SITUATED BIODESIGN: CO–CREATION OF ECOSYSTEM SUPPORT IN THE MEANDRO DEL SAY WETLAND

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FONTIBÓN, A DISTRICT OF BOGOTÁ, ACCOUNTS FOR 15% OF THE CITY'S FIXED SOURCES OF POLLUTION, CAUSING RESPIRATORY, CARDIAC, AND MENTAL HEALTH PROBLEMS AMONG ITS POPULATION. THIS PROBLEM IS RELATED TO RAPID URBANIZATION AND HEAVY TRUCK TRAFFIC ON CALLE 13 (13TH STREET), WHICH HAS DRASTICALLY REDUCED GREEN AREAS AND DAMAGED THE MEANDRO DEL SAY WETLAND. GIVEN THIS CONTEXT, THE PROJECT PROPOSES AN INTERDISCIPLINARY METHODOLOGY THAT COMBINES DESIGN, BIOLOGY, AND COMMUNITY PARTICIPATION THROUGH TERRITORY–SENSITIVE RESEARCH, STRATIGRAPHIC ANALYSIS, AND CO–CREATION. AS A RESULT, BIO–VASC WAS DEVELOPED, A SUPPORT SYSTEM INSPIRED BY BIODESIGN AND BIOMIMICRY THAT SEEKS TO ACTIVATE A SYMBIOTIC RELATIONSHIP BETWEEN THE COMMUNITY AND THE WETLAND, PROMOTING COLLECTIVE OWNERSHIP AND STRENGTHENING TERRITORIAL RESILIENCE. THIS RESEARCH DEMONSTRATES THAT FOR BIODESIGN TO BE SUSTAINABLE, IT MUST BE ROOTED IN ITS LOCAL CONTEXT, WHICH REQUIRES AN ONGOING DIALOGUE WITH ITS OWN SPATIAL PRACTICES.

KEYWORDS: LIVING SYSTEMS, WETLANDS, BIOREACTOR, BIODESIGN, BIOMIMICRY, CO–CREATION, RESILIENCE

INTRODUCTION

Luis Llanos-Hernández (2010) conceives of territory as the spatial unfolding of social relations interconnected with cultural, political, and economic factors. From a design perspective that integrates research and creation into its territory, it is necessary to raise awareness in three areas: recognizing how ways of life inhabit space from their social construction; analyzing the aesthetic landscape and resources; and understanding how available materials are transformed using techniques specific to the context (De los Reyes & Agudelo, 2023).

Based on this understanding, the research focuses on Fontibón, a neighborhood in Bogotá that was deprioritized in the capital's initial planning. Consequently, since the 16th century, it has served as a strategic hub for the transport of goods across the nation. Today, known as Calle 13 (13th Street), it serves as a primary access route to the capital, having been assimilated as an outsourced center undergoing rapid urbanization (Cortés Solano, 2007). DANE (the National Administrative Department of Statistics) recorded a 2024 population of 408,155 for Fontibón. The area's activities are concentrated in the industrial and service sectors (factories, auto repair shops, parking lots), which impair air quality and thus the quality of life of the local population. In 2012, the Bogotá City Council reported that Fontibón accounted for 15% of the capital's fixed sources of pollution. According to Farrow et al. (2022), areas with localized pollution are more likely to cause collateral health effects such as heart disease, respiratory problems, low birth weight, and even mental health complications. The above is directly related to particulate matter (PM) 1, which comes from fuel combustion, dust suspended in the air, and fixed sources of pollution. An additional consequence of rapid urbanization and industrialization was ecosystem disruption, progressively and significantly reducing the area of the Meandro del Say wetland by 82.38% (García-Ubaque et al., 2020, p. 5). Figure 1 shows the deterioration of the wetland between 1970 (Figure 1a) and the present day (Figure 1b).

In this context, Bogotá's wetlands serve as crucial carbon sinks, retain sediments, and reduce pollution levels. Critically, they also help lower airborne PM concentration through dry deposition (Zhao et al., 2021). Preserving the ecological health of these wetlands is therefore essential to maintaining these vital functions.

Resilience refers to a system's ability to survive and persist within a dynamic environment. This means that the wetland demonstrates resilience against increased urban land use and fuel burning in its surrounding area. This project adopts Meadows' (2009) vision of using learning to encourage the human community to become aware of this capacity for resilience. In this way, residents will appreciate coexisting with the wetland, aligning actions and goals to preserve and enhance the restorative powers of this system.

Therefore, any intervention must work in concert with this living system. As Meadows (2009, p. 79) states, living systems "self-organize through learning, diversification, complexification, and evolution". This evolution is driven not by mere survival, but by symbiotic interactions. Consequently, the Fontibón community must align its territorial dynamics with the health of the wetland, allowing it to be guided by the system's capacity for self-organization. Thus, this project integrates biodesign and biomimicry to bridge human and non-human perspectives. Biodesign, as defined by Danies et al. (2020), interprets observations of nature to rethink humanity's relationship with the environment. Complementing this, biomimicry adapts natural mechanisms, forms, and processes for design applications (Sánchez Ruano, 2010). Together, this combined approach enables a systematic analysis of the wetland's own mechanisms, informing the development of solutions to mitigate human impacts on the ecosystem.

From this perspective, design must engage in a constant dialogue with biology to extract applicable lessons. Recognizing that wetland plants act as carbon sinks and retain airborne sediments (Schuster et al., 2024), this project analyzes the structures and mechanisms behind these functions to translate them into a design framework.

Therefore, it is necessary to devise a support system that promotes symbiotic interaction between the community and the wetland, integrating the concept of Ecosystem Services developed by the Colombian Ministry of Environment and Sustainable Development (2017), which considers urban ecosystems as

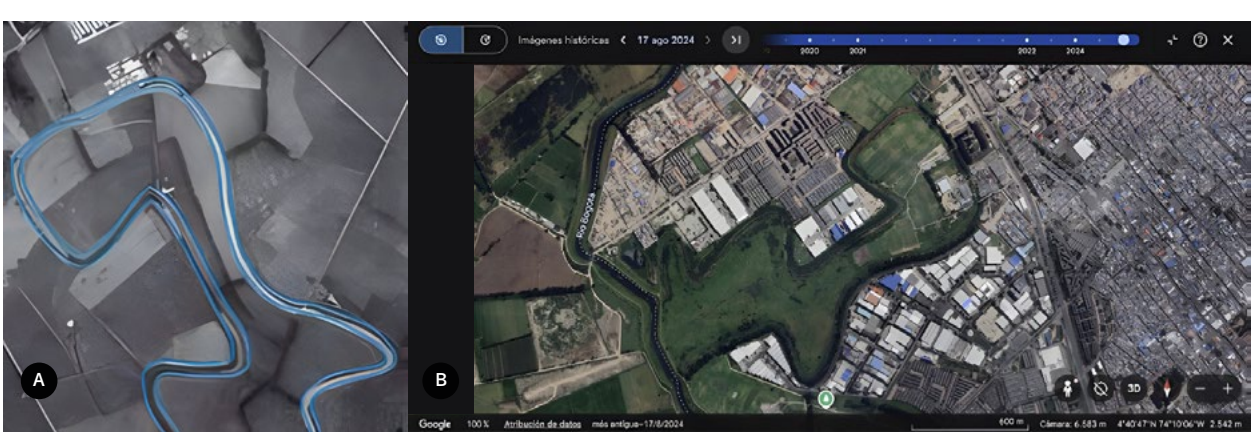


FIGURE 1. (A) Meandro del Say Wetland: 1978 record taken from Meandro del Say (Ramsar Convention on Wetlands, n.d.); and (B) Google Earth reference in August 2024.

generators of quality of life. To achieve this, the Ministry stipulates that the service must fulfill three objectives: (1) promote the generation of knowledge about the structure and functioning of ecosystems; (2) facilitate the recovery of the natural functioning of an ecosystem; and (3) offer sustainable uses that benefit present and future generations.

This project employs speculative design as a core methodology to raise awareness and transform community agency regarding air quality in Fontibón. This approach, aligned with a sensitive territorial understanding, encourages critical reflection by the community on the impact of pollution on their health and the resilience of the wetland, and promotes the ideation of innovative future scenarios that apply contextual practices alongside biodesign knowledge to translate them into alternatives focused on that possible symbiotic relationship between humans and non-humans.

This raises the question: How, through a sensitive understanding of the territory and biomimicry-inspired biodesign, can we speculatively design a support system based on ecosystem services that contributes to the recovery of the Meandro del Say wetland and promotes sustainable symbiotic interaction for the human and non-human inhabitants of Fontibón?

OBJECTIVES

Guided by this question, the project's overall objective is to propose a support system that provides an ecosystem service that contributes to the recovery of the Meandro del Say wetland.
In this regard, the following specific objectives are established:

- Analyze territorial dynamics from the perspectives of ways of life, landscape, and technology to understand how the community inhabits, transforms, and perceives its environment.
- Abstract biomimetic lessons derived from the structures of living wetland systems to guide the design of the support system.
- Design a community-centered support system for ongoing reflection and adaptation.

STATE OF THE ART

The restoration of urban wetlands is crucial, as vegetated areas with water bodies effectively reduce particulate matter (PM) concentration by intercepting, absorbing, and depositing airborne particles (Zhao et al., 2021). However, in highly polluted environments such as Fontibón, wetland plants can reach a saturation point where their leaves no longer retain PM (Zhou et al., 2020). Therefore, this project adopts an ecosystem services approach. The goal is to devise a support system that restores the wetland's natural functions through community engagement and biodesign principles, thereby enhancing its resilience and capacity to provide this critical service.

In response to environments that limit respiratory health, projects are emerging to mitigate impacts on communities. The following references are pivotal for analyzing how collaborative spatial practices enable symbolic place-making. They provide a foundation for conceptualizing design as a mediator in community-environment relations.

A notable example is the Liquid 3 bioreactor by Spasojević (2021), developed in Serbia, a country ranked 28th worst for air quality. This system uses microalgae to capture CO2 and produce oxygen. With high efficiency in reducing airborne pollutants, the 600-liter bioreactor performs a photosynthetic function equivalent to 200 square meters of green space.

Likewise, BIO.tech Hut by ecoLogicStudio explores human participation through manual pumping to oxygenate the reactor, demonstrating that a reactor can simultaneously improve air quality and promote caring interaction with a living system (PhotoSynthetica, n.d.).

Boat Biologs by Kuvavala (2021), although different in its materiality, is a project conceived for the canals of the United Kingdom, where communities live on houseboats. Kuvavala created gardens with native plants that fill the dead spaces between the boats and the edges of the canal.

Similarly, El Bicho de Arquitectura Expandida (Architizer, n.d.) analyzes the spatial practices of the rap community in Bosa and proposes a co-creation process for the construction of a multifunctional structure for concerts, workshops, and discussions.

It is also important to consider projects inspired by biomimetic concepts. Chinchilla's Organic Growth Pavilion (n.d.) studies the light branching of hydrangeas, as their floral structure provides diffuse shade and cross ventilation, which is adapted, grown, and reinterpreted within the pavilion using recycled materials. This project applies a co-construction process, encouraging participation and reflecting that "Learning from nature helps take care of human wellbeing naturally, beautifully, and intuitively" (Chinchilla, n.d., para. 1).

Together, these projects explore how design can become a mediator between living systems, urban environments, and community. While Liquid 3 and Biotech Hut reveal the potential of microalgae, Boat Biologs and El Bicho demonstrate that appropriation arises when design is constructed collectively and responds to local conditions. Although the use of microalgae is effective as the basis for the project, it is necessary to analyze in parallel how native wetland plants can offer solutions for improving air quality. Similarly, it is important to understand the technical and social capabilities of the territory in order to promote a sense of direct ownership of its application in this ecosystem service.

METHODOLOGY

This project involves co-creation with the human and non-human community of Fontibón around a Wizard of Oz prototype3 to contribute to the recovery of the wetland and promote symbiotic interaction between the population and the ecosystem. To this end, 16 people were interviewed, including two industrial workers, a business administrator, four truck drivers, a recycler, and eight automotive operators. Participants were selected based on criteria of territorial relevance: priority was given to individuals who travel through or frequent the wetland area and others who are unfamiliar with the Meandro del Say, but whose daily routine involves high exposure to PM2.5, associated with Calle 13 and the dynamics of automotive workshops. The methodology is organized into five phases, summarized in Figure 2.

1. FIELDWORK

Following the framework proposed by De los Reyes and Agudelo (2023), surveying a territory involves not only reviewing it from the literature but also traveling through it and observing how its spatial and ecological dynamics manifest themselves. Therefore, two field visits were planned. The first, on September 1, 2024, aimed to spatially identify Calle 13 and the wetland through

photographic records and semi-structured interviews, in order to recognize the profiles of users who transit these spaces and understand their perceptions of air quality, pollution, and the functions of the wetland. The second, on October 7, 2024, consisted of a new tour of the wetland and auto repair shops to photograph the material and technical aesthetics of Fontibón and, based on semi-structured interviews with truck drivers and repair shop workers, to investigate their perceptions of air quality and pollution, as well as their vision of an environmentally ideal Fontibón based on a device capable of purifying the air. A protocol was developed for both days, incorporating objectives and a set of open-ended questions grouped by participant profile. The full version of the interview protocol is presented in Annex 1.

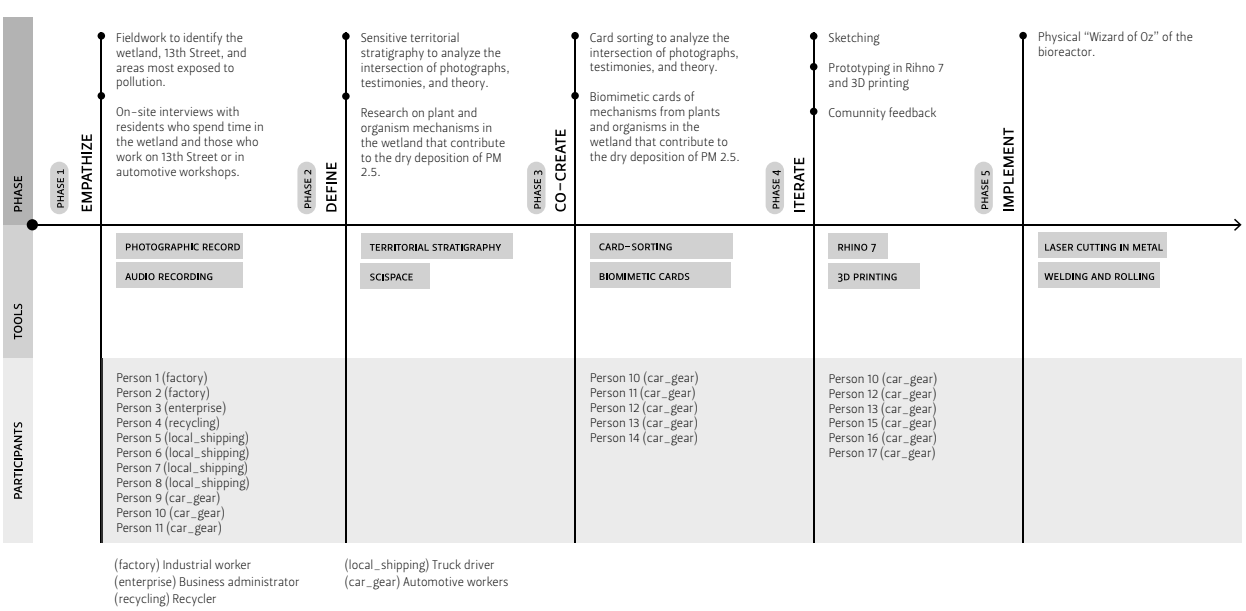


FIGURE 2. Methodology phases. (Phase 1) Empathize through fieldwork and on-site interviews. (Phase 2) Define based on territorial stratigraphy and research into wetland plant mechanisms for application in creation. (Phase 3) Co-create through card sorting and the implementation of biomimetic cards. (Phase 4) Iterate from sketches and three-dimensional prototypes to bring to the community and receive feedback. (Phase 5) Implement a Wizard of Oz of the product.

2. DEFINE

Sensitive Territorial Stratigraphy

After the fieldwork phase, the analysis is approached from a comprehensive understanding of the territory, based on the intersections and gaps that emerge between the testimonies, the photographic records, and the theoretical and contextual framework of the project. To this end, we propose sensitive territorial stratigraphy, a tool that allows for the systematic visualization of research findings, understanding the territory as a dynamic fabric of ways of life, landscape, and techniques [Table 1]. The analysis was materialized in diagrams representing categories constructed inductively by grouping testimonies with similar meanings. The names of the categories are conceptually derived from what the participants expressed. The recurrence of mentions in testimonies guided the prioritization of topics for cross-referencing with the photographic record and the theoretical, historical, or conceptual framework.

TABLE 1. SENSITIVE TERRITORIAL STRATIGRAPHY TEMPLATE

PHOTOGRAPHS	IMAGES THAT SUPPORT THE TESTIMONIES
Testimonials	Excerpt from interview (person X, date)
Theoretical research	Direct quotations from the theoretical or contextual framework (last name, first initial, date, page)

Research into the mechanisms of wetland plants and organisms

By reviewing the flora of the Meandro del Say wetland reported in Flora and fauna of the Meandro del Say wetland (Acueducto, n.d.), an initial exploration was carried out with the support of Scispace artificial intelligence (AI) to identify which species could be associated with processes of reducing PM2.5 suspended in the air. With this preliminary filter, five plants were identified for further study of the mechanisms involved, to translate these principles into biomimetic inputs that would guide the development of cards for the creative development of the final product.

Likewise, based on reports of microalgae populations in the Salitre (Pulido López, 2015), Jaboque (Arcos-Pulido and Gómez Prieto, 2006), Guaymaral, Santa María del Lago, and Tibanica (Guillot Monroy et al., 2017), a list of microalgae with potential for application in the design of the ecosystem support system is compiled.

3. CO-CREATE

Card-sorting

In line with the El Bicho project (Architizer, n.d.), design decisions are understood as a process that arises from the analysis of spatial practices and seeks to generate symbolic and material appropriation of space through the direct participation of actors in the creation of a product. In this regard, based on the stratigraphy, a card-sorting activity was implemented with a set of four cards generated from the photographs taken in Phase 1-Empathize so that each participant could individually define the shape, scale, and location of the support system (Figure 3). To facilitate understanding of how microalgae-based technology could be adapted to the local context, visual scenarios were used that were familiar to the community's everyday experience. The exercise was carried out with five participants from an auto repair shop located on 13th Street. For the analysis, in each session, the card placed by the participant at the highest priority level was recorded; then, these selections were consolidated by means of a frequency count. The results were represented in graphs ordered from lowest to highest to visualize the aggregate prioritization, and the most frequently mentioned options were considered as design decisions to be taken into account.

Based on a review of scientific literature, supported by Scispace, biomimetic cards were developed that summarize lessons learned about structures and mechanisms associated with improving air quality. These cards are inspired by the Masters of Nature set (Atarraya STEM, 2022), which illustrates the structures and functions of organisms that can guide design solutions to socio-environmental problems. In this project, each card highlights the name of the organism, an image alluding to its mechanism, a text excerpt from the article that supports its understanding, and the corresponding bibliographic reference (Figure 4). This resource allows for the comparative visualization of the mechanisms of different organisms and their projection as functional and conceptual references for the creation of the support system.

4. ITERATE

Sketches and prototyping

Based on the convergence between the card-sorting results and the biomimetic cards, hand sketches and digital prototypes are developed in Rhino 7 to visualize the support system located in the territory through photomontages that facilitate dialogue with the community. In this way, the images become a tool for collective reflection and feedback, enabling adjustments to be made to the design in order to respond to the spatial needs identified.

5. IMPLEMENT

Wizard of Oz

Based on these iterations, a physical prototype similar to the Wizard of Oz was consolidated and implemented in the context to generate reflection on how the support system can amplify territorial sensitivity and promote symbiotic interaction between humans and non-humans. Elements of the territory's aesthetics and biomimetic principles were integrated into the prototype to enhance its function in relation to the wetland.

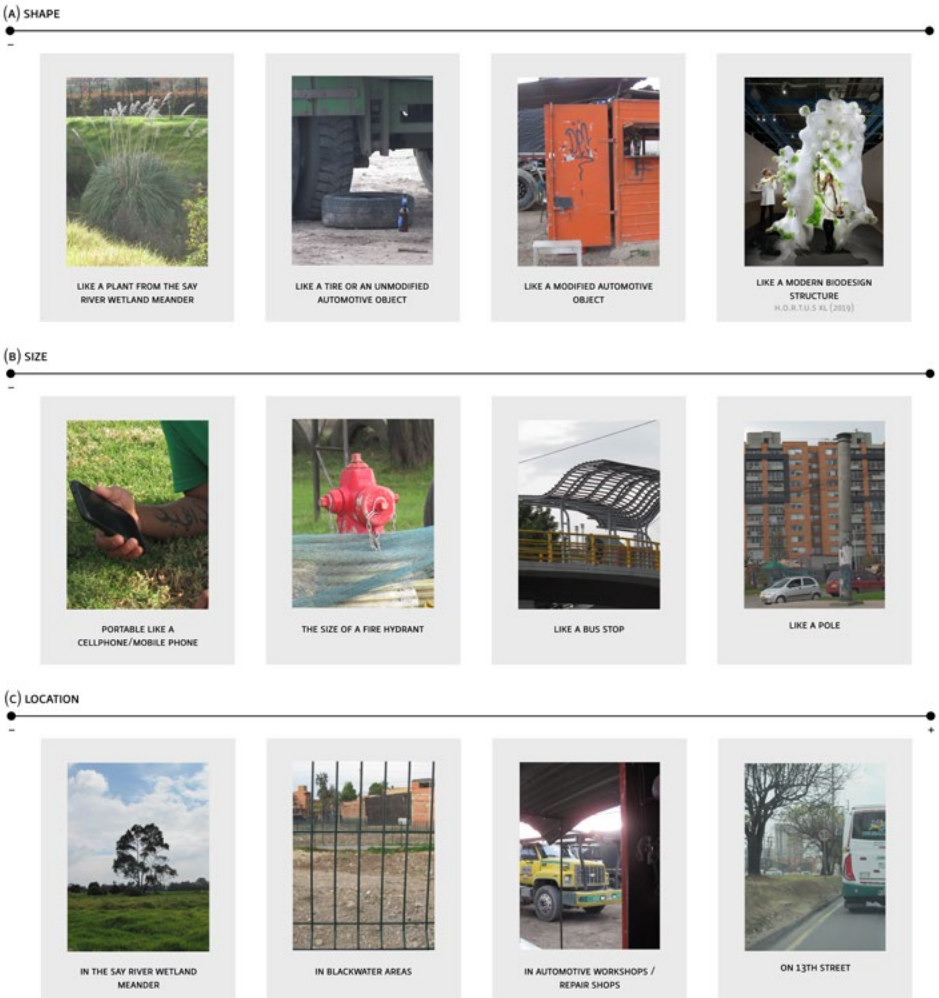


FIGURE 3. Card sorting. (a) Shape of the support system; (b) Size in space; (c) Location of the support system. Biomimetic cards.

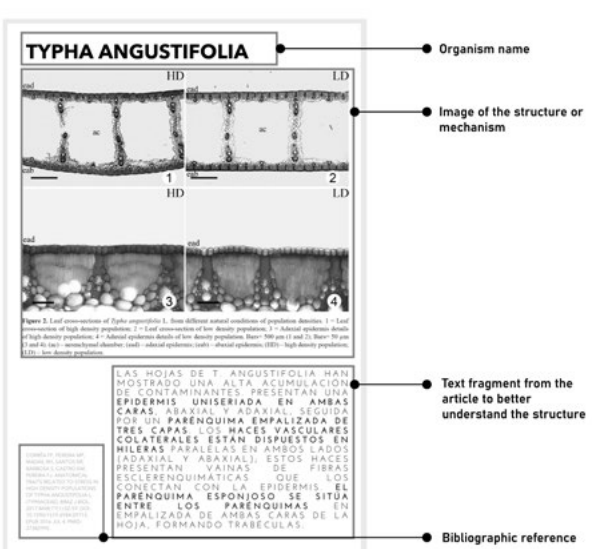


FIGURE 4. Biomimetic card structure.

RESULTS

1. EMPATHIZE

Fieldwork

On September 1, 2024, the first survey of the territorial landscape was conducted, identifying that 50% of the wetland is home to eighteen soccer fields. This space, recognized as an urban setting for economic and leisure activities, shows clear signs of environmental deterioration. In contrast, at the opposite end of the spectrum, the Zona Franca Metropolitan Park retains greater ecosystem vitality and humidity (Figure 5).

To the north lies Calle 13, where there is constant heavy vehicle traffic. Residents and the region have developed a close relationship with these vehicles, and their lives revolve around them, with parking lots, tire repair shops, workshops, and spare parts sales. However, the constant dust suspended by vehicular traffic has led the community to normalize the resulting respiratory and environmental conditions as a part of daily life (Figure 6).

INTERVIEWS

Table 2 contains excerpts from seven interviews conducted with a total of ten people in Phase 1 – Empathize of the project. These were selected and prioritized based on the patterns that emerged from the testimonials.

The interview data confirm that Fontibón functions as a strategic economic territory, where both the wetland and the trucking industry serve as vital sources of income. Thus, the transport of goods and the utilization of the wetland have become indispensable for the livelihoods of Fontibón's residents (Table 2, items 1.1 and 2.1). Consequently, the community has normalized the consequences of pollution for both their environment and health (Table 2, items 4.1, 4.2, and 4.3). This normalization manifests in concepts like "black areas", sectors such as the land surrounding Calle 13 that are perceived as unredeemable for green space and thus receive little attention or protection (Table 2, items 3.1 and 3.2). Ultimately, this reflects a broader dynamic where agency

FIGURE 5. Meandro del Say Wetland. (A) Wetland area with soccer fields. (B) Zona Franca Metropolitan Park. Source: photographs by Alexandra Huertas (fieldwork September 1).

FIGURE 6. Calle 13. (A) Auto repair shop and spare parts store. (B) Mobile tire repair shop on Calle 13. Source: photographs by Alexandra Huertas (fieldwork October 7).

over the territory's health is delegated to a third party, as seen with the wetland and government entities.

Even so, the aesthetic landscape of the wetland, with its greenery and surrounding trees, is perceived as a safe place in Fontibón, and this symbolic relationship with the landscape motivates residents to want to see more green spaces in the area (Table 2, items 5.1 and 5.2).

TABLE 2. INDUCTIVE CATEGORIES AND EXCERPTS FROM FIELDWORK TESTIMONIES

1. LAND AGENCY	
1.1 Person 3	"We are facing a legal dilemma with these environmental agencies because the property is located in the wetland". "We comply with having waste collection systems in place and ensuring that our activities do not extend beyond the wetland".
2. ECONOMIC RESILIENCE	
2.1 Person 1	"They are tractor-trailers, but what can you do if they are the ones transporting the food?"
2.2 Person 2	"It's a little heavier because here you only work with trucks".
3. BLACK AREAS	
3.1 Person 6	"There are no green areas here; here we find black areas. Nobody cares".
3.2 Person 8	"There are no green areas, very few".
4. WE DON'T SMOKE, BUT CARS DO.	
4.1 Person 9	"I suffer a lot from colds. Here, it's impossible not to be in contact with dust".
4.2 Person 11	"It didn't take long, but lately we've had the flu, the girl, and him."
4.3 Person 6	"We don't smoke, but cars do."
5. PERCEPTIONS OF AIR QUALITY	
5.1 Person 3	"On Calle 13 is intense, on the wetland, not so much."
5.2 Person 1	"Here, you hardly feel that way, especially in these green areas".
6. RECLAIMING THE TERRITORY	
6.1 Persona 9	"For me, it is impossible to plant trees again".
6.2 Persona 11	"It would be nice to see more trees, because I'm from the countryside, I really miss nature".

2. DEFINE

Sensitive territorial stratigraphy

The photographs in Table 3 reveal the excess dust in Fontibón; the wetland, although perceived as less polluted, is highly exposed to PM2.5 saturation and has a high probability of emitting CO2 and CH4.

Table 4 confirms the high presence of trucks, whose activity conditions spatial practices and causes respiratory problems due to prolonged exposure.

Furthermore, Table 5 identifies "black areas", hostile spaces with low community ownership, delegated to authorities, which perpetuates environmental degradation.

Thus, the desire to inhabit black areas is reflected in the spatial technique of applying nature where objects and automotive structures are adapted to the territory through structural and chromatic modifications (Table 6). Therefore, this project must be situated within that artificial nature and generate a symbolic appropriation that recognizes the wetland as a living organism within the urban ecosystem.

3. CO-CREATE

Card-sorting

Before starting the card sorting, the Liquid 3 project was presented as an external reference. From there, a discussion arose about how to integrate similar technology into the Fontibón landscape. The results reflect how the community translates this technology into ways of life and techniques that are territorially close (Figures 7 to 9).

Following prioritization, the workshops revealed that using plants to represent the wetland fostered a sense of care and symbolic responsibility among participants (Figure 7).

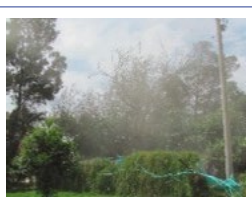
The community sees a need to adapt the support system to a compact, mobile format that is compatible with the spatial priority of their work for trucks (Figures 8 and 9).

This activity shows that the territorial appropriation of a biodesign technology depends not only on its biological functionality, but also on its symbolic and spatial translation. The community recognizes the need to improve air quality, but its relationship with the territory is based on familiarity and care: what is perceived as alive or close generates responsibility, while what is foreign or imposed is delegated.

Biomimetic cards

Based on the previous review of flora and microalgae, biomimetic cards are designed for the species Typha angustifolia, Azolla filiculoides, and Desmodesmus sp. (Figure 10), selected for their capabilities and structures associated with metabolic respiration, contaminant accumulation, and gas exchange. The expanded characterization and selection criteria are presented in Annex 2.

TABLE 3. SATURATED PERCEPTIONS

Photographs				
Testimonials	4.1	5.1	5.2	
Theoretical research	"In dry weather, after a certain period of time, the adsorption of contaminants by leaves reaches a saturation point, after which the leaves no longer absorb any more particles." (Zhou et al., 2020 p. 2) "Crucially, the degradation of natural wetlands is causing the release of significant amounts of CO_2 and, to a lesser extent, CH_4, effectively turning wetlands into carbon sources". (Schuster et al., 2024, p. 2)			

Note. The photographs in tables 3 to 6 were taken by Alexandra Huertas during fieldwork (September 1 and October 7, 2024).

TABLE 4. WE DON'T SMOKE, BUT CARS DO

Photographs			
Testimonials	4.1	4.2	4.3
Theoretical research	"Health impacts can be attributed to exposure to pollutants, such as low birth weight, premature birth, increased asthma symptoms, and mental health problems". (Farrow et al., 2022, p. 4)		

Note. The photographs in tables 3 to 6 were taken by Alexandra Huertas during fieldwork (September 1 and October 7, 2024).

TABLE 5. CONSERVATION AS A THEME IN SOME

Photographs				
Testimonials	1.1	6.1	3.1	3.2
Theoretical research	"The most effective way to deal with resistance is to find a way to align the various objectives of the subsystems, usually by establishing an overall objective that allows all actors to overcome their limited rationality". (Meadows, 2009, p.115) "Guide social actors on the conservation, preservation, restoration, and management of urban biodiversity knowledge, highlighting its importance in terms of the services it provides to the inhabitants of our cities and how to incorporate it into environmental planning and management processes." (Ministry of Environment and Sustainable Development & Alexander von Humboldt Biological Resources Research Institute. 2017, p. 2)			

Note. The photographs in tables 3 to 6 were taken by Alexandra Huertas during fieldwork (September 1 and October 7, 2024).

TABLE 6. ARTIFICIAL NATURE

Photographs				
Theoretical research	"It is our nature, which we control, into which we introduce our culture and in which we recognize ourselves, that thus presents a dimension that makes the artificial one of the components of our environment".			

Note. The photographs in tables 3 to 6 were taken by Alexandra Huertas during fieldwork (September 1 and October 7, 2024).

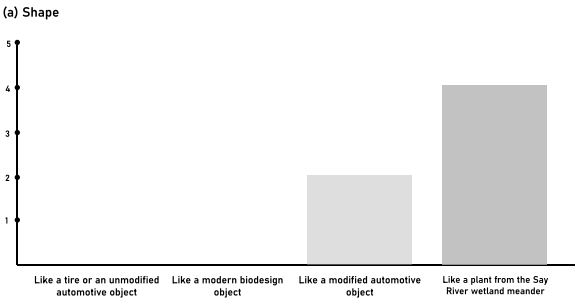


FIGURE 7. Card sorting results. Prioritization of form.

FIGURE 8. card sorting results. prioritization by size.

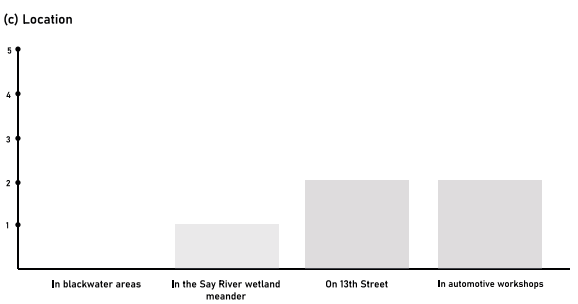


FIGURE 9. Card-sorting results. Prioritization of size.

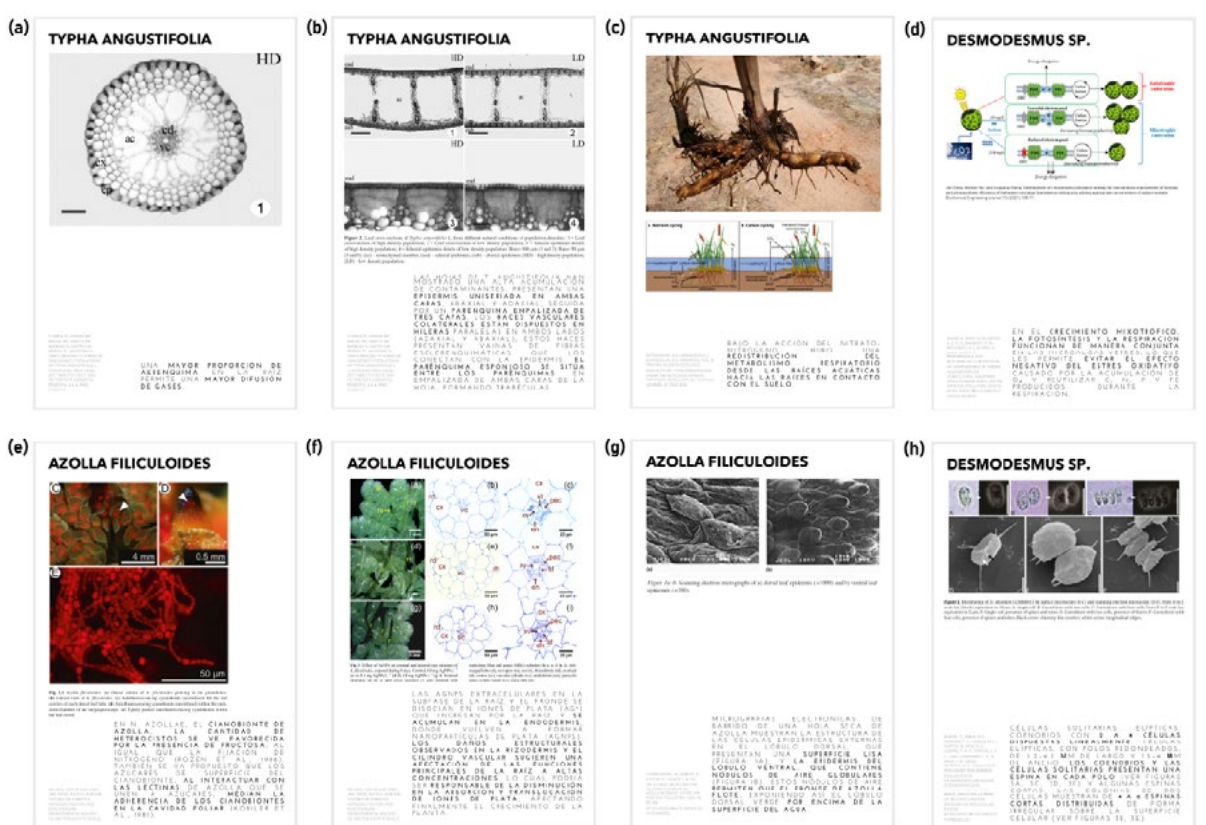


FIGURE 10. Biomimetic cards inspired by the living systems of the Meandro del Say.

4. ITERATE

Prototyping

To integrate without obstructing the space, the application of a compact microalgae bioreactor is being evaluated as a support system, with dimensions of 10 x 34 x 40 cm, internal mirrored walls, and top aeration (Ahangar, 2023). Applying these conditions to the support system, the metal mufflers of trucks are taken as an aesthetic reference, as their holes facilitate gas transpiration and their material reflects the light necessary for microalgae growth (Figure 11). entorno urbano.

This proposal is also inspired by the cylindrical vascular structure of the roots of Azolla filiculoides, which is conceptually represented as a metal cylinder that concentrates large amounts of pollutants (Figure 10f). Likewise, to minimize system saturation, holes inspired by the aerenchyma structure of Typha angustifolia (Corrêa et al., 2017) are incorporated to facilitate gas exchange in the bioreactor (Figure 11a).

With these parameters, the first iteration of the support system is developed, as shown in Figure 12.

Feedback

Considerations regarding spatial sustainability arose, and participants 15, 16, 17, and 18 proposed editing the structure to fit the T-shaped metal bases of the workshop premises, thus ensuring greater spatial reach (Figure 13).

Although the reference to trucks is effective, there is a disconnect with the symbolism of the wetland, so they suggest incorporating an explicit representation of Typha angustifolia, whose silhouette allows the liquid content of microalgae in the bioreactor to be visualized as "breathing", reinforcing its symbolism in the urban environment.

FIGURE 11. *Metal truck muffler. Source: photograph by Alexandra Huertas (November 18).*

FIGURE 12. *Digital prototype (A) and initial photomontage (B).*

FIGURE 13. *T-shaped structures in automotive workshops. Source: photographs by Alexandra Huertas (November 18).*

5. IMPLEMENT

With these adjustments, the prototype is redefined as shown in Figure 14 and materialized in a Wizard of Oz, BIO-VASC (Figure 15).

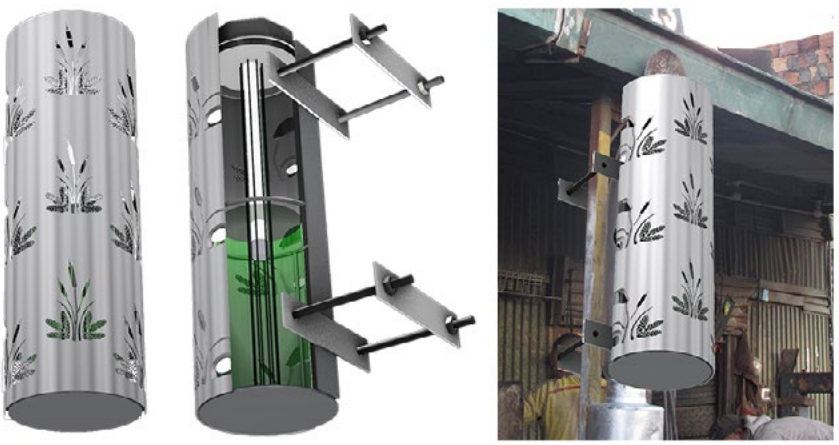


FIGURE 14. *T-shaped metal structures in automotive workshops.*

FIGURE 15. *BIO-VASC. Acrylic and metal prototype measuring 50 x 18 x 18 cm. It contains a vertical aeration and lighting system. Source: photograph by Alexandra Huertas (December 7).*

DISCUSSION

Returning to the research question, this work finds that sustainable design emerges from understanding and working with Fontibón's territorial ways of life, landscape, and techniques, achieved through community participation and appropriation grounded in contextual aesthetics. This creates a link between the community and biodesign projects in specific territories, ensuring their long-term use, as demonstrated by the El Bicho de Arquitectura Expandida and Boat Biologs de Kuvavala projects, which show how biodesign is not only implemented but can also be appropriated and applied by the community. Furthermore, beyond ensuring the technical functionality of the bioreactor, transforming this project and its process into opportunities to learn about the resilient capacity of the wetland lays the foundation for a symbiotic relationship that encourages critical reflection on the context.

Firstly, in the field of design, observing territorial dynamics is not only a tool for recording but also a way of constructing situated knowledge with design value. This project demonstrates the potential of triangulating information from photographic records, interviews, and theoretical frameworks, which allows for systemic findings anchored in context. This facilitates a sensitive understanding of how a community inhabits, transforms, and perceives its environment, guiding the project toward specific needs. Sensitive territorial stratigraphy is established as a means of comprehensively visualizing this context: on the one hand, testimony reveals perceptions and experiential memories; photography documents spatial reality; and the theoretical framework allows for the interpretation of causes and the contextualization of qualitative findings. This interdisciplinary approach enabled the analysis of key concepts like "black areas". These are not merely colloquial terms but refer to zones shaped by historical processes, particularly rapid urbanization that transformed the landscape, erased green spaces, and now faces economic imperatives that constrain its recovery. At the same time, this uprising allowed for the recognition of the aesthetics associated with the territory, expressed in material practices such as the modification of automotive parts. This guided the aesthetics and structure of BIO-VASC toward an artificial nature, consistent with the need to inhabit uninhabitable spaces using local techniques and knowledge, such as truck mechanics.

Secondly, this project engages with complex concepts—PM2.5, dry deposition, metabolic respiration, and diverse biological structures—to translate them into applicable design principles. However, it also underscores the urgent need to make biodesign's scientific foundations more accessible to creative designers, who may lack formal biology training but seek to build rigorous, science-informed arguments. In this sense, artificial intelligence-based tools such as Scispace can significantly facilitate the search for and structuring of scientific arguments, although critical reading and a deep understanding of each article remain essential. Complementarily, instruments such as biomimetic cards applied in this project and previously proposed by Atarraya STEM (2022) represent an effective strategy for bringing biology closer to design. These cards allow for quick and visual analysis of an organism's mechanisms and project them as conceptual or functional references within the creative process.

Finally, the design acted as an iterative mediator that amplifies the ecosystemic capacities of the wetland by articulating living systems, spatial practices, and territorial dynamics. This

process translated qualitative and biomimetic knowledge into design criteria that were relevant and familiar to the community context. Far from traditional functional validation, the prototyping phase materialized symbiotic interactions in an artifact that makes the invisible visible, activating reflection and community appropriation.

This approach allowed the community to engage with biological concepts through familiar references, which were reflected in the card-sorting activity. This not only facilitated understanding of these topics but also catalyzed ideas adapted to the context. Tools such as hand sketches, digital and physical prototyping, translated collectively defined parameters into physical tangibility. Beyond exploring their form and hypothetical functionality, the prototypes enabled constant feedback throughout the creative process. In this way, BIO-VASC manages to condense both community suggestions and identified biomimetic principles. The final artifact, a simulated Wizard of Oz with microalgae, aeration, and vertical lighting, becomes a reflective object that, through its process, was able to highlight an environmental issue and invited the community to recognize invisible pollution and value the resilience of the Meandro del Say wetland. In turn, BIO-VASC has the potential to evolve into a functional solution in future research, in collaboration with experts in microbiology, microalgae cultivation, and bioreactor design.

CONCLUSION

This research focused on understanding the ways of life, landscape, and techniques of Fontibón, using sensitive territorial stratigraphy that triangulates photographs, testimonies, and theoretical frameworks to arrive at systemic findings aligned with the local needs of the community and the wetland in the face of air pollution.

Thus, biodesign and biomimicry were introduced as applicable community practices, connecting the BIO-VASC project to Fontibón's spatial and aesthetic context. Tools like SciSpace AI and biomimetic cards supported the application of scientific knowledge, optimizing the design iterations.

BIO-VASC, conceived as an Oz-like microalgae bioreactor, aeration, and vertical lighting, is positioned as a reflective object that highlights an overlooked environmental issue and invites the community to recognize PM2.5 pollution and the resilient value of wetlands for their primary function of dry deposition of PM. This project has functional potential for future collaboration with experts in microbiology, microalgae cultivation, and bioreactor design.

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ANNEX 1

Protocolo de entrevista semiestructurada para trabajo de campo
Primera parte (septiembre, 2024)

- Duración aproximada: (15 min)
- Lugar/condición: (calle 13 / parque metropolitano Zona Franca (humedal Meandro de Say) / Club Real Boyacá (humedal Meandro de Say)
- Registro: (audio siempre; fotos solo si autorizan)

Objetivos

- Identificar la calle 13, las zonas residenciales alrededor del humedal Meandro del Say y el humedal.
- Escuchar las percepciones de la calidad del aire, la contaminación, y las funciones del humedal.
- Reconocer los perfiles de usuarios que transitan el humedal y trabajan cerca a la calle 13.

Protocolo

- Se inició cada encuentro con una introducción al propósito de la tesis y del trabajo de campo; y a la identidad de la investigadora (Alexandra Huertas).
- Se obtuvo consentimiento informado verbal (sin firma) para la participación y, de manera separada, para el registro audiovisual (audio/fotografía).
- Se recogieron únicamente datos contextuales básicos (código del participante (Persona 1, Persona 2...), rol/ocupación y antigüedad en ese trabajo).
- Posteriormente, se continuó con las siguientes preguntas:

Preguntas para el público que está involucrado con lo industrial

- ¿Cómo se ha sentido viviendo en Fontibón?
- ¿Cómo se siente frente los efectos que puede generar la industria en otras personas? ¿Le gustaría cambiar algo al respecto?
- ¿Siente que su salud ha sido influenciada por la actividad industrial?
- ¿Ha visto que la calidad del aire ha cambiado a lo largo del tiempo?
- ¿Cada cuando suele tener enfermedades respiratorias? ¿Tiene algún familiar que presente más seguido estos síntomas?
- ¿Qué necesita usted que mejore en términos de calidad del aire?

Preguntas para el público que transita el humedal

- ¿Cómo se ha sentido viviendo en Fontibón?
- ¿Ha visto que la calidad del aire ha cambiado a lo largo del tiempo?
- ¿Cada cuando suele tener enfermedades respiratorias? ¿Tiene algún familiar que presente más seguido estos síntomas?
- ¿Qué necesita usted que mejore en términos de calidad del aire?
- ¿Cómo se siente en relación con el humedal?
- ¿Ha presenciado cambios del humedal?
- Si supiera que estos humedales tienen la capacidad de retener contaminantes, pero que está perdiendo esta capacidad por su deterioro ¿Cómo se sentiría?
- ¿Qué haría usted para cambiar el deterioro de los humedales?
- ¿Conoce entes reguladores que se encarguen de la salud del humedal?

Segunda parte (octubre, 2024)

- Duración aproximada: (15 min)
- Lugar/condición: (calle 13 / talleres automovilísticos)
- Registro: (audio siempre; fotos solo si autorizan)

Objetivos

- Registrar la estética de Fontibón desde sus objetos, técnicas, texturas y espacios.
- Escuchar las percepciones de la calidad del aire y la contaminación según los conductores de camión.
- Cuestionar a los locales cuál es la estética que los caracteriza, cuál sería un Fontibón ideal ambientalmente; y cómo se imaginan un artefacto que purifique el aire en Fontibón.

Protocolo

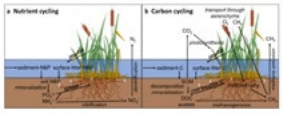
- Se inició cada encuentro con una introducción o recuento del propósito de la tesis y del trabajo de campo; y a la identidad de la investigadora (Alexandra Huertas) de no conocer a los participantes previamente.
- Se obtuvo consentimiento informado verbal (sin firma) para la participación y, de manera separada, para el registro audiovisual (audio/fotografía).
- Se recogieron únicamente datos contextuales básicos (código del participante (Persona 1, Persona 2...), rol/ocupación y antigüedad en ese trabajo).
- Posteriormente, se continuó con las siguientes preguntas:

Preguntas para conductores de camión

- ¿Por qué conducen la calle 13?
- ¿Qué percepciones tiene cuando ingresa a Fontibón?
- ¿Cómo se siente frente los efectos contaminantes que puede generar el tráfico sobre el ecosistema y las personas? ¿Le gustaría cambiar algo al respecto?
- ¿Usted ha visto afectada su salud por la quema de combustible?
- ¿Qué ideas le surgirían si le comento que rehabilitando el humedal Meandro del Say con organismos vivos como las algas se podría reducir la contaminación?
- ¿Cómo podría aportar usted a la rehabilitación del humedal desde su labor como conductor de camión?
- Preguntas para operarios de talleres automovilísticos
- ¿Qué es característico visualmente en Fontibón?
- ¿Cuál sería su Fontibón ideal ambientalmente?
- ¿Si uno aplicara un artefacto que purifique el aire en Fontibón, cómo cree que se vería? ¿Dónde cree que debería estar ubicado?

ANEXO 2
Biomimetic cards

TYPHA ANGUSTIFOLIA



BAJO LA ACCIÓN DEL NITRATO, NITRÓGENO, HUBO UNA **REDISTRIBUCIÓN DEL METABOLISMO RESPIRATORIO** DESDE LAS RAÍCES ACUÁTICAS HACIA LAS RAÍCES EN CONTACTO CON EL SUELO.

TYPHA ANGUSTIFOLIA

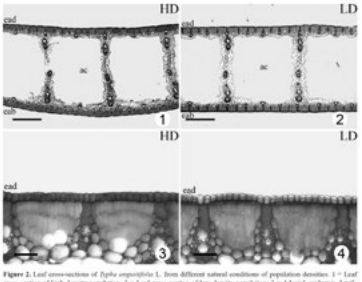
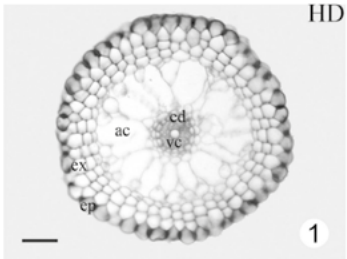


Figure 2. Leaf cross-sections of *Typha angustifolia* L. from different natural conditions of population densities. 1 = Leaf cross-section of high density population; 2 = Leaf cross-section of low density population; 3 = Adaxial epidermis details of high density population; 4 = Adaxial epidermis details of low density population. Bars= 500 μm (1 and 2); Bars= 50 μm (3 and 4). (ac) – aerenchymal chamber; (cad) – adaxial epidermis; (cab) – abaxial epidermis; (HD) – high density population; (LD) – low density population.

LAS HOJAS DE T. ANGUSTIFOLIA HAN MOSTRADO UNA ALTA ACUMULACIÓN DE CONTAMINANTES. PRESENTAN UNA **EPIDERMIS UNISERIADA EN AMBAS CARAS**, ABAXIAL Y ADAXIAL, SEGUIDA POR UN **PARÉNQUIMA EMPALIZADA DE TRES CAPAS**. LOS **HACES VASCULARES COLATERALES ESTÁN DISPUESTOS EN HILERAS** PARALELAS EN AMBOS LADOS (ADAXIAL Y ABAXIAL); ESTOS HACES PRESENTAN VAINAS DE FIBRAS ESCLERENQUIMÁTICAS QUE LOS CONECTAN CON LA EPIDERMIS. **EL PARÉNQUIMA ESPONJOSO SE SITÚA ENTRE LOS PARÉNQUIMAS EN EMPALIZADA DE AMBAS CARAS DE LA HOJA, FORMANDO TRABÉCULAS.**

TYPHA ANGUSTIFOLIA



UNA **MAYOR PROPORCIÓN DE AERÉNQUIMA EN LA RAÍZ PERMITE UNA MAYOR DIFUSIÓN DE GASES.**

AZOLLA FILICULOIDES

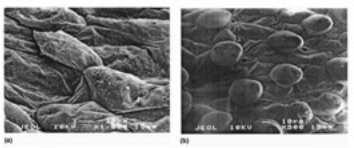


Figure 1a–b. Scanning electron micrographs of a) dorsal leaf epidermis (×1000) and b) ventral leaf epidermis (×500).

MICROGRAFÍAS ELECTRÓNICAS DE BARRIDO DE UNA HOJA SECA DE AZOLLA MUESTRAN LA ESTRUCTURA DE LAS CÉLULAS EPIDÉRMICAS EXTERNAS EN EL LÓBULO DORSAL, QUE PRESENTAN UNA **SUPERFICIE LISA** (FIGURA 1A), Y **LA EPIDERMIS DEL LÓBULO VENTRAL, QUE CONTIENE NÓDULOS DE AIRE GLOBULARES** (FIGURA 1B). ESTOS NÓDULOS DE AIRE **PERMITEN QUE EL FRONDE DE AZOLLA FLOTE**, EXPONIENDO ASÍ EL LÓBULO DORSAL VERDE **POR ENCIMA DE LA SUPERFICIE DEL AGUA.**

AZOLLA FILICULOIDES

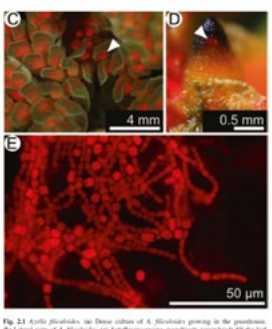


Fig. 2.1 *Azolla filiculoides*. (a) Dense culture of *A. filiculoides* growing in the greenhouse, (b) Lateral view of *A. filiculoides*, (c) Autofluorescencing cyanobionts (arrowhead) fill the leaf cavities of each dorsal leaf lobe, (d) Autofluorescencing cyanobionts (arrowhead) within the individuals chamber of the megasporocarps, (e) Tightly packed autofluorescencing cyanobionts within the leaf cavity

EN N. AZOLLAE, EL **CIANOBIONTE DE AZOLLA, LA CANTIDAD DE HETEROCISTOS SE VE FAVORECIDA POR LA PRESENCIA DE FRUCTOSA**, AL IGUAL QUE LA FIJACIÓN DE NITRÓGENO (ROZEN ET AL., 1986). TAMBIÉN SE HA PROPUESTO QUE LOS AZÚCARES DE SUPERFICIE DEL CIANOBIONTE **AL INTERACTUAR CON LAS LECTINAS DE AZOLLA QUE SE UNEN A AZÚCARES, MEDIAN LA ADHERENCIA DE LOS CIANOBIONTES EN LA CAVIDAD FOLIAR** (KOBILER ET AL., 1981).

AZOLLA FILICULOIDES

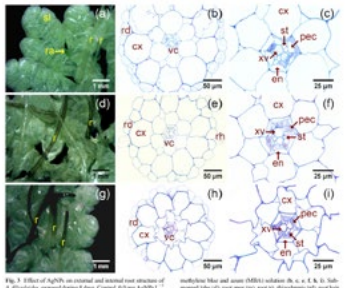


Fig. 3 Effect of AgNPs on external and internal root structure of *A. filiculoides*, exposed during 8 days. Control, 0.0 mg $AgNPs.L^{-1}$ (a–c); 0.1 mg $AgNPs.L^{-1}$ (d–f); 1.0 mg $AgNPs.L^{-1}$ (g–i). External structure (a, d, g) and cross sections (1 μm) stained with methylene blue and acure (MBA) solution (b, c, e, f, h, i). Submerged lobe (sl), root apex (ra), root (r), rhizodermis (rd), root hair (rh), cortex (cx), vascular cylinder (vc), endodermis (en), pericycle (pec), xylem vessel (xv), sieve tube (st)

LAS AGNPS EXTRACELULARES EN LA SUBFASE DE LA RAÍZ Y EL FRONDE SE DISOCIAN EN IONES DE PLATA (AG+) QUE INGRESAN POR LA RAÍZ Y **SE ACUMULAN EN LA ENDODERMIS**, DONDE VUELVEN A FORMAR NANOPARTÍCULAS DE PLATA (AGNPS). **LOS DAÑOS ESTRUCTURALES OBSERVADOS EN LA RIZODERMIS Y EL CILINDRO VASCULAR SUGIEREN UNA AFECTACIÓN DE LAS FUNCIONES PRINCIPALES DE LA RAÍZ A ALTAS CONCENTRACIONES**, LO CUAL PODRÍA SER **RESPONSABLE DE LA DISMINUCIÓN EN LA ABSORCIÓN Y TRANSLOCACIÓN DE IONES DE PLATA**, AFECTANDO FINALMENTE EL CRECIMIENTO DE LA PLANTA.

DESMODESMUS SP.

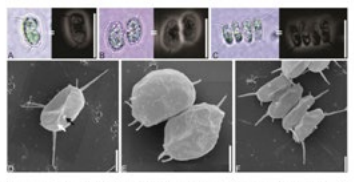
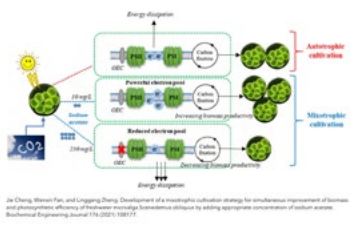


Figure 3. Morphology of *D. abundans* UGMMH3 by optical microscopy (A-C) and scanning electron microscopy (D-F). From A to C scale bar: (black) equivalent to 10 μm. A: single cell. B: Coenobium with two cells. C: Coenobium with four cells. From D to F scale bar equivalent to 5 μm. D: Single cell, presence of spines and tubes. E: Coenobium with two cells, presence of thorns. F: Coenobium with four cells, presence of spines and tubes. Black arrow: chimney-like rosettes; white arrow: longitudinal ridges.

CÉLULAS SOLITARIAS ELÍPTICAS, COENOBIOS CON **2 A 4 CÉLULAS DISPUESTAS LINEALMENTE**. CÉLULAS ELÍPTICAS, CON POLOS REDONDEADOS, DE 5.2–6.2 MM DE LARGO Y 1.5–4 MM DE ANCHO. **LOS COENOBIOS Y LAS CÉLULAS SOLITARIAS PRESENTAN UNA ESPINA EN CADA POLO** (VER FIGURAS 3A, 3C, 3D, 3F) Y ALGUNAS ESPINAS CORTAS. LAS COLONIAS DE DOS CÉLULAS MUESTRAN DE **4 A 6 ESPINAS CORTAS DISTRIBUIDAS** DE FORMA IRREGULAR SOBRE LA SUPERFICIE CELULAR (VER FIGURAS 3B, 3E).

DESMODESMUS SP.



EN EL **CRECIMIENTO MIXOTRÓFICO, LA FOTOSÍNTESIS Y LA RESPIRACIÓN FUNCIONAN DE MANERA CONJUNTA** EN LAS MICROALGAS VERDES, LO QUE LES PERMITE **EVITAR EL EFECTO NEGATIVO DEL ESTRÉS OXIDATIVO** CAUSADO POR LA ACUMULACIÓN DE O_2 Y REUTILIZAR C, N, P Y FE PRODUCIDOS DURANTE LA RESPIRACIÓN.