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INTEGRATING LOCAL AND ACADEMIC EXPERTISE: A CASE STUDY ON MANGROVE RESTORATION AT BOM JESUS COVE, FUNDÃO ISLAND, RIO DE JANEIRO

Thiago Fagundes Leão
http://lattes.cnpq.br/2631142937811682

Jairton Carlos Alves da Silva
http://lattes.cnpq.br/7760614330107403

Caio Valente Lucini

Mariana de Oliveira Silva

Cristine Carvalho
https://lattes.cnpq.br/7823717384081700

Gustavo Mendes de Melo
http://lattes.cnpq.br/0156044708409947

Gustavo Vaz de Melo
http://lattes.cnpq.br/1277500968645130

Carla Muniz Sabino
http://lattes.cnpq.br/0748998065316873

Elza Maria Neffa Vieira de Castro
http://lattes.cnpq.br/0748998065316873

Susana Beatriz Vinzon
http://lattes.cnpq.br/8691577953460509

Rodrigo Hoerner Morais Marques
http://lattes.cnpq.br/3657486039971055

Raphaela Moreira Bertolotti
http://lattes.cnpq.br/3250773519614986

INTRODUCTION

Floating debris in oceans and coastal waters represents a severe environmental threat on a global scale. The root of the problem lies primarily in the failures or deficiency of solid waste management on land, a complex challenge that requires comprehensive solutions that consider political, economic, social and cultural aspects. Although restructuring the solid waste management system is essential in the long term, immediate actions are necessary to minimize the direct impacts of floating debris on coastal and marine ecosystems to reduce the existing environmental liability.

In this context, the Orla Sem Lixo (OSL) project aims to plan, implement, test and monitor integrated solutions within the principles of nature-based solutions (NbS) to mitigate floating solid waste in coastal areas. The project's premises are that floating waste must be intercepted, collected, transported and recycled, in a process that is easily replicable, dialogues with and involves the local community, is effective and low-cost, transforming solid waste into resources and thus ensuring the economic and environmental sustainability of the process.

The active involvement of local stakeholders, supported by a focus on equity, trust, learning and empowerment, enhances decision-making related to environmental issues (Borges et al., 2017). This engagement increases the likelihood that environmental policy decisions are perceived as integrated and just, taking into account a diversity of values and needs while recognizing the complexity of human-environment interactions (Richards et al., 2004). For greater effectiveness, the involvement of these stakeholders should be institutionalized, fostering organizational cultures that facilitate processes in which objectives are generally negotiated with uncertain outcomes (Reed, 2008).

One of the objectives of OSL is to propose a solution aimed at developing model for sustainable job and income generation for local communities, framed within an ecosystem-based integrated management approach to floating waste. This approach can be understood as "an integrated management strategy that considers the entire ecosystem, including humans" (McLeod et al., 2005), where the complexity and relationships within adjacent ecological systems are acknowledge alongside social objectives and governance in coastal area management (Aswani et al., 2012; Carter et al., 2015; Long et al., 2015). Such an initiative presents an opportunity to maximize ecosystem services while promoting ecological resilience and appropriate productive activities (Lithgow et al., 2019).

By leveraging the exchange of scientific and academic knowledge with the traditional knowledge of fishing communities, the project has facilitated the integration of Coastal Engineering, Social Technology and Communication groups with two active groups on Fundão Island, Rio de Janeiro. This collaboration has led to the design and installation of barriers in mangrove areas. A pilot area has been utilized to retain waste and assess the ecological effects following its removal, employing both in situ environmental assessment and video monitoring tools.

The objective of this paper is to present the collaborative process employed to mitigate the negative impacts of floating waste, involving both the local community and researchers. In this context, it is emphasized that the communities actively contributed to the development of the solution, valuing the synergy between local knowledge and academic research.

METHODOLOGY

The ongoing work is based on the Action Research methodology, which promotes the horizontal participation of stakeholders in planned social, educational and technical actions. This approach emphasizes the active involvement of local communities in identifying problems, developing solutions, and implementing actions.

The steps of this methodology include: (1) participatory diagnosis: identification and topics of interest to the fishing communities involved; (2) educational processes: mobilization and awareness-raising of the fishing community through workshops and collective actions based on local generating themes (Freire, 1983); (3) meetings and lectures: promotion of ecopolitical awareness for the insertion of the fishing community in a model of job and income generation, focusing on the transformation and conservation of the natural environment; (4) network of knowledge and practices: facilitation of the incorporation of sustainable production practices and encouragement of the emergence of emancipatory common sense (Neffa, Ritto, 2014; Neffa; Pimentel, 2015).

Table 1 presents the chronology of all activities addressed by the project, in meetings or workshops with fishing communities, from the beginning of the project until July 2023. On this date, the first stage of participatory construction of barriers to protect mangrove areas is concluded.

During the integration activities between fishing communities and UFRJ researchers, the OSL Social Technology team formalized conversation circles, the "Café com Orla", where a space for horizontal exchange is promoted among participants, thus resulting in an effective participatory construction of solutions to the demands raised. The Café com Orla aims to provide an informal and short-term environment, which results in more

Date	Event	Location	Involved
21/02/2022	AMAVILA Meeting (Residents Association of Vila Residencial)	Vila Residencial (Cidade Universitária)	Fishermen Residential Village and OSL Researchers
18/03/2022	APAP Meeting (Prainha Artisanal Fishermen's Association)	Auditório CT (UFRJ)	Prainha Fishermen and OSL Researchers
30/04/2022	Characterization of Garbage in Prainha	Prainha (Enseada do Fundão)	AMAVILA, APAP, AMBEV, PU, APALIF, OSL
26/05/2022	Sampler Presentation	Auditório CT (UFRJ)	Fishermen Residential Village and Prainha, OSL Researchers
05/06/2022	Environment Day – ORLA Explains	Prainha (Enseada do Fundão)	Fishermen from Vila Residencial and Prainha, Researchers and students from UFRJ
16/06/2022	Sampler Installation	Baía de Bom Jesus (Ilha do Fundão)	Fishermen Residential Village and Prainha, OSL Researchers
28/06/2022	EBJ Measurement Campaign	Baía de Bom Jesus (Ilha do Fundão)	Fishermen Residential Village and OSL Researchers
12/07/2022	Sampler Removal	Baía de Bom Jesus (Ilha do Fundão)	Fishermen Residential Village and Prainha, OSL Researchers
27/07/2022	1st Bom Jesus Mangrove Cleanup Action	Manguezal de Bom Jesus	Fishermen Residential Village and Prainha, OSL Researchers
27/07/2022	Camera installation (center of the plot)	Manguezal de Bom Jesus	OSL Researchers
16/08/2022	Participatory Diagnostic Feedback	Vila Residencial	Fishermen Residential Village, Researchers OSL TS
18/08/2022	Participatory Diagnostic Feedback	Prainha (Enseada do Fundão)	Prainha Fishermen, OSL TS Researchers
01/09/2022	"Café com Orla"	Prainha (Enseada do Fundão)	Prainha Fishermen, OSL Researchers
01/09/2022	"Café com Orla"	Vila Residencial	Fishermen Residential Village, OSL Researchers
13/09/2022	Presentation of mangrove barrier material	Vila Residencial	Fishermen Residential Village and Prainha, OSL Researchers
14/09/2022	Barrier assembly workshop	DIPRO (Cidade Universitária)	Fishermen Residential Village and Prainha, OSL Researchers
26/09/2022	Barrier Installation	Manguezal de Bom Jesus	Fishermen Residential Village and Prainha, OSL Researchers
26/09/2022	Camera installation (barrier)	Manguezal de Bom Jesus	OSL Researchers
15/10/2022	Camera installation (tidal channels)	Manguezal de Bom Jesus	OSL Researchers
27/10/2022	"Café com Orla"	Vila Residencial e Prainha	Fishermen Residential Village and Prainha, OSL Researchers
09/11/2022	2nd Bom Jesus Mangrove Cleanup Action	Manguezal de Bom Jesus	Fishermen Residential Village and Prainha, OSL Researchers
17/11/2022	UFRJ IC Integration Conference	Inovateca UFRJ	Fishermen from Vila Residencial and Prainha, Researchers and students from UFRJ
18/11/2022	Presentation of the Raffia Sewing Machine	LDSC (UFRJ)	Fishermen Residential Village and Prainha, OSL Researchers, Huesker
21/11/2022	Inspection of the integrity of the MEBJ barrier	Manguezal de Bom Jesus	OSL Researchers
15/12/2022	"Café com Orla"	Vila Residencial e Prainha	Fishermen Residential Village and Prainha, OSL Researchers
21/12/2022	Float Assembly Workshop	DIPRO (Cidade Universitária)	Fishermen Residential Village and Prainha, OSL Researchers
17/04/2023	EBJ Bathymetry Measurement Campaign	Canal da VR (Ilha do Fundão)	Fisherman "Foca", Researchers and OSL Students

24/04/2023	Inspection of the integrity of the MEBJ barrier	Manguezal de Bom Jesus	OSL Researchers
24/04/2023	Camera installation (center of the plot)	Manguezal de Bom Jesus	OSL Researchers
03/05/2023	EBJ Bathymetry Measurement Campaign	Baía de Bom Jesus (Ilha do Fundão)	Fisherman "Foca", Researchers and OSL Students
05/05/2023	Float Assembly Workshop	DIPRO (Cidade Universitária)	Fishermen Residential Village and Prainha, OSL Researchers
07/05/2023	"Guanabara Bay Futures" Event	UFRJ Praia Vermelha	Fishermen Residential Village and Prainha, OSL Researchers
09/05/2023	Painting of MEBJ raffia	DIPRO (Cidade Universitária)	Brigid (OSL / ISOPOR)
12/05/2023	Barrier assembly workshop	DIPRO (Cidade Universitária)	Fishermen Residential Village and Prainha, OSL Researchers
22/05/2023	Barrier replacement	Manguezal de Bom Jesus	Fishermen Residential Village and Prainha, OSL Researchers
23/05/2023	Inspection of the integrity of the MEBJ barrier	Manguezal de Bom Jesus	OSL Researchers
05/06/2023	II UFRJ IC Integration Conference	Inovateca	Fishermen from Vila Residencial and Prainha, Researchers and students from UFRJ
08/06/2023	World Oceans Day	Museu do Amanhã	Local fishermen, UFRJ researchers and civil society
03/07/2023	Camera installation (center of the plot)	Manguezal de Bom Jesus	OSL Researchers; OSL Researchers

Table 1: Chronology of activities of the Orla Sem Lixo Project, involving partner fishing communities.

Source: Prepared by the author

effective communication among all those involved in the project, including occasional calls and clarifications about the workshops promoted and their specific objectives. For example, in these meetings, it was agreed that the fishermen participating in the workshops would be selected by rotation, preserving the equity and justice of the process.

In addition to the workshops and Café com Orla meetings, regular project activities, other events such as "Explica Orla", the IC Integration Days, "Futures of Guanabara Bay" at the UFRJ Science House, and the event promoted by the Boticário Group Foundation, on "World Oceans Day" at the Museum of Tomorrow, promoted rich exchanges between the fishermen participating in the meetings, the OSL researchers and the external public.

Given the experimental nature of the project, a mangrove area near Fundão Island, Rio de Janeiro, the main campus of "*Universidade Federal do Rio de Janeiro*" was selected. This site, located on the shores of Guanabara Bay, is depicted in Figure 1, which presents a satellite image of Fundão Island. The Bom Jesus Cove (EBJ) and its surrounding mangroves are continually affected by the influx of floating debris, which hinders both academic and public use, as well as ecological development and the provision of ecosystem services in these areas. To mitigate this, a solution was proposed to prevent floating trash from entering the ecosystem by installing barriers that adapt tidal fluctuations. The pilot area was chosen based on its proximity to the research facilities, thereby reducing logistical costs, and its smaller mangrove area, making the implementation of the pilot project more feasible.

Prior to the installation of the barrier, on July 27, 2022, the first cleaning operation was conducted on an area of 90 m^2, within the subsequently fenced plot, where 2,351 items were collected, totaling approximately 56 kg of waste. A camera was also installed on

a support fixed above the area, to monitor the ecosystem's response, particularly the behavior of crabs, tidal water movements, and debris transport. The camera captured the rising tide on the afternoon of July 29, 2022, which distributed waste over the entire monitored area. Video monitoring continued until August 2, 2022, when the area was once again completely covered in debris. This observation, particularly the reoccupation of the area by crab communities and the subsequent return of garbage, further justified the need for the proposed barriers.

Figure 1: Pilot Experiment Area and its location in Guanabara Bay.

Source: Base map extracted from Google Earth.

The barrier development process consisted of 4 stages: (a) Explaining the project objectives, discussion the effectiveness of barriers with local fishermen, and reviewing available construction materials; (b) Conducting a workshop for assembling the first barrier; (c) Installing the barrier in the EBJ mangrove; and (d) Monitoring, validating and improving the solution to ensure the effectiveness of the experiment.

RESULTS

The first meeting convened on September 13, 2022 at the Vila Residencial Pier, during which materials for the project were presented, and the installation of the barriers was discussed. Geosynthetic mesh models provided by the company *Huesker*, a partner of the "*Orla sem lixo*" Project, were demonstrated along with the materials intended for the floatation and anchoring of the barriers. It was proposed that PET bottles be utilized as flotation devices in the initial barrier construction. The meeting also included a consultation with the fishing community to identify members interested in participating in the experiment.

The first assembly workshop took place the following day. The constructed barrier measured approximately 44 meters (12 m x 12 m x 20 m) and enclosed an area of 240 m², as defined by the Coastal Engineering and Carcinology Laboratory teams. The barrier was constructed using geosynthetic screens attached to PET bottles as flotation devices. During assembly, the integrity of the bottles was checked to ensure no holes that could compromise flotation, and the barriers were sewn together with the bottles. Additional tasks included measuring the length and height of the barriers.

On September 26, 2022, the barriers were installed during low tide, as scheduled according to the tide table for Ilha Fiscal, provided by the Brazilian Navy. At this project stage, the workspace was a warehouse provided by the "*Prefeitura Universitária*" (PU), which also supported the project by transporting the barriers to EBJ. A planning and organization meeting was conducted at the beginning of the installation, during which personal protective equipment (PPE) was distributed, and specific tasks were assigned.

The monitoring, validation, and improvement phase of the project involved on-site inspections to qualitatively assess the entire area and

the structural integrity of the barrier. This was supplemented by video monitoring, achieved through the installation of a camera, to document the barrier's effectiveness in preventing the passage of floating debris and maintaining buoyancy.

The camera footage enabled the identification of potential interferences, such as branches or other obstacles, and facilitated the analysis of the barrier's interaction with the local fauna. The camera recorded images from September 26 to 30, 2022, focusing on a section at the entrance of a tidal channel, and from October 15 to 17, 2022, from a different angle. To ensure data comparability and qualitatively evaluate the ecosystem's regenerative process, a standardized camera installation angle and fixed height were used, allowing comparisons between images from July 2022 (pre-installation) and April 2023 (seven months post-installation).

The footage confirmed the barrier's effective buoyancy, which adjusted appropriately to the spring tides during the monitored periods, and its capacity to retain waste. Additionally, an increase in crab burrows within protected areas was observed, with no evidence of interference from the barrier on burrow construction or crab mobility, as shown in the comparative images from July 2022 and April 2023.

Post-installation inspections on site revealed vandalism in certain sections, including damage to the geosynthetic fabric and removal of PET bottles, which could impair the barrier's effectiveness. PET bottles were initially chosen for their recyclability and established market value, which may have contributed to the vandalism. To address this, collaboration with surfboard manufacturers was established, offering Styrofoam waste for use in the floats. Consequently, the flotation devices were replaced with raffia filled with bagged Styrofoam fragments, enhancing both buoyancy and durability of the barrier.

The replacement took place on May 22, 2023, and its efficiency was proven both by an on-site visit by researchers and fishermen on May 23, and by images from the camera, which continued to record the barriers.

CONCLUSIONS

The formalization of meetings at "Café com Orla" facilitated the exchange of experiences and the integration of diverse knowledge and expertise among project participants, including local fishermen, students, and researchers. These meetings also served as a platform to update participants on the progress of the various project initiatives. The OSL project significantly contributed to the strengthening of local fishermen's associations, such as APAP (Association of Artisanal Fishermen of Prainha) and APALIF (Association of Fishermen of Vila Residencial).

Regular integrity inspections of the barrier, often conducted proactively by community members, were crucial for its preservation and proper functioning. Incidents such as vandalism, falling trees, or interactions with branches and plants posed risks to the barrier's buoyancy and retention capabilities. The replacement of PET bottle floats with raffia filled with recycled Styrofoam bags represented a key improvement, enhancing the durability and sustainability of the barriers while reducing environmental impact and promoting a circular economy.

Video monitoring proved to be an essential tool in this complex and difficult-to-access ecosystem, where on-site inspections can be challenging. The analysis of camera images facilitated environmental characterization, simplified data acquisition and manipulation, and provided continuous updates of the monitored areas.

In this research, Artificial Intelligence (AI) techniques are being developed to detect specific objects through trained algorithms. These algorithms aim to: a) monitor crab populations

by tracking species and burrow numbers; b) assess plant growth; and c) detect the presence and movement of debris, thus aiding in the ongoing evaluation of the study area.

Finally, the implementation of the barrier successfully reduced pollution in the pilot area, leading to the redefinition of the ecosystem. By merging community and academic efforts, the OSL project sought to advance the environmental recovery of barrier-protected areas, beginning with the empowerment of local fishing communities. This model of integrated collaboration can serve as a benchmark for other coastal regions facing similar challenges, promoting conservation practices that incorporate both scientific and traditional knowledge.

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