COOKING OIL BIOFILTER BASED ON TABOA FIBER (THYPA DOMINGENSIS)

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ABSTRACT

In Brazil, oil consumption is about three billion liters per year and it is estimated that for every four liters consumed, one is discarded incorrectly, representing more than 700 million liters released into the environment without proper care annually. The present project seeks to create and evaluate the functionality of a biofilter made from Taboa (Typha domingensis) fiber for the adsorption of oils thrown in residential sinks. To achieve the objectives, comparative tests were performed with two hydrophobic materials: Paina and Taboa fibers, seeking to show the efficiency of Taboa compared to other material already researched as an oil adsorbent.

Keywords : *TBiofilter, Vegetable Oil, Taboa, Adsorption, Water Pollution*

1. Introduction

Water is one of the essential elements for life to exist, being present in 70% of the human body's composition and also covering 70% of planet Earth. However, the distribution of this resource is quite uneven among the different regions of the planet. In this sense, and considering only fresh water in liquid form, the most adequate and most used for human consumption, about 13% is found in Brazilian territory. Therefore, we are well served by this vital element (OECD, 2015; UN, 2021).

Despite all the amount of water in the country, it is not available to all due to geographical and economic factors, and even in places where water exists abundantly, it is not suitable for human consumption, which occurs more evidently in urban centers, as in the case of Recife, which despite having about 99 urban channels and five major river has a system of water rotation for its inhabitants. (GALINDO, 2009; SOUZA, et al, 2018).

According to the World Water Resources Development Report, 2021, conducted in cooperation, by different UN Agencies, water consumption on the planet has increased 6 times in the last century and continues to increase about 1% per year, resulting from population growth, economic development and changes in consumption patterns among different societies. At the same time that the demand for the resource increases, the quality of the water drastically increases the reality of water scarcity, which already affects more than 2 billion people around the world and Brazil is one of the countries that stand out in this regard. Still according to the UN (2021), it is estimated that water consumption will increase by 25% by 2030.

In addition to the physical or economic scarcity of water, the lack of this resource also occurs due to the increasing degradation of water sources and bodies of water, mainly as a result of human actions. Among the forms of water degradation, the discharge of different types of oils causes great concern, because they produce adverse effects on fauna, flora, and human life, and when it occurs on a large scale, it also affects the economy, tourism, and even daily activities. It is important to highlight that oil is one of the wastes that has a high power of contamination when thrown directly into river courses through disposal in the trash or in the drains of sinks. (BRASIL, 2010; SOUZA, et al, 2018; SILVA et al, 2021)

Given the above, this research seeks, from laboratory experiments, to evaluate the use of the taboa fiber (Typha domingensis), to create a mechanism for filtering oils dumped in household sinks.

In the history of evolution of human society, oils represent an extremely relevant resource and considering vegetable oils, their importance is not only for their use in gastronomy, but also for economic, political and biological reasons. From the Mesopotamian and Ancient Greek peoples to the present day, the use of oil plays a relevant role, since it has the most diverse applications, whether for heating, illumination, food, cosmetics production or even energy production (SANTOS, 2020).

Considering only the edible oils, according to data from the German consulting company, Oil World, the world per capita consumption of domestic oil is, on average, fifty milliliters per day. As far as Brazil is concerned, oil also plays an important role, since about three billion liters are consumed per year, according to the Brazilian Association of Vegetable Oil Industries (ABIOVE, 2022).

However, it is important to highlight that oils are highly polluting substances and with great capacity to degrade ecosystems, especially aquatic ones, because due to its chemical composition, oil is immiscible with water, i.e., they do not mix, and oil is lighter (less dense) than water and when they mix, oil stays on top of water.

On a scale of environmental impact, edible vegetable oil is less polluting than oil of fossil origin such as petroleum, however, the contamination of water by edible oil causes damage to the functioning of the 9 water and sewage treatment plants and makes waste treatment more expensive by up to 45% and the part that remains in rivers may cause soil sealing, this still contributes to the occurrence of floods. (SOUZA,2018).

Despite causing great negative impact on one of the vital elements for life, the disposal of oils in household sinks is still a silent problem that deserves more attention, debate and environmental awareness, with a view to finding solutions that add up to the protection of water resources

2. Aim and Problem Question

Lately, news about oil spills in aquatic environments has become more and more frequent and society as a whole has turned its attention to this environmental problem. In this sense, it is important to include in this debate the problem of edible oils being thrown into the sewage system through domestic sinks.

Research data from SABESP 2022 indicate that only 1 liter of oil can contaminate 25 thousand liters of water. The oil substances are not dissolved in water and, if discharged into river courses, they cause oxygen depletion and the death of aquatic species. In contact with the soil, the oil also causes contamination, not to mention the enormous damage caused by the accumulation of oil residues in the pipes of domestic sinks, which can cause serious problems for the maintenance of the networks and higher costs to make repairs and repairs (SABESP, 2022). (Fig.1).

Fig. 1: Release of edible oils in sinks Source: Alves & Araújo (2016)

In this sense, among the residues discharged into the collecting networks, lipids occupy the place of greatest pollutant of the sewage among the other materials, with about 60% of the contamination. In this context, the oil that has as final destination streams, rivers, and seas, promotes processes of environmental imbalance such as the eutrophication of water bodies and aquatic contamination in coastal areas. The discharge of oil into water bodies can also impede gas exchange and the passage of sunlight, impair breathing and photosynthesis of life submerged in a river, leading to the reduction of aquatic life or even the extinction of some of them.

In addition, oil pollution makes water treatment up to 45% more expensive, and aggravates the greenhouse effect, since the contact of water polluted by oil when flowing into the sea generates a chemical reaction that releases methane gas, a much more aggressive component than carbon dioxide. This is extremely serious when we analyze that the Brazilian federal government spends more than 600 million dollars on water treatment (ARCOVERDE,2022).

Despite being a long-debated topic, the solutions presented are still palliative or not very efficient, as in the case of storing oil in containers for later disposal and recycling, a solution that is still not very common among most Brazilians (SABESP,2022).

Data from the report of the Brazilian Association of Vegetable Oil Industries (ABIOVE) indicate that only 10% of the oil consumed in Brazil is recycled. One of the possible reasons for the low household oil recycling numbers may be the need to always have a pet bottle handy and also that the consumer has to store and deliver the product later to collection environments. Thus, the disposal process for possible reuse does not correspond to the population's perspectives and ends up being an inefficient measure since it is neglected by most users of cooking oils (ABIOVE, 2022) .

Also, according to Abiove, the consumption of edible vegetable oils in Brazil is around three billion liters per year and for every four liters consumed, one is discarded incorrectly, which represents more than 700 million liters per year thrown into the environment without proper care and control (ABIOVE, 2022).

Regarding legislation, the National Policy on Water Resources (PNRS) defines cooking oil as solid waste. For, although the oil has a liquid consistency, in contact with water it solidifies. Also, because it is a discarded waste from human activities, which is contained in a container and because it is not feasible to dispose of it in the public sewage system or in water bodies (BRASIL, 2010) (Fig.2).

Fig. 2: Flow of incorrectly discarded oil Source: Siqueira & Plese (2021)

Aiming to solve the environmental problem exposed, it is believed that the creation of a portable mechanism, capable of retaining the oil dumped in household sinks may present itself as an efficient solution. Thus, the hypothesis of this project is that the taboa fiber may be the ideal product for production in a biofilter for adsorption of cooking oil.

The objectives of the work are to produce and evaluate the use of a biofilter based on Typha domingensis (Typha domingensis) fiber for the adsorption of cooking oil thrown into household sinks and, consequently, into rivers. Analyze the viability of the taboa as oleophilic material for adsorption of lipids; Create prototypes of biofilter based on the taboa fiber with low-cost material for absorption of edible oil. Comparing the efficiency of the taboa fiber as an adsorbent of edible oil in comparison with the Paina fiber (Ceiba Pentandra), are part of the research needs.

As a theoretical basis, we took as reference the work developed by Oliveira (2010), in which the author conducted experiments to evaluate the solvent capacity of plant fibers from different species, including the aquatic macrophyte taboa (Typha domingensis).

The cattail (Typha domingensis) is a macrophyte that occurs naturally in freshwater environments. It is a perennial, herbaceous plant native to South America, with a cylindrical stem, averaging 1.5 m in height. It is quite abundant and produces about 7,000 kg of fruits (rhizomes) per hectare. Despite reproducing in a degraded environment, its rhizomes are edible, possessing protein value equal to that of corn and carbohydrates equal to that of potatoes (MOGROVEJO, 2019) (Fig. 3).

Fig. 3: Taboa plants in a construction site cavity Source: Authors (2022).

Aquatic macrophytes plants, such as Taboa, are widely used for the purpose of reducing contaminant loads and improving the quality of wastewater, because they act as biofilters in the removal of pathogenic microorganisms from the water and in the treatment of water with high load of pollutants, presenting high absorption of organic matter. The aquatic macrophytes also play the role of primary producers, providing habitat and refuge for several species of animals and also act as a substrate for algae, supporting the chain of detritus and herbivory and serving as a nutrient storage compartment (KREBS et al, 2021).

In addition to acting in water purification, Taboa is also considered an excellent adsorbent of oils, mainly from its fruit. This functionality of the plant is due to its high degree of hydrophobicity, buoyancy and high content of lipids 2.41% in its structure, providing significant surface adsorption of different types of oils, considering that the fruit has few empty spaces in its structure (OLIVEIRA, 2010).

The taboa fiber contains about 33.95% cellulose, 33.24% hemicelluloses, between 1.62% lignin, 2.06% ash and a moisture content of 9.33%. Taboa fruit has about 46.6% carbon, 5.96% hydrogen and 1.11% nitrogen and these properties contribute to lipid adsorption. (KHAN et al, 2004; Oliveira, 2010; MOGROVEJO,2019). Research attests the efficiency of the taboa fiber as an adsorbent of oils, however, tests and application of this fiber as a biofilter for sorption of edible oil were not found in the literature, which increased the interest in developing the present work. Thus, and considering that the main alternatives used to reduce the impacts resulting from the degradation of aquatic environments by edible oil spills still do not present significant results, it is expected, with this research, to contribute to the debate about the importance of developing alternative and low-cost methods that can reduce the damage caused by the release of oils in river courses using the taboa fiber.

3. Materials and Methods

Three stages were defined for the execution of the project, specified below.

Stage I: Data survey and creation of biofilter models.

The data was researched on sites of agencies and entities that work in the search for solutions to the problem of degradation of water sources and its causes, especially from the release of oils.

Based on the theoretical research, an oil sorption biofilter model was developed, considering the dimensions of different types of domestic sink drains used in Brazil. Two types of drains were chosen to create the biofilter prototype.

Stage II: Selection of the oleophilic filter material.

The choice of the Taboa tree fiber was based on the results obtained by other researches regarding biodiesel sorption and also because it is abundant and easy to find in nature. In order to carry out comparative tests, besides the Taboa tree, it was also selected Paina fiber (Ceiba Pentandra), a material already tested for the sorption of different types of oil, including vegetable oil (Fig. 4).

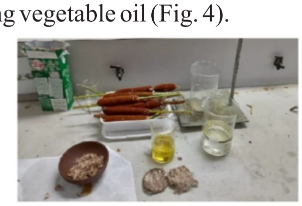

Fig. 4: Test material. Source: Authors (2022)

Stage III: Prototyping and testing with the use of taboa and kapok fibers and tulle fabric.

The biofilters were tested in reused coffee capsule containers, pet bottles, and disused sink drains.

For each filter half of a Taboa fruit was used. The fruit was loosened, crushed, and the fiber was placed inside each prototype. In the filter with the kapok fiber, half a fruit fiber was used. The fibers received lemon drops, were placed for drying and in perforated containers simulating sink drains (Fig. 5).

Fig. 5: Containers used to support the biofilter. Source: Authors (2022)

To analyze the functionality of the biofilters, five types of tests were performed, as described below (Table 1).

Table 1: test objectives performed, Recife. Source: Authors (2022)

	experiments performed in the laboratory
test 1	analyze water circulation
test 2	comparison of efficiency between diferent fibers
test 3	comparison of efficiency between different layers
test 4	comparison with the use of lemon additive
test 5	evaluation of biofilter reuse

In experiment 1, the circulation of water through Taboa and Paina biofilters prototypes was verified (Fig. 6).

Fig. 6: Prototypes of the biofilter. Source: Authors (2022)

In experiment 2, preliminary tests showed the adsorption of oil - pouring 200 ml of water and 50 ml of oil over each biofilter, the one with the Paina and the one with the Taboa fibers (Fig. 6), simulating the discharge of oil into sinks.

In experiment 3 the biofilter with a double layer of Taboa, without inserting lemon juice, was tested, seeking to verify the real capacity of oil adsorption by Taboa, the substance chosen for the biofilter.

In experiment 4, tests were performed at the Federal University of Pernambuco to compare the Taboa biofilters with and without the use of lemon (Fig. 7).

Fig. 7: Comparative test between double taboa filters with and without lemon at UFPE, Recife. Source: Authors (2022)

In experiment 5 the reuse of the Taboa biofilter was evaluated, after the oil adsorbed by the fiber was removed and the material was dried (Fig. 8).

Fig. 8: Water and oil solution after filtration. Source: the authors, (2022)

4. Results and Discussion

The tests indicate that the use of two layers of taboa fiber, forming a double filter, was more effective than the use of a single layer, being also more efficient than the biofilter of kapok fiber. The results obtained matched the results achieved by Oliveira (2010), when using the taboa fiber to absorb diesel oil. It is worth noting that the experimentation process cost only the value of one kilogram of lemon and 1m² of tulle to produce the biofilter prototypes.

After the experiments it was observed that the double Taboa fiber filter adsorbed about 49 ml of the 50ml poured and the water flowed without difficulty. Thus, the biofilter showed an average efficiency of 99% absorption, confirming the oleophilic property and hydrophobicity of Taboa, while the millet biofilter obtained an oil adsorption of about 60%. The part of oil (10 ml) that managed to pass through the Taboa filter presented a different coloration and the water had a clearer appearance (Table 2).

Table 2: corroborative results performed at UFPE, Recife.Source: Authors (2022)

Tests	Liquid Volume (ml)	Oil Retention Volume (ml)	Percentual Retention
1: biofilter with lemon	Oil(50 ml) Water(200 m	45 ml	80% of retention
2: biofilter without lemon	Oil(50 ml) Water(200 m	49 ml	98% of retention

These results indicate that the double biofilter made of woven wattle without the use of lemon has a higher efficiency than the others. It is important to emphasize that tests were also performed with the taboa fiber after the first use, attesting to the possibility of reusing the material, after cleaning and removing the absorbed oil.

The corroborating results attest to the effectiveness of the biofilter produced, being a viable and sustainable solution to the serious problems arising from the discharge of oil into river courses from households. After being used in the biofilters, the fibers of the Taboa and Kapok were stored in a container for later removal of the adsorbed oil. The plant material will be sent to Sempre Viva, a non-governmental organization that performs the separation of oil for soap production and the introduction of plant compounds in a biodigester system in order to synthesize fertilizer and biogas.

5. Conclusion

In view of the tests performed and the corroborating results achieved, it can be concluded that the taboa is a viable alternative as a material for making the oil filter for adsorption of household oils. For being an ecologically sustainable material, of low cost and easy to obtain, the taboa has its viability confirmed. So far, the experimentation has shown results within the authors' expectations and, as a further step, it is planned to introduce the use of the biofilter in 10 homes in order to monitor the performance of the biofilter in a real situation.

It is believed that an accessible, practical and innovative solution to the issue of domestic oil disposal is possible with the use of the Taboa biofilter. Thus, it is also expected that the research can contribute to the development of a sustainable alternative of easy development and application and low cost, aiming to considerably reduce serious socio-environmental problems such as the improper disposal of oil into the sewage system.

Finally, it is noteworthy that this research is innovative, considering that no literature has been found about the possible production of a biofilter made of Taboa bean. It is hoped that the product created will contribute to reduce the damage caused by the discharge of oil into rivers and contribute to a healthier environment for all, in close accordance with the Sustainable Development Goals proposed by the UN.

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