison with the standard.
7. Determine recommendations.
8. Knowledge transfer to the community.

PARTIAL RESULTS

The analysis of the seven sources of self-supply in Barrio Popular 1 and La Avanzada reveals a significant reliance on non-centralized sources within the community, primarily due to their low cost. Through interviews and observations, we identified external factorssuch as steep slopes, nearby hydrographic networks, and social activities that impact water quality.

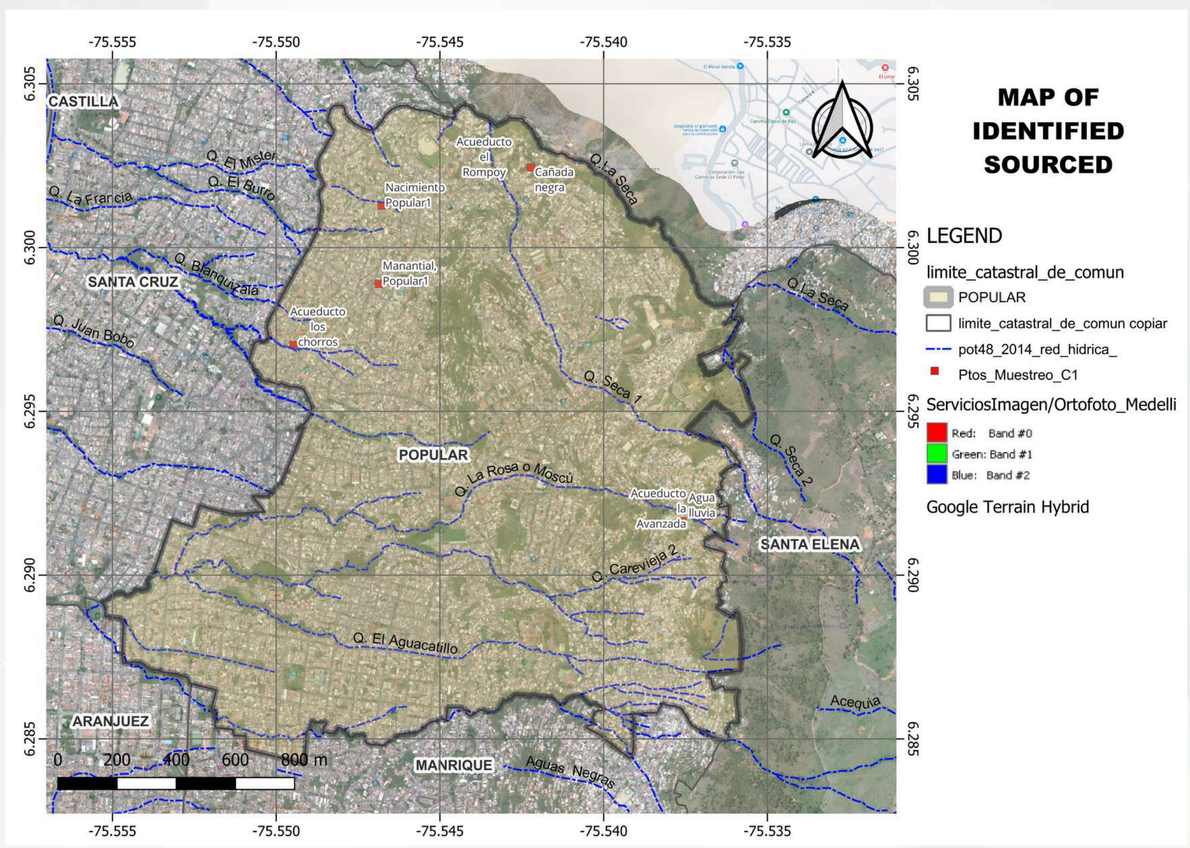


Figure 1. Map of sources, own elaboration.

Figure 2. sources identified, own elaboration.

Parameter		Rain water	La Avanzada aqueduct	Popular spring 1	Resource of Chorros	Resolution2115/2017
Alkalinity (mg/L)	April	20	34	6	56	
	September	12	34	38	54	
	October	10	10	40	62	200
Turbidity (UNT)	April	17.50	19.49	0.22	0.35	
	September	4,92	4,15	0,78	0,49	
	October	38.29	6,09	0,12	0,16	2
pH	April	7.518	7.414	7.712	7.659	
	September	7,016	6,8	7,182	7,378	
	October	6,760	6,73	7,478	7,31	(6,5 - 9,0)
Conductivity (µS/cm)	April	98.2	101.1	309	500	
	September	79,6	76,5	339	437	
	October	122,7	87,4	345	504	1000

Table 1. Physicochemical results, own elaboration.Green color is in compliance with the standard, red color exceeds the maximum permissible limit.

	Muestreo	Rain water	La Avanzada aqueduct	Popular spring 1	Resource of Chorro
Mesophiles (UFC/100ml)	April	>200	>200	120	>200
	September	>200	>200	150	12
	October	>200	180	16	26
Total Coliforms (UFC/100ml)	April	>200	>200	>200	2
	September	>200	>200	140	2
	October	>200	>200	>200	19
Fecal Coliforms (UFC/100ml)	April	22	27	7	0
	September	>200	24	0	0
	October	140	56	4	0
Enterococos fecales (UFC/100ml)	April	40	15	2	2
	September	>200	34	0	0
	October	>200	>200	3	3
Pseudomona aeruginosa (UFC/100ml)	April	5	0	25	0
	September	60	50	40	0
	October	2	100	19	9

Table 2. Microbiological results, own elaboration. Green color is in compliance with the standard, red color exceeds the maximum permissible limit. CT Total coliforms, CF Fecal coliforms

PARTIAL CONCLUSIONS

The identified sources show variability in water quality, with non-compliance in turbidity and high levels of microbiological contamination, especially in rainwater and La Avanzada community aqueduct samples, exceeding the limits established by *Resolution 2115 of 2007*. Lack of maintenance and exposure to external factors, such as animal activity and poor infrastructure, negatively affect water quality, making it necessary to implement appropriate management practices.

Bibliographic References

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Evaluation of phosphorus solubilization efficiency with *Trichoderma* sp. and *Aspergillus* sp. in soils with contrasting mineralogy

Anlly Danelly Silva Durango[1]; Evelyn Cossio Marin[1]; Isabela Espitia Cogollo[1]; Dorcas Zúñiga Silgado[2];Carlos Fidel Granda[3]

1.IUCMA Environmental Engineering Students

2. Thematic advisor

3. Methodological advisor

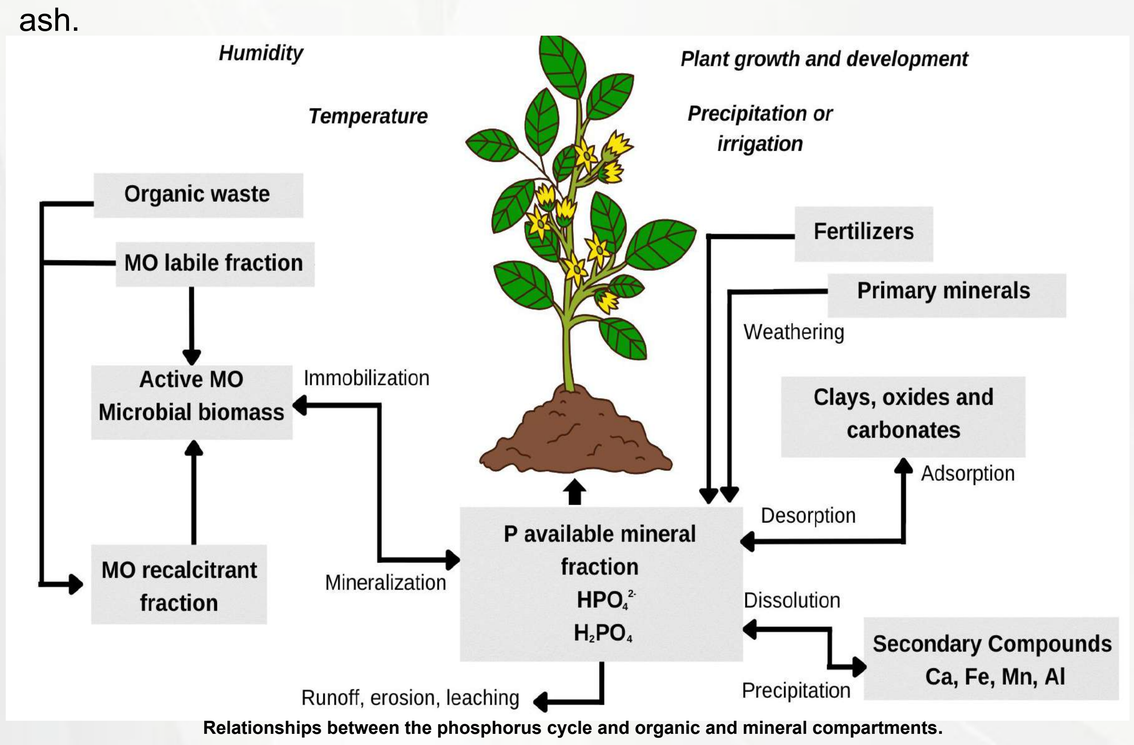
PROBLEM

Phosphorus (P) is an essential macronutrient for all plant processes, however it is not mobile neither bioavailable for phytoabsorption. The ability of microorganisms, especially fungi, to solubilize inorganic phosphorus (IP) has been considered one of the most important traits associated with phosphate nutrition, however, the impact of soil mineralogy on P solubilization efficiency has not been emphasized.

THEORETICAL FRAMEWORK

Fungal strains release metabolites into the environment by various mechanisms, including organic acids and phytase enzymes. *Aspergillius* sp and *Trichoderma* sp have been shown to be beneficial fungi for increasing P bioavailability in soils.

Vertisols are clayey soils with montmorillonite, Entisols are less evolved soils that contain kaolinite clay and Andisols are soils derived from volcanic ash.



Relationships between the phosphorus cycle and organic and mineral compartments.

HYPOTHESIS

Microorganism-soil relationship

The phosphorus solubilization efficiency with *Aspergillus* sp and *Trichoderma* sp depends on the mineralogical composition of the soil.

OBJECTIVES

GENERAL

- Evaluate the effect of soil mineralogy on phosphorus solubilization efficiency with *Aspergillus* sp - *Trichoderma* sp.

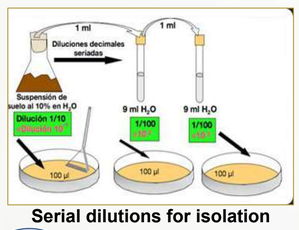
SPECIFIC

- Select phosphorus-solubilizing strains of *Aspergillus* sp and *Trichoderma* sp isolated from rhizospheric econiches, rhizoplanes and endophytes.
- Identify molecularly phosphorus-solubilizing strains of *Trichoderma* sp and *Aspergillus* sp.
- Quantify phosphorus solubilization efficiency by means of solubilization kinetics with *Aspergillus* sp and *Trichoderma* sp.
- Determine the effect of soil mineralogy on phosphorus solubilization efficiency with *Aspergillus* sp and *Trichoderma* sp.

REFERENCES

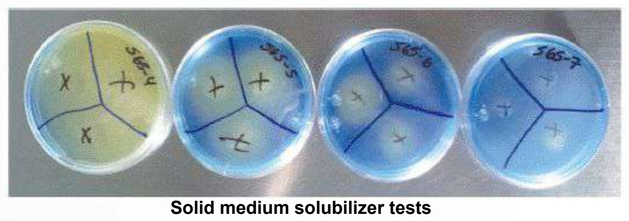
METHODOLOGY

1 Select phosphorus-solubilizing strains of *Aspergillus* sp and *Trichoderma* sp isolated from rhizospheric econiches, rhizoplanes and endophytes



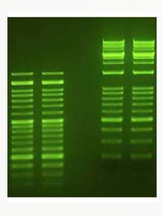
Serial dilutions for isolation

Isolation on rose bengal agar



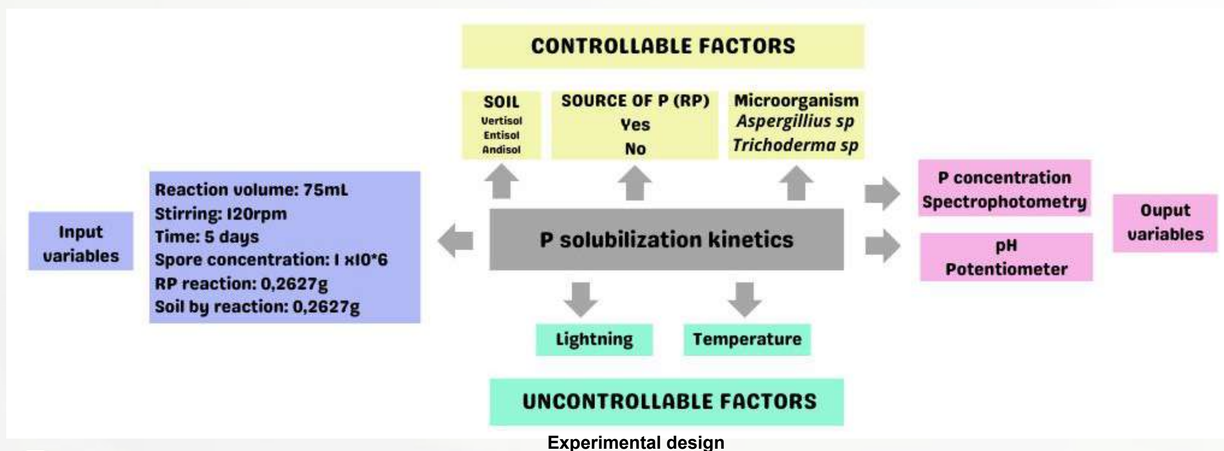
Solid medium solubilizer tests

2 Identify molecularly strains of *Trichoderma* sp and *Aspergillus* sp, phosphorus solubilizers.



Genomic DNA isolation, PCR, sample purification, Nanodrop reading and electrophoresis run

3 Quantify the efficiency of phosphorus solubilization through solubilization kinetics with *Aspergillus* sp and *Trichoderma* sp



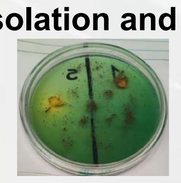
Experimental design

4 Determine the effect of soil mineralogy on the solubilization efficiency of fungal strains *Aspergillus* sp and *Trichoderma* sp, and the secretion of organic acids.

Analysis of ANOVA, General Linear Model (GLM) and Multiple Comparison Analysis (PCA), in addition to means separation tests; both with a significance level (P) ≤ 0.05.

PARTIAL RESULTS AND ANALYSIS

Isolation and selection of phosphorus-solubilizing fungal strains.



Aspergillus sp solubilization test

Aspergillus sp isolated axenic

Trichoderma sp solubilization test

Trichoderma sp isolated axenic

Molecular identification

	Aspergillus sp.	*Trichoderma* sp.
Concentración (ng/uL)	2498	6441.5
260/280	1,75	2,15
260/230	1,35	1,94

DNA extraction results using the Phenol-Chloroform method

PARTIAL CONCLUSIONS

The fungal strains *Trichoderma* sp. and *Aspergillus* sp. evaluated have proven to be effective in improving the bioavailability of phosphorus in the soil, because they are effective in solubilizing phosphate rock.

XXIV SEMANA DE LA FACULTAD ARQUITECTURA E INGENIERÍA

Formulation and evaluation of biochar encapsulation with beneficial microorganisms for promoting plant growth

Alejandra Marín Quitian - Itza Manuela Santos Díaz - Manuela Galvis Salcedo

Thematic advisor: Laura Osorno - Fidel Granda - Ramirez

Methodological advisor Fidel Granda - Ramirez

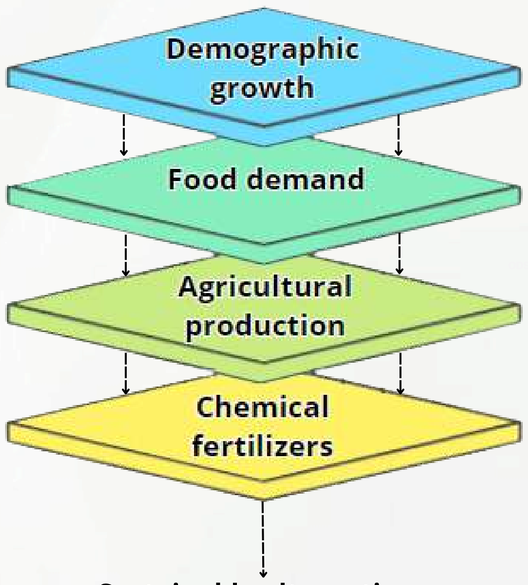
PROBLEM

ONU (2019): From 7.700 million, it will grow to **9.700** million by **2050**.

ONU (2014): More than **600 million** people in the world will suffer from hunger **by 2030**

FAO (2012): To double by **2030**

- **Costly:** Ministry of agricultura
- **Contaminants**
- **Imported:** Food insecurity



ODS impacts

Sustainable alternatives

Renewables, economic, local

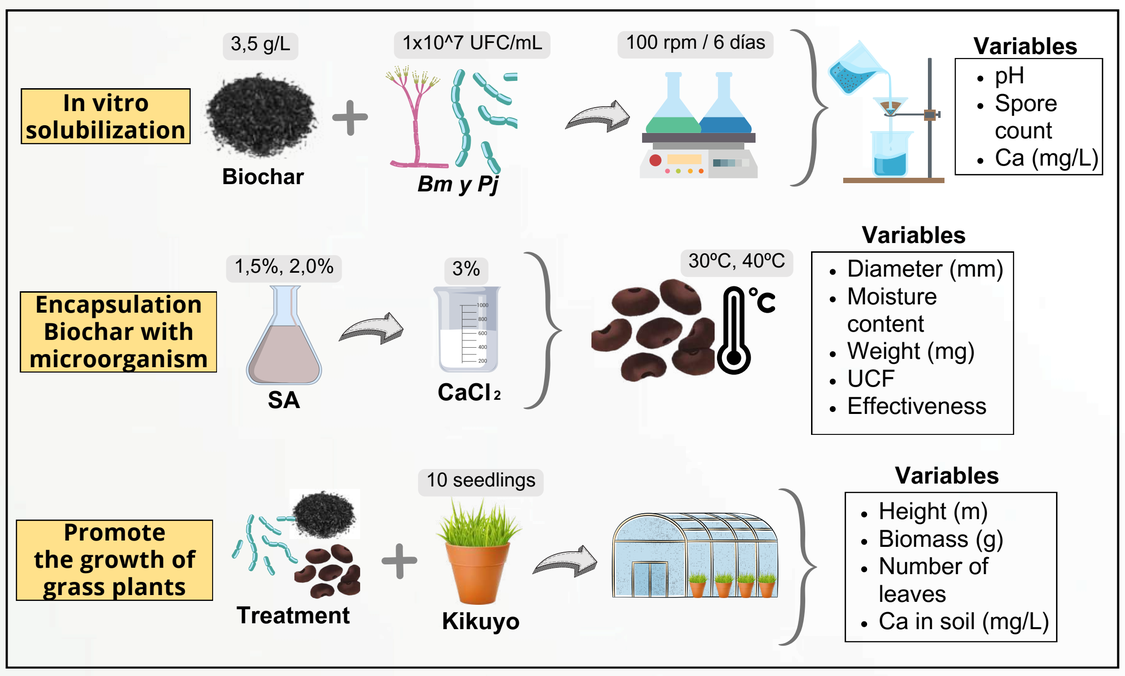

Microorganisms

\+


Biochar

Knowledge gap: Difficulties in **viability and effectiveness** of the microorganism.

METHODOLOGY



RESULTS AND ANALYSIS

Biochar characterization

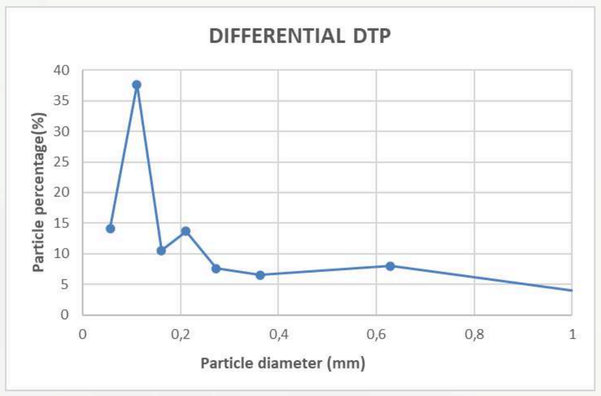


Figure 1. Particle size distribution (DTB) obtained by (AGD) (differential particle size analysis).

Table 1. biochar analysis (characterization).

Parameter	Result	Unit	Analytical method
pH	9.40	-	Potentiometer
EC	2.99	dS/m	
Moisture	2.36	%	-
Oxidizable Organic C	35.46	%	Ignition
Total N	0.23	%	Kjeldahl
N-NO3	18.80	mg/Kg	Selective Ion
N-NH4	0.12	mg/Kg	Colorimetry
C/N	154.17	-	Ratio
$_4$ P2O5	0.49	%	Colorimetry
CaO	3.58	%	Atomic absorption
K2O	1.27	%	
MgO	1.19	%	
SO4	0.36	%	Turbidimetry
B	ND	%	Colorimetry

Biosolubilization of biochar *In Vitro*

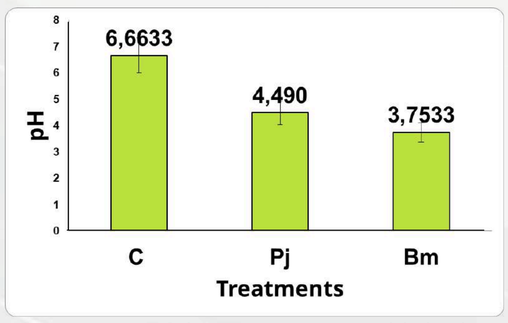


Figure 2. pH of the treatments established.

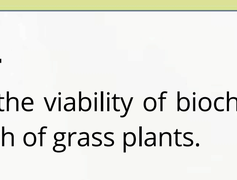
Table 2. Solubilization of biochar.

Parameters	Mass of biochar(g/L)	Solubilized mass (g/L)	Solubilization ratio
C	2,82	0,68	1,00
Pj	2,10	1,40	2,05
Bm	1,18	2,32	3,40

THEORETICAL FRAMEWORK

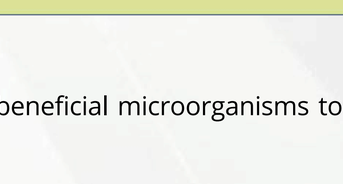
Biochar

It is obtained through biomass pyrolysis, improves the soil, but its nutrients are not always available to plants.



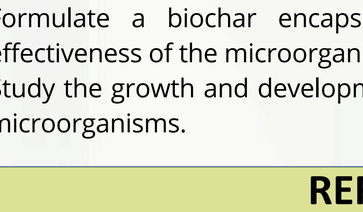
Bacillus megaterium (Bm) and *Penicillium janthinellum (Pj)*

Solubilize nutrients and improve their availability in the soil.



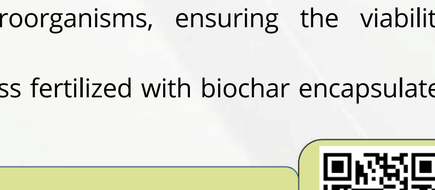
Encapsulated

In sodium alginate (SA) matrices provides stability to immobilized microorganisms, protecting them from the external environment and improving their viability.



Grass Kikuyo

Is productive, resilient, and prevents erosion, making it key in the agronomic industry.



OBJECTIVES

GENERAL

- Evaluate the viability of biochar encapsulated with beneficial microorganisms to promote the growth of grass plants.

SPECIFIC

- Determine the biosolubilization of biochar with beneficial microorganisms.
- Formulate a biochar encapsulation with microorganisms, ensuring the viability and effectiveness of the microorganism.
- Study the growth and development of kikuyu grass fertilized with biochar encapsulated with microorganisms.

PARTIAL CONCLUTIONS

- The biochar has fine particles (37.64% in 100/200 mesh) that optimize the surface for the inoculation of microorganisms, favoring their viability and activity.
- The decrease in pH in the solutions treated with *Bacillus megaterium* and *Penicillium janthinellum* indicates that the microorganisms are producing organic acids, which means that they are carrying out solubilization processes.
- The treatment with Bacillus megaterium showed the highest solubilization ratio (3.40), highlighting this microorganism's strong ability to break down and solubilize biochar components.

REFERENCES

XXIV SEMANA DE LA FACULTAD ARQUITECTURA E INGENIERÍA

Study of perception on the provision of cleaning services in solid waste management in the Manila neighborhood.

Yazmín Rojas[1], Oscar Fernando Pérez[1], Karen Valencia[1].

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INTRODUCTION

THEORITICAL FRAMEWORK: Economic growth in a neighborhood may be associated with the arrival of new industries, businesses, and increased investment in infrastructure. This phenomenon attracts more residents, which increases population density and, consequently, waste generation. According to urbanization studies, a larger population implies an increase in waste production, which requires an adequate response from local authorities in terms of the provision of public cleaning services.

PROBLEMATIC: This research arises in a context where the increase in population, economic growth, commercial activities, hotel development, and tourism activities have generated a significant increase in waste generation, which poses challenges in terms of efficiency and satisfaction of collection and final disposal services.

OBJETIVES

General Objective

- Evaluate the perception of residents of the Manila neighborhood of the municipality of Medellín, regarding the quality of the public sanitation service provided by the public service provider company.

Specific Objective 1

- Examine the relevant documentation in relation to the provision of cleaning services and the current regulatory guidelines, establishing the factors that describe the quality of the cleaning service.

Specific Objective 2

- Determine the perception of the provision of public sanitation services by residents of the Manila neighborhood through a survey.

Specific Objective 3

- Analyze the data obtained on the perception of public services provided, in order to propose strategies or recommendations for improvement.

METODOLOGY

Stage 1: Document review.

- Collection of documented information.
- Analysis and evaluation of legal and technical information.
- Determination of factors in the provision of cleaning services.

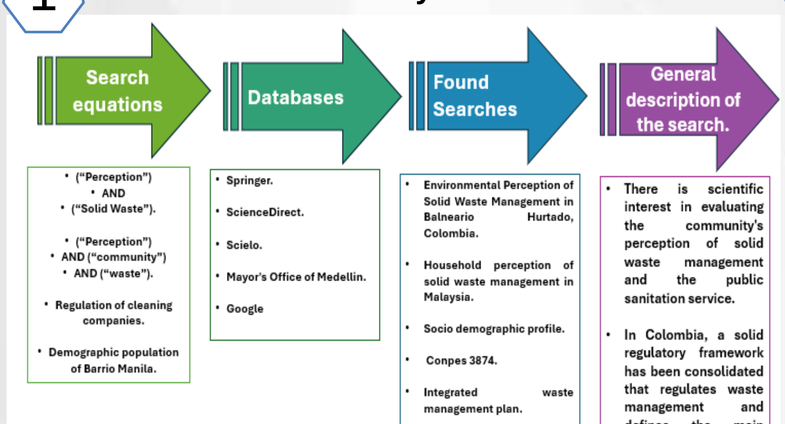
Stage 2: Application of the measurement instrument.

- Definition of the sample size.
- Field reconnaissance work.
- Design (Servqual) and structuring of the survey in Google Forms.
- Field application of the instrument.

Stage 3: Information synthesis Statistical.

- Analysis of the results.
- Structuring of recommendations and improvement actions.
- Socialization to the community.

1 Documentary review



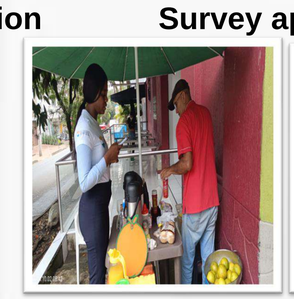
2 finite population

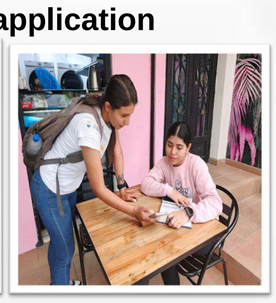
$$n = \frac{N.Z^2.p.(1-p)}{E^2.(N-1)+Z^2.p.(1-p)}$$

$$n = \frac{755*1{,}96^2*0{,}95*(1-0{,}95)}{0{,}05^2*(755-1)+1{,}96^2*0{,}95*(1-0{,}95)} = 66{,}68 = 67 \text{ users}$$

Survey elaboration

Survey application





3 ANALYSIS AND RESULTS

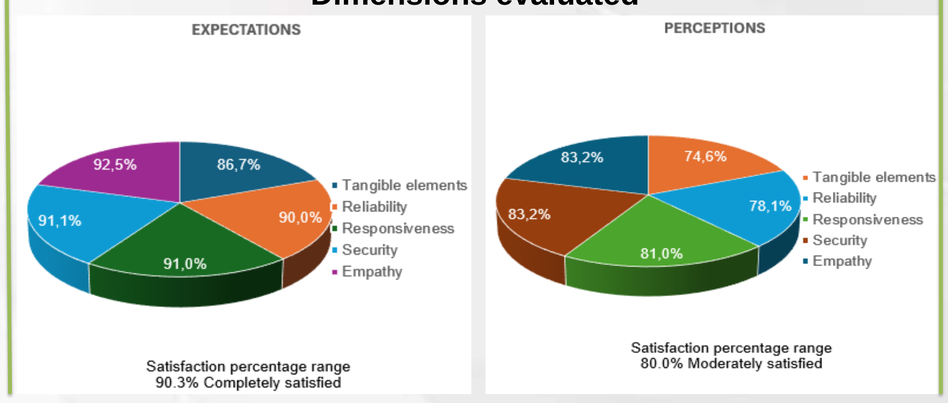
Results of validity and reliability of the questionnaire

Reliability and validity tests	Expectations	Perceptions
Media	6,32	5,60
Standard Deviation	1,19	1,49
Alfa de Cronbach	0,946	0,934
KMO*	0,858	0,875
Test of Bartlett (p<0.05)	< 0,001	< 0,001

*Construct validation test of the Kaiser-Meyer-Olkin (KMO Measure)

Sociodemographic questions

Dimensions evaluated



Service quality index ICS

Averages	Tangible elements	Reliability	Responsiveness	Security	Empathy
Perceptions	5,219	5,468	5,667	5,821	5,821
Expectations	6,070	6,303	6,368	6,378	6,478
Difference	-0,851	-0,836	-0,701	-0,557	-0,657
ICS General	-0,720				

4 Conclusions

1. The overall Service Quality Index (SQI) is -0.720, indicating that perceptions are below expectations. This gap reveals a general dissatisfaction among users, who feel that the service does not fully meet their expectations.

2. The sanitation company in the Manila neighborhood complies with the minimum collection frequency of six days a week, twice a day, although they do not comply with the established schedules.

3. The service provider is considered moderately acceptable, since the residents express dissatisfaction with the waste disposal points, although the company has taken steps to resolve them.

4. Users are not satisfied with the waste containers, considering them inadequate and outdated for the sector's needs.

Literature:

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XXIV SEMANA DE LA FACULTAD ARQUITECTURA E INGENIERÍA

Biostabilization of quarry sludge by *Bacillus spp.* for calcite precipitation

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[b] Thematic advisors
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Introduction

The construction industry is one of the main sources of pollution worldwide and faces significant challenges due to the various types of waste it produces. Quarry sludge is one of these by-products, causing serious environmental impacts due to the limited alternatives for its utilization. Biostabilizing them is an a sustainable alternative for using quarry sludge, in other construction process. This can be achieved through the use of microorganisms, in a process know as microbiological calcite precipitation (MICP), where microorganisms, specially bacteria, are used to precipitate calcite, improving soil properties by increasing particle cohesion.

Theorical framework

Bacillus spp. → *Bacillus mycoides* *Bacillus pasteurii* → Microbiological calcite precipitation (MICP) → Calcite → Ca

Mining of aggregate materials → Quarry sludge →

Oxides	Formula	%p/p
Calcium Oxide	CaO	1.01
Aluminum Oxide	Al_2O_3	21.22
Iron Oxide	Fe_2O_3	10.38
Silicon Oxide	SiO_2	49.83
Titanium Oxide	TiO_2	1.73
Sodium Oxide	Na_2O	3.49
Magnesium Oxide	MgO	2.21
Manganese Oxide	MnO	0.26
Potassium Oxide	K2O	0.00
Phosphorus Oxide	P_2O_5	0.40
Sulfur Oxide	SO_3	0.00
Chromium Oxide	Cr_2O_3	0.01
Calcination Losses	LOI²	4.82

Objectives

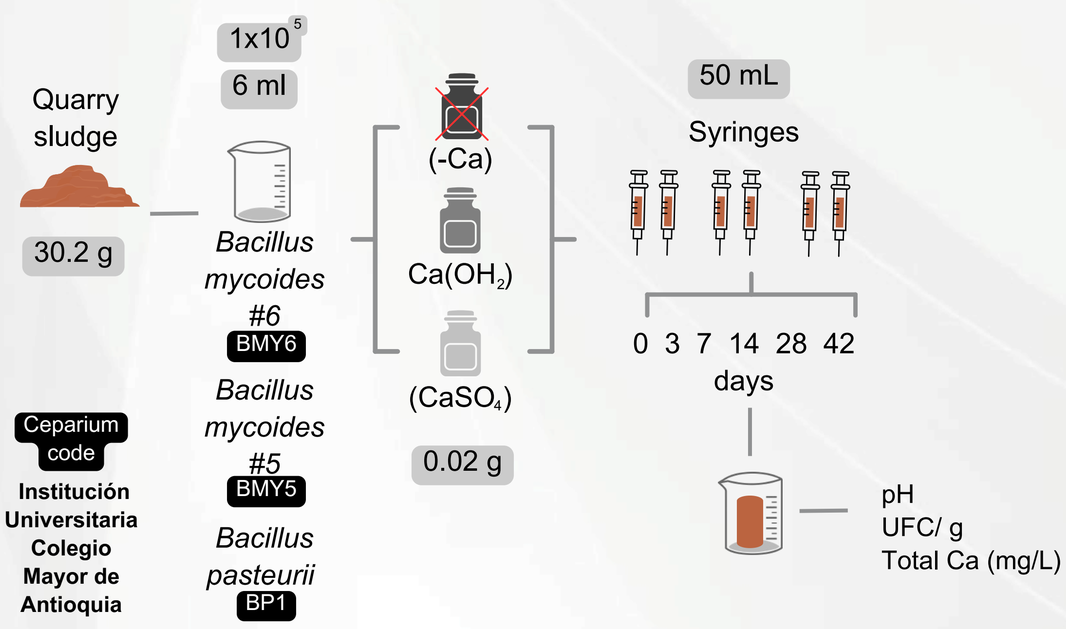
General

Evaluate calcite precipitation effect of different strains of *Bacillus* spp. in a quarry sludge sample for its potential application for construction materials.

Specifics

- Determine the influence of calcium addition to the strains on the bioprecipitation calcite in quarry sludge.
- Define the effect of the calcite precipitation in the quarry sludge at differents periods of time.
- Evaluate the total calcium precipitation efficiency of the strains.

Methodology



Results

Quarry sludge

Figure 1. Dry quarry sludge

Syringe holder

Figure 2. Assembly day 7

Quarry sludge cylinder

Figure 3. C2 (-Ca) disassembly day 7

Bacillus mycoides #6

Figure 4. C1($Ca(OH)_2$) growth disassembly day 14

Bacillus mycoides #5

Figure 5. C2 (-Ca) growth disassembly day 7

Bacillus pasteurii

Figure 6. C3 ($CaSO_4$) growth disassembly day 28

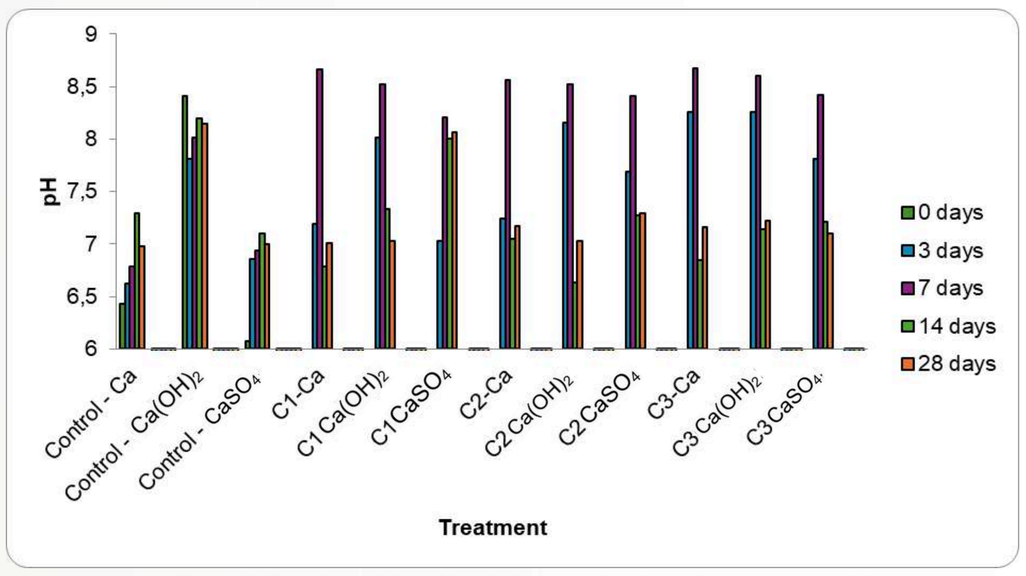


Figure 7. Bar chart of the pH variation as a function of treatments and time

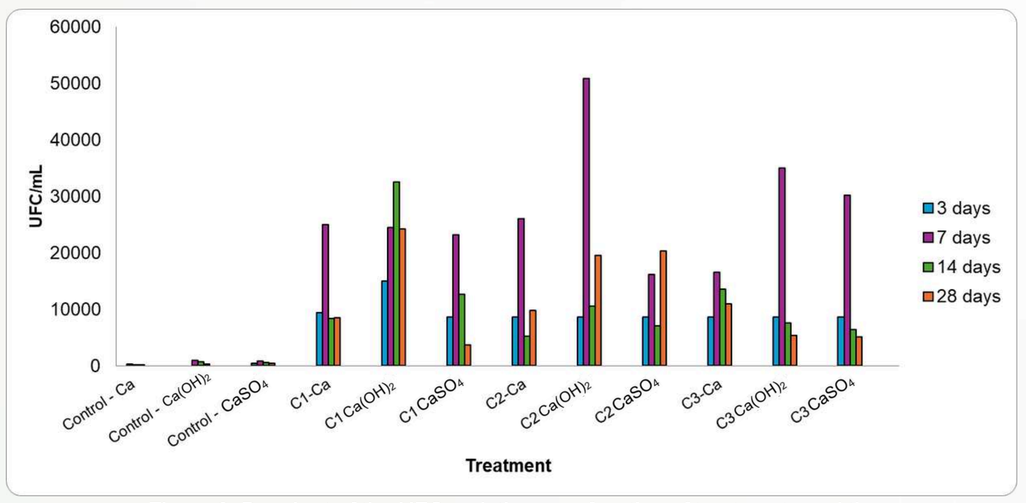


Figure 8. Bar chart of the UFC variation as a function of treatments and time

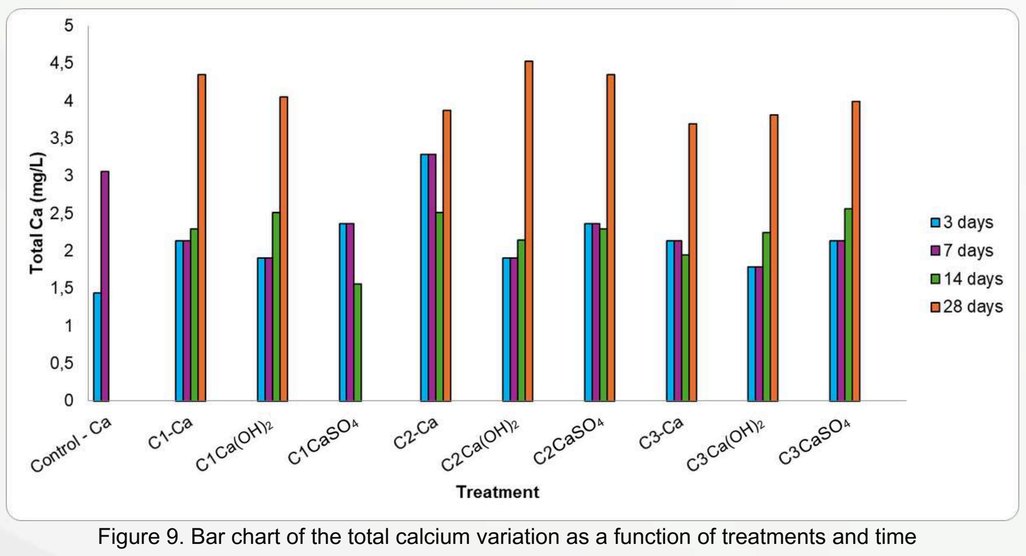


Figure 9. Bar chart of the total calcium variation as a function of treatments and time

Conclusions

- Significant variations in pH are evident with the addition of strains and calcium sources over time, indicating a calcite precipitation process.
- An increase in the number of colonies over time was observed, compared to the controls, observing the disappearance of microbial strains other than *Bacilus spp.*
- Survival of the bacteria is evident, maintaining their activity, for each period of time.
- An increase in the amount of total calcium is observed as more days pass.

Supplementary material

Bibliography