

XXVI SEMANA DE LA FACULTAD

ARQUITECTURA E INGENIERÍA

Nombre de la Actividad:

MUESTRA INVESTIGATIVA. Presentación Poster:
Avances de los proyectos de investigación del
programa de Ingeniería Ambiental

Curso:

Anteproyecto de investigación

Docente:

Andrea Tamayo Londoño. Fidel Granda

Programa:

Ingeniería Ambiental

Objetivos de la actividad:

Presentar los avances de resultados de los proyectos
de investigación de los estudiantes de Ingeniería
Ambiental

Productos a divulgar:

Poster de las propuestas de investigación de los
estudiantes de Ingeniería Ambiental

XXVI SEMANA DE LA FACULTAD

ARQUITECTURA E INGENIERÍA

Comparison of indicators for the circular economy in the context of Colombian companies

Author: Jenny Martínez Botero Thematic Advisor: Julián Esteban López Correa Methodological Advisors: Andrea Tamayo Lodoño Carlos Fidel Granda Ramírez

Research problem:

The lack of consensus and clear metrics on how organizations reported their actions related to the circular economy, which hinders sector-wide evaluation and comparison.

Theoretical Framework:

The circular economy (CE) aims to replace the traditional linear model by promoting waste reduction and material reuse to close the production-and-consumption loop[17]. On a global scale, especially in the European Union, CE is a strategic priority — but it faces significant challenges in measuring and reporting its practices due to the lack of standardized criteria[18].

In Latin America and Colombia, there are regulatory and technological barriers that hinder the adoption of CE and the implementation of indicators adapted to the local context, which limits evaluation and the design of effective public policies. Scientific output on CE and sustainability has grown steadily in recent years, reflecting a growing interest in consolidating indicators that enable comparability and transparency in business management [20].

Objectives:

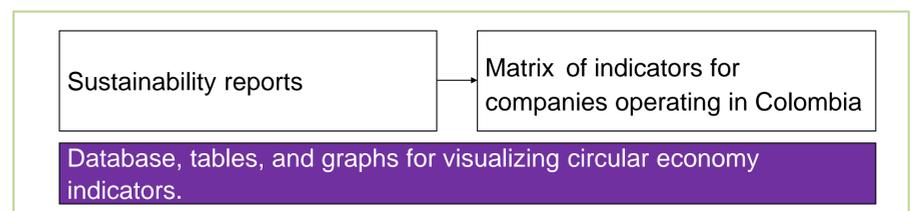
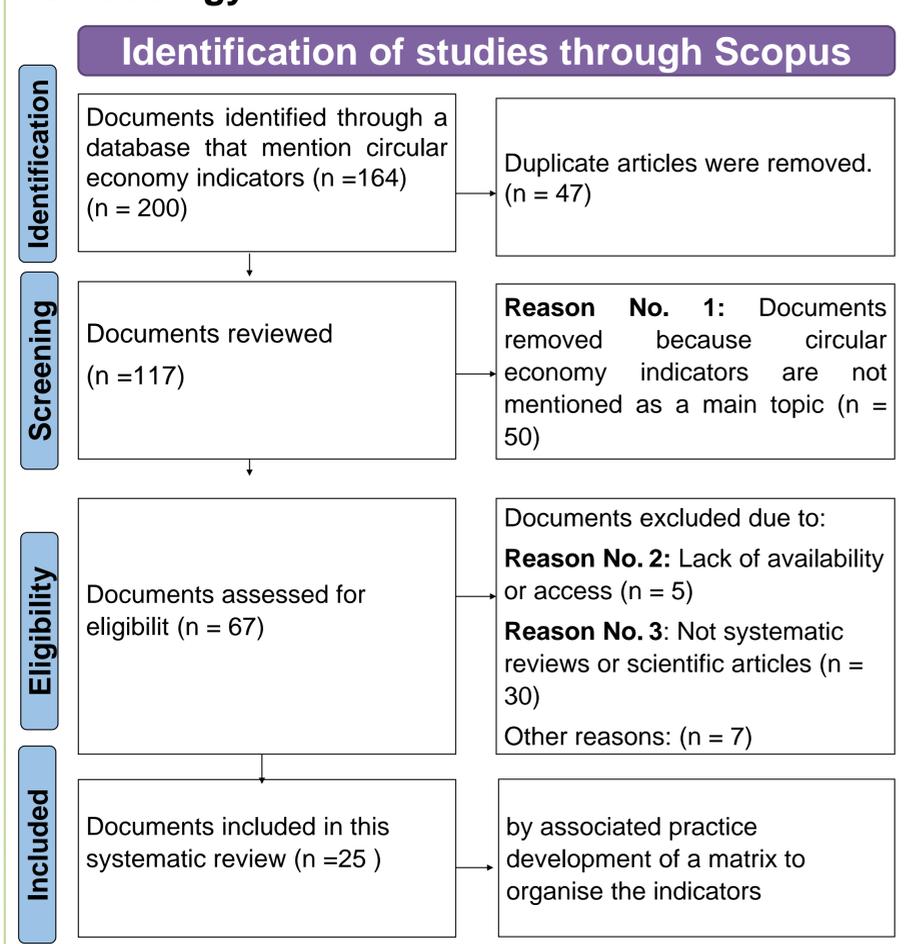
General

Comparison of indicators for the circular economy in the context of Colombian companies.

Specific

- Determine the circular economy indicators reported in the scientific literature.
- Identify the circular economy indicators in the sustainability reports of Colombian companies.
- Consolidate circular economy indicators reported by Colombian companies.

Methodology:



Partial results:

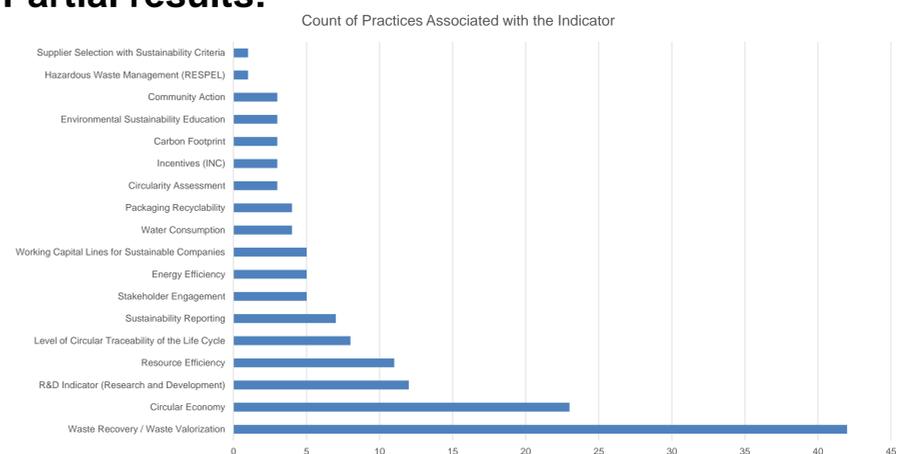


Fig 1. Integrated circular economy indicators associated with the different practices identified in the literature review.

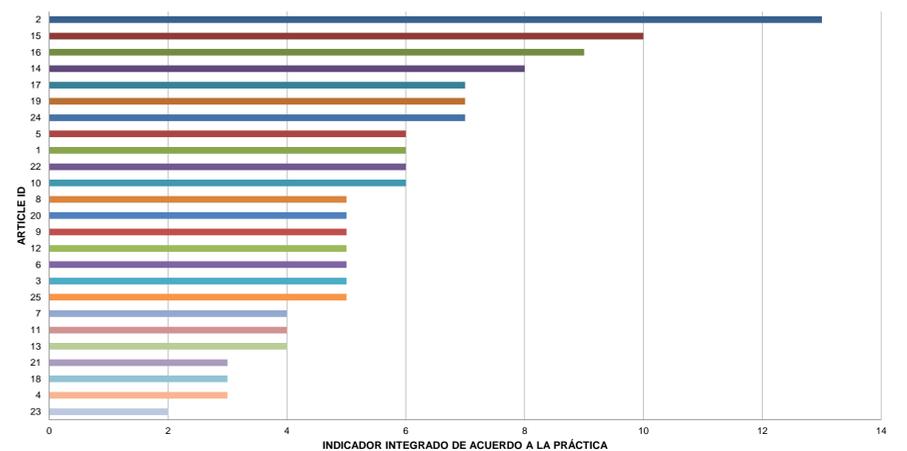


Fig 2. Distribution of the integrated indicators by practice per analyzed article.

Analysis:

A total of 143 circular economy indicators were identified, with waste recovery standing out as the most frequent practice. The systematization through a matrix allowed for grouping and clarifying these indicators, facilitating their application. A growing academic and business interest in measuring the circular economy was evident between 2021 and 2025.

Partial conclusions:

The review of 25 articles from 2021 to 2025 identified 143 original circular economy indicators, which were classified by practice and consolidated into 18 categories to facilitate their use. The methodology highlighted the importance of grouping indicators according to practice in order to eliminate redundancies. Furthermore, a growing scientific interest in the topic is observed, underscoring the need to consolidate common indicators. Most studies focus on technical and operational aspects, while governance, traceability and social actions receive less attention, indicating the opportunity to integrate these dimensions for a more comprehensive measurement.

Reference:



INSTITUCIÓN UNIVERSITARIA
COLEGIO MAYOR
DE ANTIOQUIA®



ARQUITECTURA E INGENIERÍA

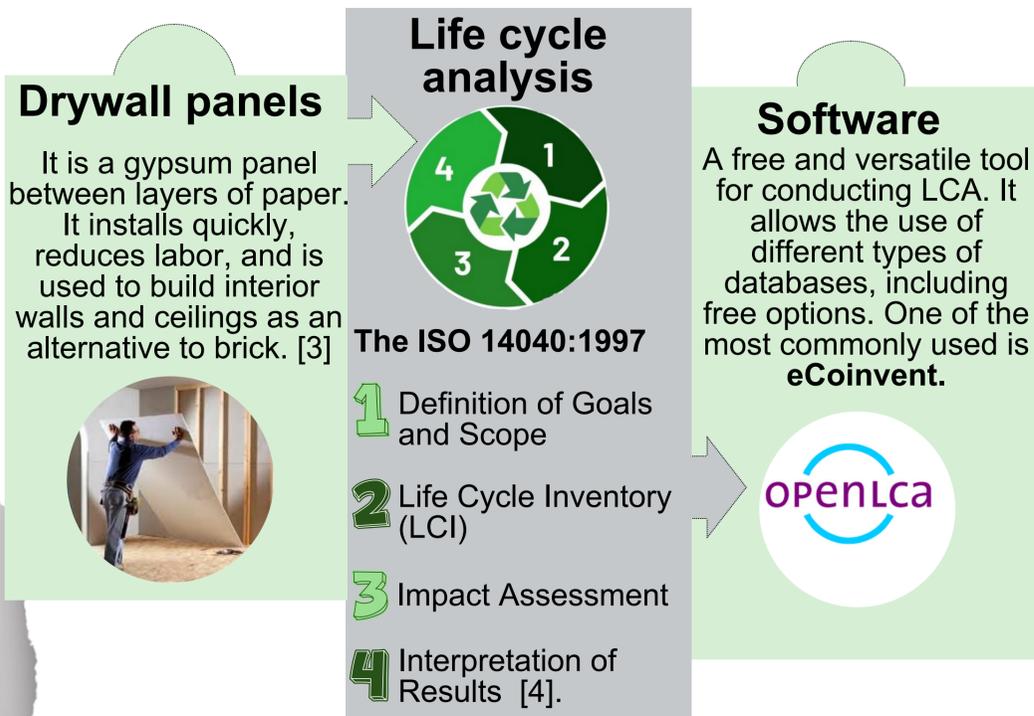
Life Cycle Analysis of the production of conventional and recycled drywall

Diana Carolina Marulanda Zabala-Estefania Palacio Arango
 Thematic advisor: Juan David Correa Estrada
 Methodological Advisor: Andrea Tamayo- Carlos Fidel Granda

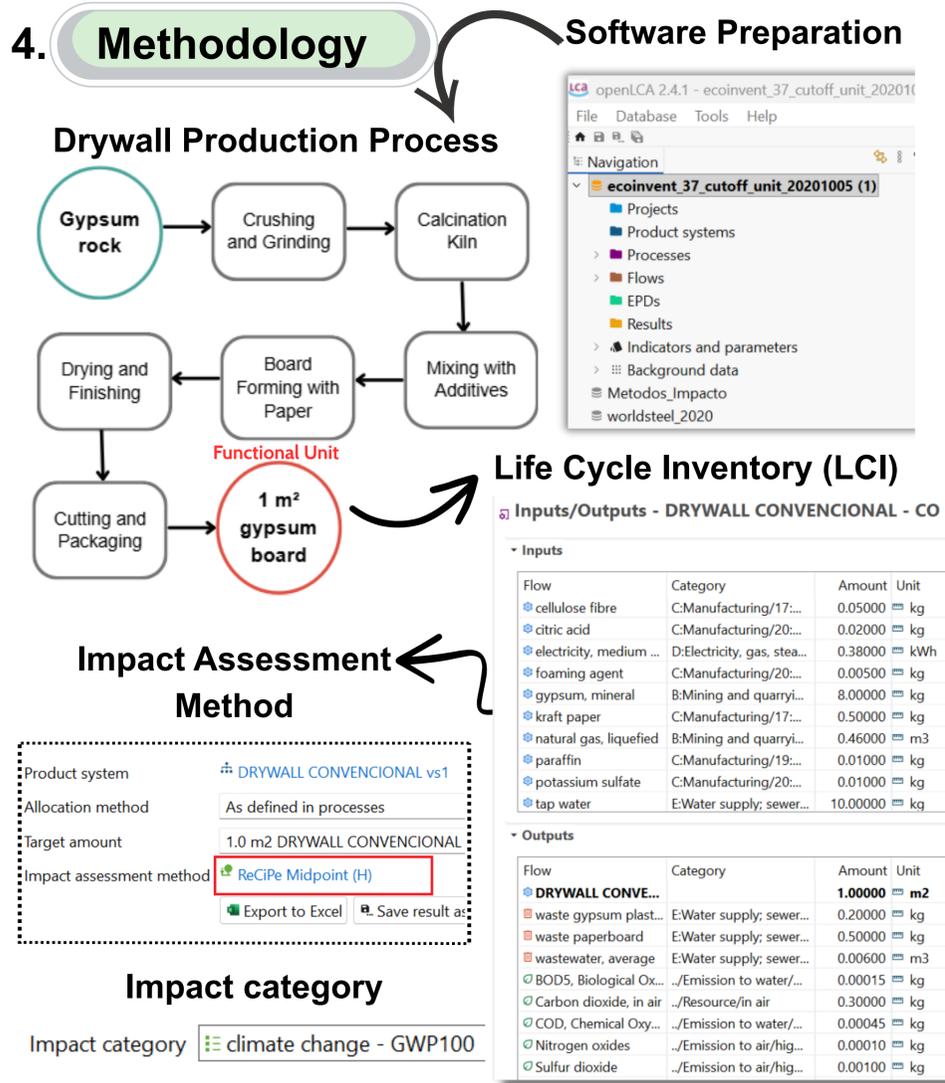
1. Problem definition

Drywall is a widely used construction material for interior walls and ceilings, manufactured with natural or recycled gypsum. Its conventional production has a significant environmental impact due to intensive resource consumption and greenhouse gas emissions. Furthermore, the waste generated poses a serious environmental problem, especially in Colombia, where only 5% of this waste is recycled.[1] The decomposition of drywall in landfills releases polluting gases that damage the environment. Therefore, it is essential to evaluate and compare the environmental impact of conventional and recycled drywall during its production stage using a Life Cycle Assessment (LCA) based on the ISO 14040 standard, in order to promote more sustainable alternatives in construction.[2]

2. Theoretical framework



4. Methodology



5. Partial Results

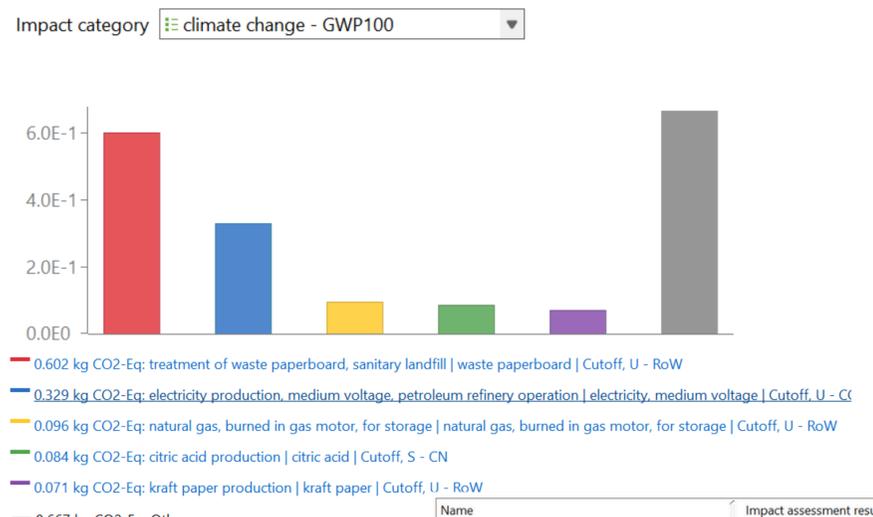


Figure No. 1 Climate change results

References

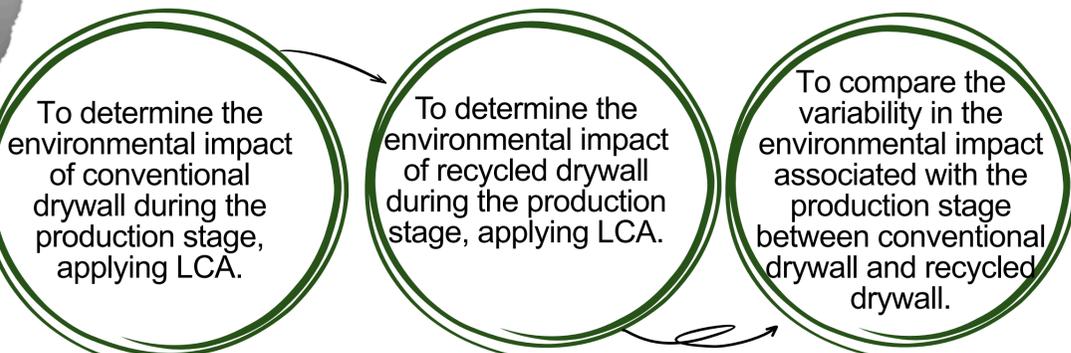


Name	Impact assessment result
agricultural land occupation - ALOP	0.00529 m2a
climate change - GWP100	1.84799 kg CO ₂ -Eq
fossil depletion - FDP	0.81420 kg oil-Eq
freshwater ecotoxicity - FETPinf	0.02788 kg 1,4-DCB-Eq
freshwater eutrophication - FEP	0.00069 kg P-Eq
human toxicity - HTPinf	0.49936 kg 1,4-DCB-Eq
ionising radiation - IRP_HE	0.06743 kg U235-Eq
marine ecotoxicity - METPinf	0.02059 kg 1,4-DCB-Eq
marine eutrophication - MEP	0.00343 kg N-Eq
metal depletion - MDP	0.00012 kg Fe-Eq
natural land transformation - NLTP	-0.00010 m2
ozone depletion - ODPinf	1.33043E-7 kg CFC-11-Eq
particulate matter formation - PMFP	0.00678 kg PM10-Eq
photochemical oxidant formation - POFP	0.00659 kg NMVOC
terrestrial acidification - TAP100	0.00848 kg SO ₂ -Eq
terrestrial ecotoxicity - TETPinf	0.00411 kg 1,4-DCB-Eq
urban land occupation - ULOP	0.01330 m2a
water depletion - WDP	0.02173 m3

Figure No. 2 Results Categories Impact Methods

3. Objectives

To comparatively evaluate the environmental impact of conventional drywall and recycled drywall in the production stage, through the application of Life Cycle Analysis (LCA)



6. Partial Conclusions

According to the ReCiPe impact assessment method, the climate change category (GWP100) shows the highest impact, with a value of 1.84799 kg CO₂-Eq. This result is mainly attributed to paper/cardboard waste management and energy consumption during production. Therefore, improving energy efficiency and optimizing waste management are the most effective strategies to reduce the environmental impact of drywall.

ARQUITECTURA E INGENIERÍA

Use of biobased materials and microalgae in the immobilization of cadmium in agricultural soils and its effect on plant mineral nutrition

Authors: Yefferson Torres, Susana Cañola, Ana María Guzmán

Thematic advisor: Andrea Tamayo, Julián López

Methodological advisors: Andrea Tamayo, Fidel Granda

Research problem

In Colombia, soils tend to accumulate cadmium (Cd) due to their parental origin and anthropogenic activities, posing risks to agriculture, human health, and food security. Although strategies such as phytoremediation and biochar application have been used to reduce Cd bioavailability [6], the combined use of biobased amendments such as digestate, biochar-digestate, and microalgae for Cd immobilization in agricultural soils has not yet been assessed. What is the effect of applying biobased materials such as digestate, biochar - digestate, and microalgae on cadmium immobilization in agronomic soils?

Objectives

General: Evaluate the effect of different biomaterials used as amendments in cadmium (Cd) - contaminated soils, as well as their simultaneous influence on plant mineral nutrition.

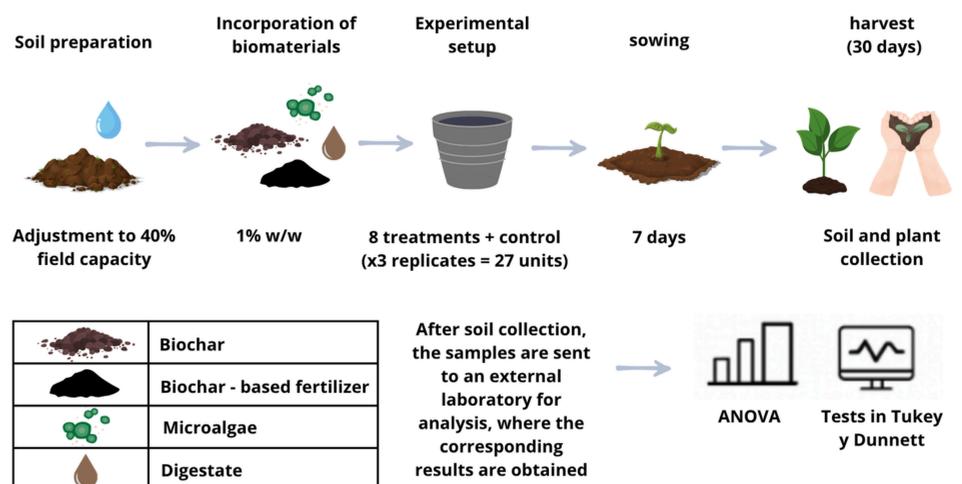
Specific:

- Characterize the biomaterials selected for use as amendments in cadmium (Cd)-contaminated soils, considering their physicochemical properties and potential to provide nutrients.
- Evaluate the effect of biomaterials on the immobilization of cadmium present in agricultural soils, determining their remediation capacity.
- Analyze the impact of biomaterials on the nutrition of plants grown in treated soils, observing possible improvements in the absorption of essential nutrients.

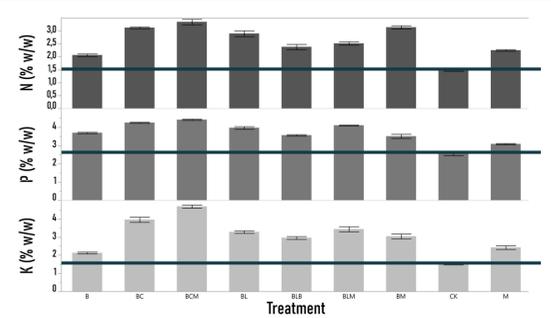
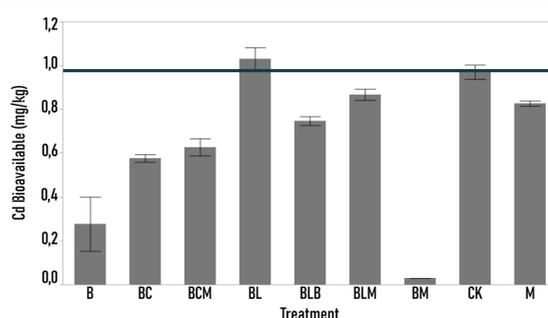
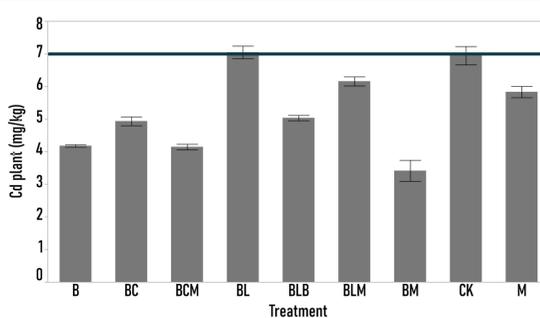
Theoretical framework



Methodology



Partial results and analysis



Biochar characteristics	CS	Loaded Biochar characteristics	CS - BF	Digestate characteristics	BL
EC ($\mu\text{S cm}^{-1}$)	519 \pm 9.0	EC ($\mu\text{S cm}^{-1}$)	1750 \pm 11.4	EC ($\mu\text{S cm}^{-1}$)	1575 \pm 8.0
pH	10.3 \pm 1.0	pH	8.9 \pm 0.9	pH	8.25 \pm 0.12
Ash content (%)	26.9 \pm 0.7	Ash content (%)	28.5 \pm 2.8	NPK (mg/L)	23,000 \pm 5 / 18,000 \pm 13,0 / 18,000 \pm 10,1

Partial conclusions

- The use of bio-based amendments proved to be an effective alternative for reducing cadmium (Cd) mobility in agricultural soils, with the combination of biochar and microalgae (BM) standing out as the most efficient treatment, achieving a significant reduction in the metal's bioavailability in both soil and plants.
- The application of biochar, digestate, and microalgae promotes sustainability by transforming waste into amendments that restore soils and strengthen agriculture.
- Bio-based amendments represent a sustainable solution for the remediation of contaminated soils, contributing to food security and the achievement of the Sustainable Development Goals (SDGs).

References



INSTITUCIÓN UNIVERSITARIA
COLEGIO MAYOR DE ANTIOQUIA®



ARQUITECTURA E INGENIERÍA

Valorization of end-of-life tires as a source of carbonaceous materials for carbocatalytic degradation of emerging concern pollutants in wastewater

Authors

^{1,2}Juan David Valencia; ²John Edison Mesa; ²Laura Vanessa Castañeda

Thematic advisor

¹Alba Nelly Ardila

Methodological advisor

²Andrea Tamayo; ²Carlos Fidel Granda



¹ Politécnico Colombiano Jaime Isaza Cadavid | ² Institución Universitaria Colegio Mayor de Antioquia



Problem

1.5 billion tires are produced every year
 ↓
 4 million tons of end-of-life tires (ELTs)
 ↓
 In Colombia, approximately 950000 tons of ELTs are generated

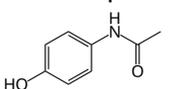
These wastes are highly recalcitrant



Emerging Concern Pollutants



Acetaminophen



- Increase in COD
- Increase in BOD
- Increase in TOC
- Decrease in dissolved oxygen

Released into ecosystems

Conventional water treatment systems are not capable of removing



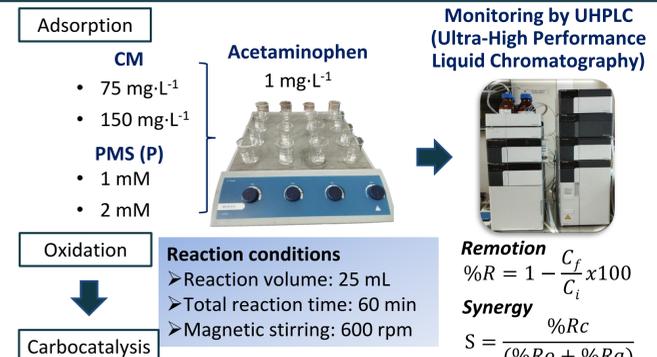
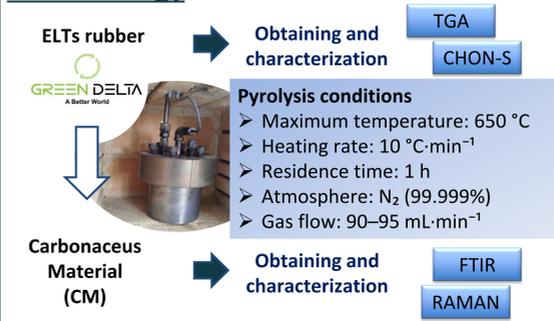
Theoretical Framework



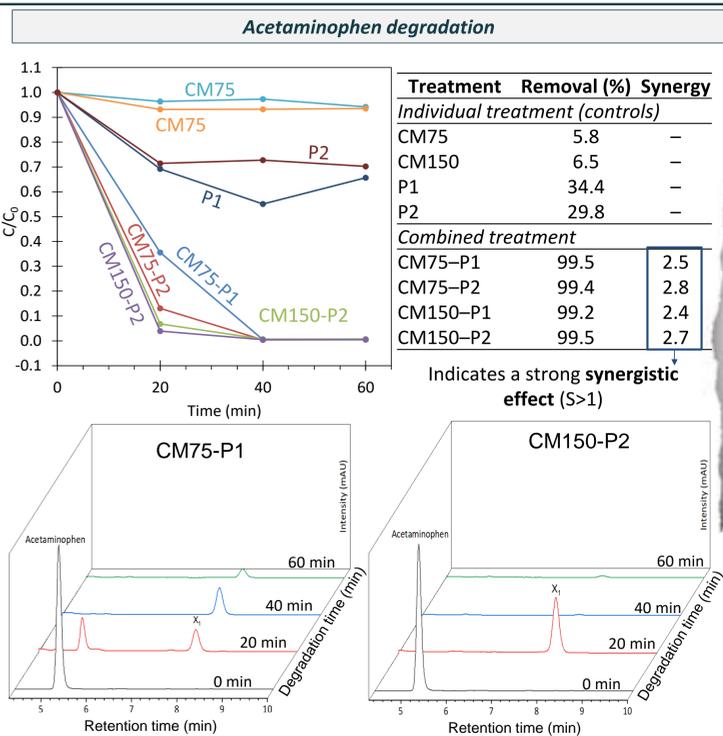
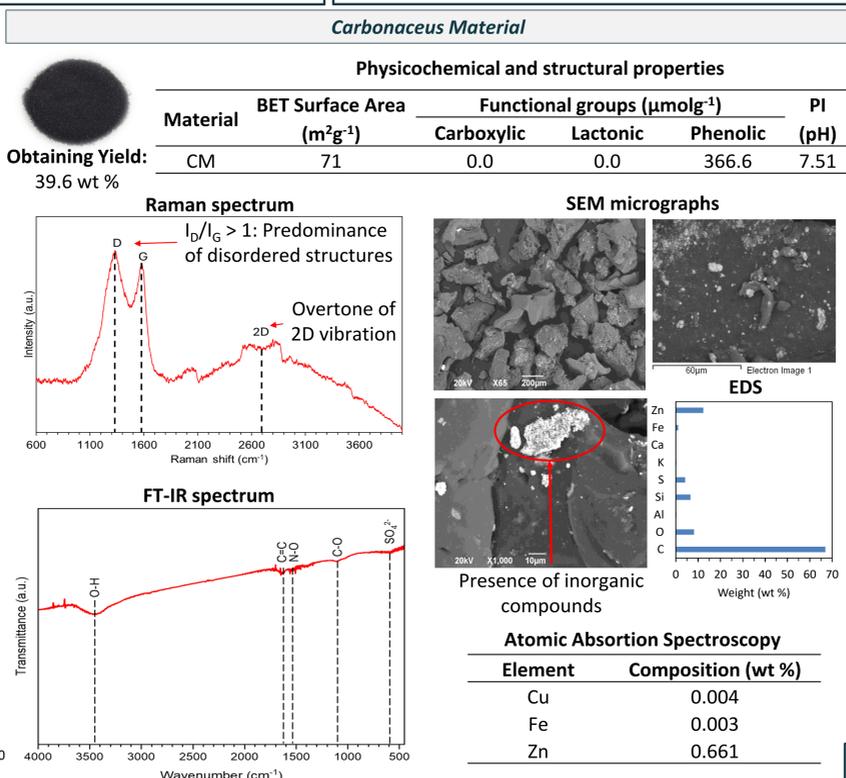
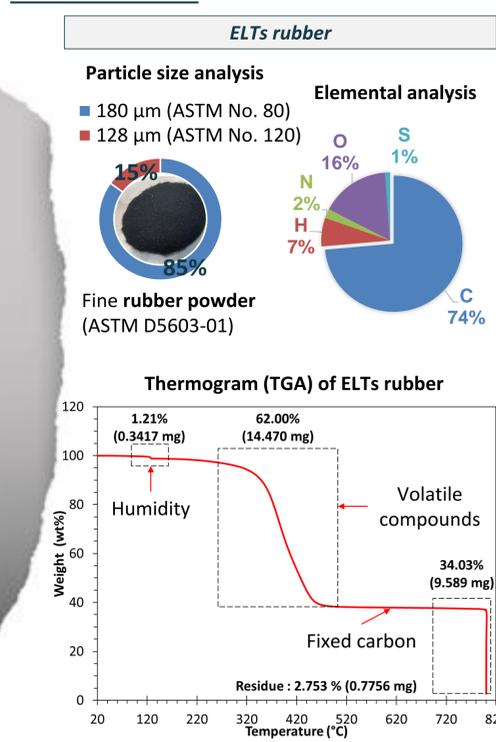
Objectives

- General**
- Study the application of carbon-based materials derived from end-of-life tires in carbocatalytic processes for the degradation of emerging concern pollutants in wastewater.
- Specifics**
- Analyze the physicochemical properties of the carbon-based materials obtained from pyrolysis of end-of-life tires.
 - Determine the best conditions for degradation of acetaminophen — used as a model pharmaceutical compound — in synthetic waters via carbocatalytic processes.
 - Evaluate the removal of acetaminophen — used as a model pharmaceutical compound — in real wastewater using carbocatalytic processes.

Methodology



Partial Results



Partial Conclusions

End-of-life tire rubber proved to be an efficient and sustainable precursor for the synthesis of carbon-based materials through controlled thermal pyrolysis. The carbonaceous material obtained exhibited favorable physicochemical and structural properties, including an appropriate surface area, the presence of oxygenated functional groups, inorganic compounds and a disordered graphitic structure, which collectively enhanced its catalytic activity toward peroxymonosulfate activation. Under optimized operational conditions, the carbocatalytic system achieved over 90% degradation of acetaminophen, evidencing a synergistic effect between adsorption and oxidation mechanisms.

These findings confirm that carbon materials derived from waste tires are not only viable but also high-performance alternatives for the degradation of emerging pharmaceutical contaminants in water.

Where waste meets purpose: rubber that restores the purity of water

Acknowledgments

The authors would like to thank the "Ministerio de Ciencia Tecnología e Innovación" for funding the project entitled "Comprehensive valorization of post-consumer and industrial waste for the development of materials with catalytic potential under a circular economy approach, code 82312," approved within the framework of Call No. 890 of 2020, "Call for the strengthening of Science, Technology and Innovation (ST&I) in Public Higher Education Institutions (HEIs) 20."



INSTITUCIÓN UNIVERSITARIA COLEGIO MAYOR DE ANTIOQUIA



XXVI SEMANA DE LA FACULTAD

ARQUITECTURA E INGENIERÍA

Challenges and opportunities for the circular economy in the leather industry: a case study company

Authors: Alba María Contreras Medina, Laura Yarihany Carvajal Muñoz, Paula Prada Culma
Thematic advisor. Andrea Tamayo Londoño. **Methodological advisor.** Andrea Tamayo, Carlos Fidel Granda.

Problem

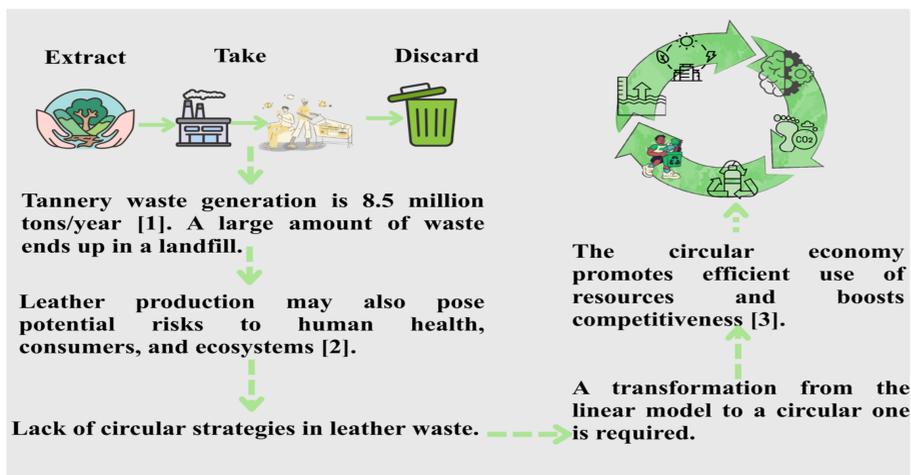


Figure 1. Research problem.

Objectives and Methodology

General objective: Identify the challenges and opportunities of the circular economy in the leather industry.

Specific objectives and development of the methodology:

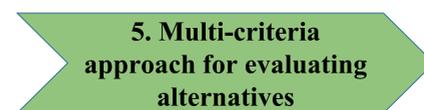
1. Determine systems and subsystems within the framework of the circular economy in the case study company.



2. Analyze the flow of materials in systems and subsystems, particularly in the ordinary waste stream, for incorporation into a circular economy scheme.



3. Establish a roadmap for a circular economy for ordinary waste in the leather industry that allows for visualizing the relationship between uses and potential applications.



- Definition of criteria and subcriteria.
- Choosing the weighting of criteria with relevant company stakeholders.
- Building the roadmap for the circular economy.

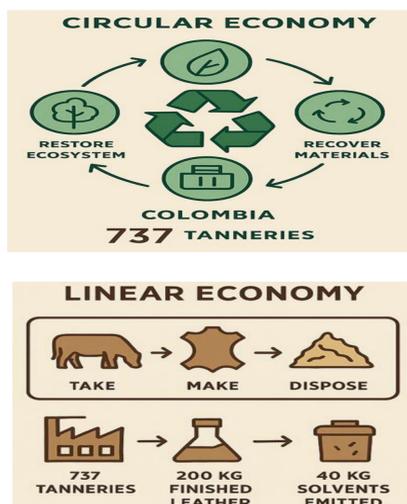


Theoretical framework

The leather industry plays a key role in the global economy through its contribution to local economies and job creation [1].

In Colombia, an additional 640 kg of solid waste is produced [4].

Innovative methods like MCDM improve decisions to reduce pollution produced by this industry [5].

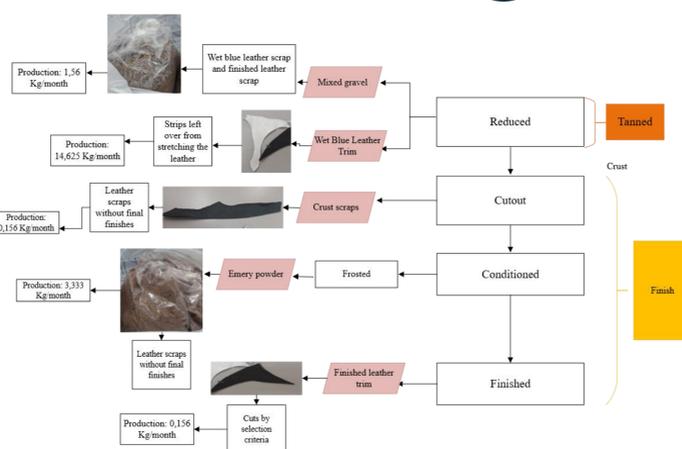


Partial results and analysis

1

- According to PMIRS, approximately 439,25 tons of ordinary waste are generated per month.
- **Commitments to Sustainability EC**
 - Reuse of industrial waste (consumption of wet blue gravel in the manufacture of labels and protectors).
 - Replacing inputs with sustainable alternatives.

2



3

Table 1. Characteristics of prioritized waste in the company

Waste type	Waste type	Characteristics	Valorization alternatives
Wet blue cutout	14,625	Contains chromium in the wet finishing stage.	Vegetable tanning, landfills. Incineration.
Mixed gravel	1,56	Generated in the lowering process.	
Cropping in crust	0,156	Generated in the dry finishing stage and in the trimming process.	Raw material for manufacturing thermoacoustic insulation panels
Grinding powder	3,333	leather finish	Valorization of collagen proteins

Figure 4. Systems and subsystems defined for waste identification

Conclusions

- The conducted assessment made it possible to identify and define systems and subsystems related to the generation and management of the waste produced by the company.
- Critical points were identified in the company's production processes, which facilitated the recognition of the five ordinary wastes that were prioritized. Each was assigned its generated quantity, frequency, classification, and current recovery method. This allowed a real understanding of the company's situation.

References

XXVI SEMANA DE LA FACULTAD

ARQUITECTURA E INGENIERÍA

Evaluation of the effect of ozone on the bacterial content of an agricultural soil

Authors: Camilo Andrés Díaz Ramírez - Juan Camilo Posada Blandón - Santiago Vasquez Correa - Valentina Marcela Torres Rico

Thematic advisor: Fidel Granda-Ramirez - Laura Osorno Bedoya

Methodological advisor: Fidel Granda-Ramirez - Andrea Tamayo Londoño

PROBLEM

Agricultural soils present a high bacterial load due to the use of contaminated waters and decomposing organic matter. [1]. Traditional chemical methods leave residues and deteriorate soil quality [2]. Therefore, a sustainable alternative is required, such as the use of ozone, which reduces microbial contamination without altering soil properties [3].



<https://www.bestosco.com/tratamiento-de-la-contaminacion-del-suelo-causada-por-la-explotacion-de-yacimientos-petrolieros/ama/> www.cibicera.mg/doc-estudios-usar-aguas-residuales-composicion-del-estrato-de-mexico/ <https://www.portafuturo.com/noticias/2024/05/28/uso-de-contaminantes-del-suelo/>

THEORETICAL FRAMEWORK

Ozone (O₃) is a highly reactive oxidant capable of eliminating microorganisms by destroying membranes and cellular components [4]. Its strong oxidative potential allows it to react with lipids, proteins, and nucleic acids, leading to the disruption of essential biological functions in bacteria, fungi, and viruses. In agricultural soils, the application of ozone acts as a disinfectant without generating toxic residues or significantly modifying the physicochemical properties of the soil [5]. Moreover, ozone decomposes rapidly into oxygen (O₂), which prevents long-term environmental contamination and promotes a more sustainable soil microbiome balance. This technology is therefore considered a clean and environmentally friendly alternative to conventional chemical disinfectants [6]. Its use has shown promising results in reducing pathogenic loads, improving soil hygiene, and minimizing the need for synthetic agrochemicals.

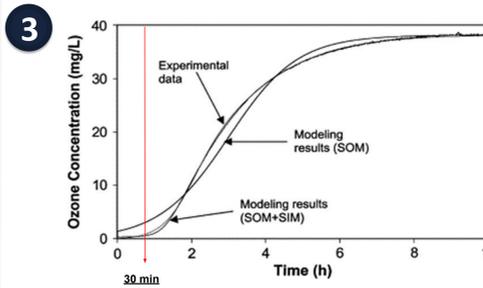
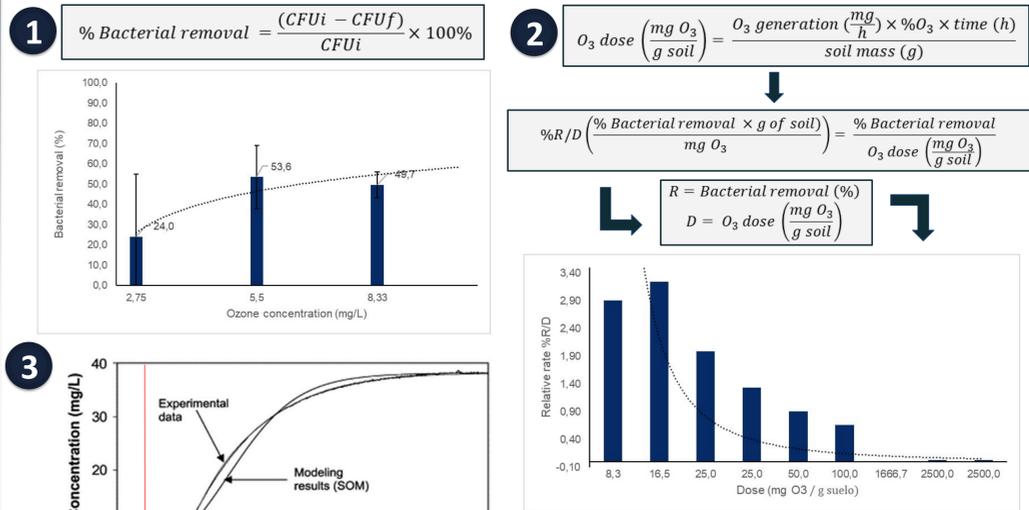
OBJECTIVES

General: Evaluate the effect of ozone on the bacterial content of an agricultural soil.

Specific:

1. Implement a system that incorporates ozone to reduce the total number of bacteria in the soil.
2. Identify the effect of ozone on the presence of total bacteria in the soil.
3. Define the effects of ozone on the agricultural capacity of the soil.

PARTIAL RESULTS

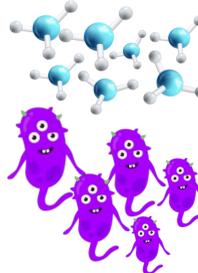


The system has not yet reached the point where ozone input exceeds or balances consumption by organic and inorganic matter in the soil. Therefore, very little ozone is available to remove microorganisms.

%R/D INTERPRETATION

High %R/D values → Ozone is more efficient, achieving greater removal with low doses.

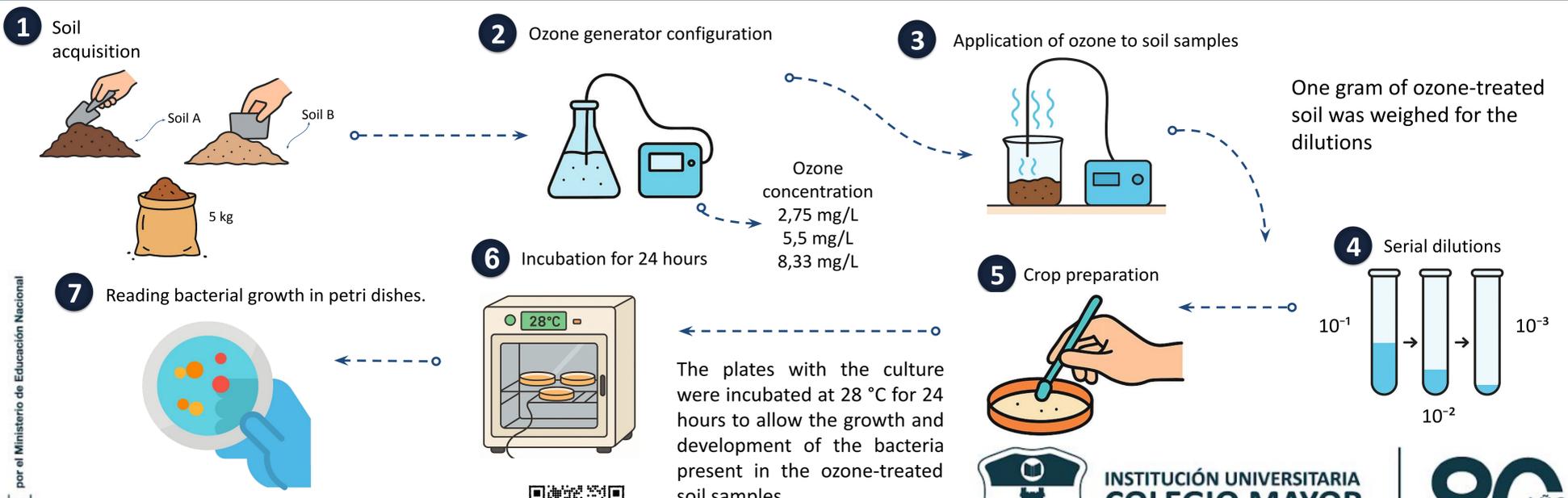
Low %R/D values → Ozone is less efficient, requiring more ozone consumption to achieve a low increase in removal.



PARTIAL CONCLUSIONS

1. At low ozone doses, the microbial removal rate is considerably lower than at intermediate doses, indicating that increasing ozone concentration increases removal efficiency up to a point, after which the efficiency tends to stabilize or slightly increase.
2. Ozone demand is influenced by both organic and inorganic matter in the soil, implying that different types of soil may require higher amounts of ozone to reach similar disinfection levels.
3. Increasing the dose does not always lead to a proportional improvement in microbial removal, suggesting the process can be optimized by adjusting the dose and avoiding excessive ozone use to achieve efficient results.

METHODOLOGY



The plates with the culture were incubated at 28 °C for 24 hours to allow the growth and development of the bacteria present in the ozone-treated soil samples.

REFERENCIAS



ARQUITECTURA E INGENIERÍA

PRODUCTION OF BIOCHAR FROM BIOSOLIDS: A CIRCULAR ECONOMY APPROACH FOR ENHANCING METHANE GENERATION AND WASTE VALORIZATION

AUTHORS: Jose Luis Guloso Vivares, Sofía Villegas Ramírez, Loraines Paola Ovalle Mola, Lesli Melisa Salas Giraldo.

THEMATIC ADVISOR(S): Juan David Correa Estrada, Andrea Tamayo Londoño.

METHODOLOGICAL ADVISOR(S): Andrea Tamayo Londoño, Carlos Fidel Granda Ramirez

PROBLEMATIC

Biosolids from wastewater treatment plants (WWTPs) pose environmental and economic challenges due to the linear nature of conventional management practices such as incineration, landfilling, or direct land application [1],[2]. Pyrolysis offers a circular and sustainable alternative, converting biosolids into biochar, syngas, and bio-oil. Among these, biochar stands out for its potential to enhance anaerobic digestion, improving process stability and increasing biogas production. This approach can transform WWTPs into centers of renewable energy generation, contributing to a circular economy and more sustainable resource recovery [3], [4].



OBJECTIVES

GENERAL

Evaluate the effect of biochar produced from biosolids on methane yield during the anaerobic digestion of primary effluent, as a circular economy strategy in wastewater treatment plants.

SPECIFIC

- Obtain biochar from the pyrolysis of WWTP biosolids for its potential use as an additive in anaerobic digestion.
- Determine the physicochemical and structural characteristics of the biochar obtained from WWTP biosolids.
- Evaluate the effects of biochar on the efficiency of anaerobic digestion of primary effluent, particularly on methane production.

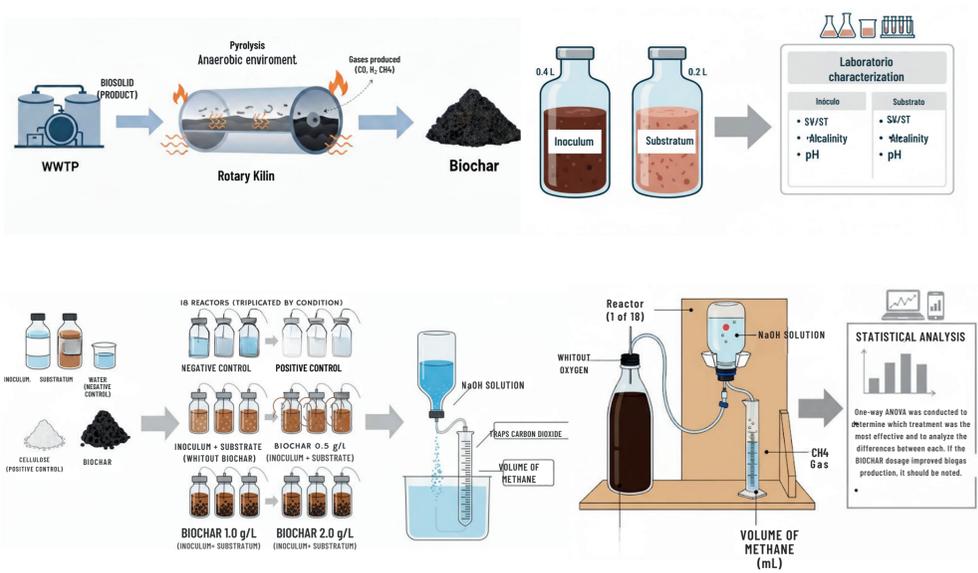
THEORETICAL FRAMEWORK

The valorization of biosolids through pyrolysis to produce biochar drives the circular economy and enhances anaerobic digestion by increasing biogas production, stabilizing pH, and adsorbing inhibitors [5]. Recent studies support its effectiveness, and its application aligns with national regulations that promote sustainable management and renewable energy in wastewater treatment plants (WWTPs) [6].

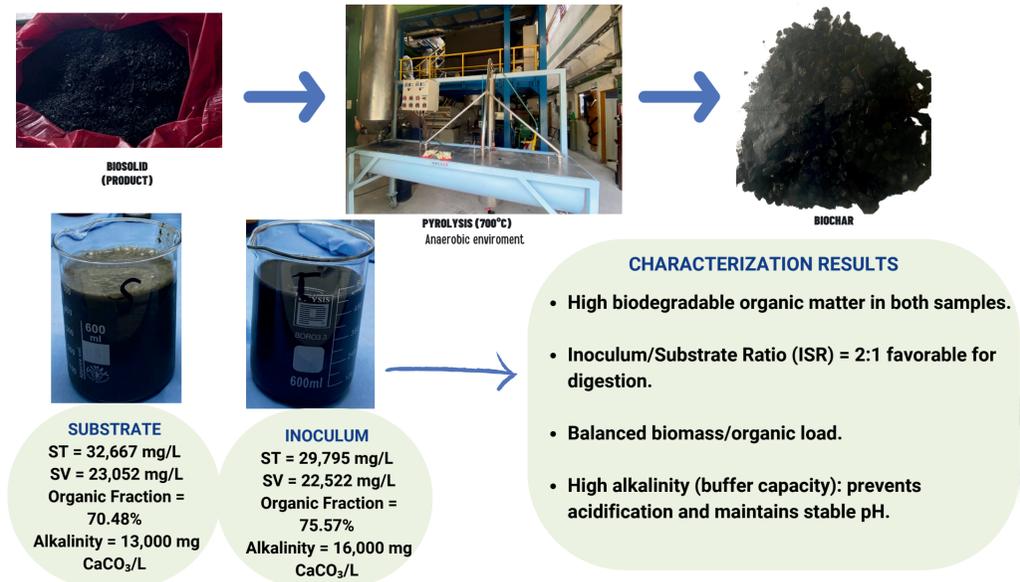


Aspect	Anaerobic Digestion	Biochar
Process	Converts organic matter into biogas	Produced by pyrolysis of biosolids
Function	Stabilizes sludge and generates energy	Enhances AD, adsorbs inhibitors, and stabilizes pH
Advantages	Renewable energy source.	Increases methane yield and supports circular economy

METHODOLOGY



RESULTS AND ANALYSIS



CONCLUSIONS

- It is possible to obtain biochar from biosolids, an innovative and eco-friendly strategy for managing waste at wastewater treatment plants. This process reduces the environmental impact of biosolids and supports renewable energy generation by increasing methane production during anaerobic digestion. This solution aligns with national regulations that promote sustainable management and resource recovery.
- Volatile solids in the substrate (23,652 mg/L) and the inoculum (22,522 mg/L) are similar, indicating a suitable organic load and supporting stability. The higher level in the substrate suggests greater biodegradable potential.

