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Use of the *Moringa oleífera*Lam seed and biological filters as an alternative method for the clarification of raw water

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Abstract: The objective of this work was to analyze the efficiency of the *Moringa oleifera* Lam seed when associated with the biological filter for clarification of raw water. For the filtration system, three containers were used and installed in a decreasing way. The first container was used as a decanter for the addition of raw water and Moringa seeds, the second used as a biological filter obtaining divisions for the filter media such as: cuttings, ceramics, activated carbon and the third container for receiving filtered water. The raw water samples were collected at the Water Treatment Station and the seeds were collected from the planting of the same species. Comparative physical-chemical analyzes of raw water with water treated with seeds and filtered were carried out, and the results represented in graphs. The biological filter shows efficiency by clarifying only the raw water and when added to the water treated with the seed it favors even more the physical-chemical quality. The vegetable coagulant and the biological filter are an alternative method for clarifying water, since it is necessary to control the filtration period, proving that 10h00min of filtration is the best time to reduce turbidity and pH stability.

Keywords: Biological coagulant, treatment, filtration, comparative parameters.

Introduction

The *Moringa oleífera* Lam is a native tree from the North of India, composed of only one genre (Moringa), fourteen known species and because it is a tropical vegetable, easily adaptable it is currently found in many countries (Bhatia et al., 2007; Rangel, 2011). It's fruit is a type of pod with three faces that contains a large number of seeds (Bezerra et al., 2004).

The use of *M. oleífera* seed for the clarification of water with turbidity has been the subject of many scientists studies (Ndabigengesere et al., 1995; Moraes, 2004; Santos et al., 2013).

In some developing countries, poor communities use water from rivers for consumption and domestic use. However, these superficial resources close to urban zones, industries and deforested areas are the ones most affected by pollution containing a great variety of particles and those increase the turbidity levels, especially during the rainy season (Borba, 2001). Therefore, the lack of investments to treat or do basic sanitation of the water, which are important to remove impurities, leads to diseases and infections caused by contaminations (Pereira, 2006; Jacinto et al., 2011).

The chemical coagulants act in the agglutination of organic and inorganic substances that contemplate the clarification of water with turbidity. The aluminum sulfate ($Al_2(SO_4)_3$) is a reagent usually used in conventional treatments. However sometimes it is not available at a reasonable price (Santos et al., 2013). Besides, the use of that product produces a toxic non-biodegradable waste, making it difficult to be decomposed in the environment (Lima Vaz, 2009).

As we need alternative and more economical methods to treat the water, many studies have been made with the seed of *Moringa oleífera* Lam, species that has coagulant and bactericidal properties (Rangel, 2011; Formentini - Shimitt, et al., 2014). Researches have demonstrated that the natural coagulant agents present advantages in the treatment of water and effluents when compared to chemical agents when it comes to biodegradability, low cost and toxicity (Santos et al., 2013).

The seed of the *Moringa* plant contains amino acids, fatty acids, vitamins, nutrients and phenolics, which are functional groups able to absorb suspense materials and mechanic ions (Moraes, 2004; Yin, 2010). In this sense it is classified as one of the best vegetables for the clarification of water, mainly when associated with

simple sedimentation, with slow filtering (Formentini-Schmitt et al., 2014), being able to lower the turbidity without altering the pH (potential of hydrogen), therefore not causing corrosion problems (Gallão et al., 2006; Pritchard et al., 2010).

Another convenient operation for the clarifying of water is through filtering, a process developed many years ago that consists of a system with a slow sand filter that is able to reduce the turbidity (Duarte, 2011). Alternatively in the projection of that system you can have modifications such as changing the filtering mean material like for instance, natural zeolites (Mwabi et al., 2011), tree bark or others that present the ability to retain particles (Baig et al., 2011).

However, there is not enough research with natural methods to clarify water with high turbidity coming from effluents, streams and rivers that need low cost investments for treatment. In that context this paper has the purpose of analyzing the efficiency of the *Moringa oleífera* Lam seed when associated to the biological filter to clarify raw water, looking to compare the physical parameters (turbidity levels) and chemical (pH levels) before and after the treatment.

Materials and Methods

To make this experiment a biological filter was installed in the Zoology Laboratory of Unifunec - Centro Universitário de Santa Fé do Sul/SP in August 2019. The raw water was collected directly from the first effluent arrival of SAAE - Serviço Autônomo de Água, Esgoto e Meio Ambiente from the city of Santa Fé do Sul/SP and the *M. oleífera* Lamseeds werecollected from a harvest of the species in General Salgado/SP, a city close to the area.

The filtering system was installed in a decreasing way, associated to the process of decantation of the raw water treated with the seeds (Image 1). For the installation were used a plastic box and to glass recipients with a capacity of 50 liters each, being that one recipient had 4 divisions and was used as filter. Another box was installed above on the wall, being used for decantation of the raw water that was treated with crushed seeds. On the side of that box a tube was inserted and a tap to control the volume of water going down to the next recipient, the biological filter. The filter was made of glass to facilitate the visibility of the color of the water and for safety, to be able to support the weight of the added materials, and for that they had 4 descendent divisions to organize the filtering means like: large gravels added to the first division, medium gravel on the second, smaller ones on the third and ceramic and activated charcoal added to the last division. On the side of the filter it was also inserted an opening for the filtered water to come out, leading it to the third recipient that contained a subversive pump with the purpose of redirecting the water back to the biological filter, making it a continuous filtration process.

Image 1. Biological Filter System.
1: Decanter. **1.a:** Outflow of water treated with seeds.
2: Biological Filter. **2.a:** Receipt of treated water. **2.b:** Flow rate of filtered water.
3: Receipt of filtered water. **3.a:** Submerged pump. **3.b:** Filtered water directed to the filter again.
Source: The authors.

As an experimental outline two evaluation methods were used, with two repetitions each, with the purpose of analyzing the efficiency of the filtration systems. In all those tests 55 liters of raw water were collected and one liter was taken as a comparative sample to be used in the laboratorial analysis.

The first method's goal was to evaluate the efficiency of the biological filter using the raw water. To do so the decantation of the water collected in the first recipient of the system went on for 02h00min and after that the water was released to the biological filter, and redirected to the filter throughout a 24 hours period. However, that period samples were taken at 05h00min; 10h00min and 15h00min to be analyzed.

Next, the second method was used to evaluate the efficiency of the Moringa seed in the clarifying of the raw water when associated to the biological filter. Following the recommendations of Ndabigengesere & Narasiah (1998),250 seeds were used for 50 liters of water. The seeds were peeled, grounded, weighed in an analytical scale and, in the end, were added to raw water in the decanter, waited for the sedimentation of the suspended particles for 02h00min and then directed it to the biological filter to be continuously filtered. Samples of the water treated with the seeds, samples of treated and filtered water with the same duration of filtration as the first method to do the physical analysis (turbidity levels) and chemical (pH levels) in order to compare the parameters of the raw water (Image 2). Having those results, the variables of turbidity and pH were submitted to variance analysis (SISVAR) through the Turkey test ($p<0,05$) and the significant differences were compared and described in charts.

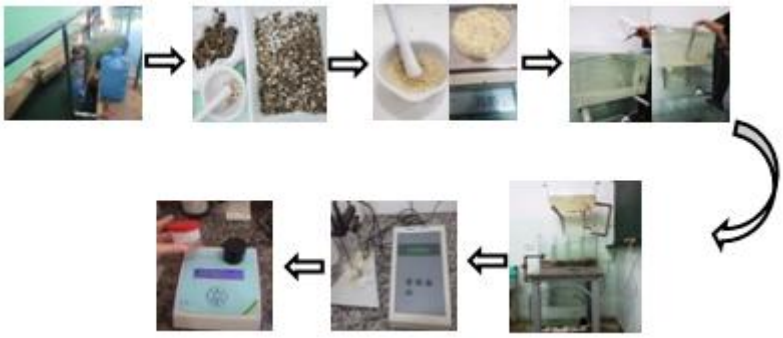

Image 2. Quadrogram of the materials and methods used for the experiment.
Source: The authors.

Results and Discussion

On the first method, it was observed that the biological filter presented efficiency in clarifying the raw water. For that reason, with 05h00min and 10h00min of filtration the water was visually with less turbidity. The physicochemical analysis of the first test pointed to satisfactory results, in which the water filtered for 10h00min presented statistically ($p<0,05$) the best level of turbidity of 3.27, a lot lower index if compared with the raw water that had a level of 9.02. As well as the second test, the filter reached a better clarification after 10h00hrs of filtration, were the raw water started with 14.85 of turbidity and was reduced to 5.89. The pH levels of both tests had statistic differences but both maintained an index between 7.0 and 8.0, that is considered as neutral (Image 3). In fact, the suspended particles present in the raw water stayed adhered to the materials in the biological filters, assisting in the clarifying process of the water. The use of gravel and ceramic as filtering means idealizes the modification of materials for the filtering system (Mwabi et al., 2011; Baig et al., 2011) when verified the capacity of removing the colloidal substances. However, at 15h00min of filtration there was an increase in turbidity and lowering of the pH for both test 1 and test 2, verifying indexes of turbidity of 7.25and 8.79 and indexes of pH of 6.89 and 6.67, respectively.

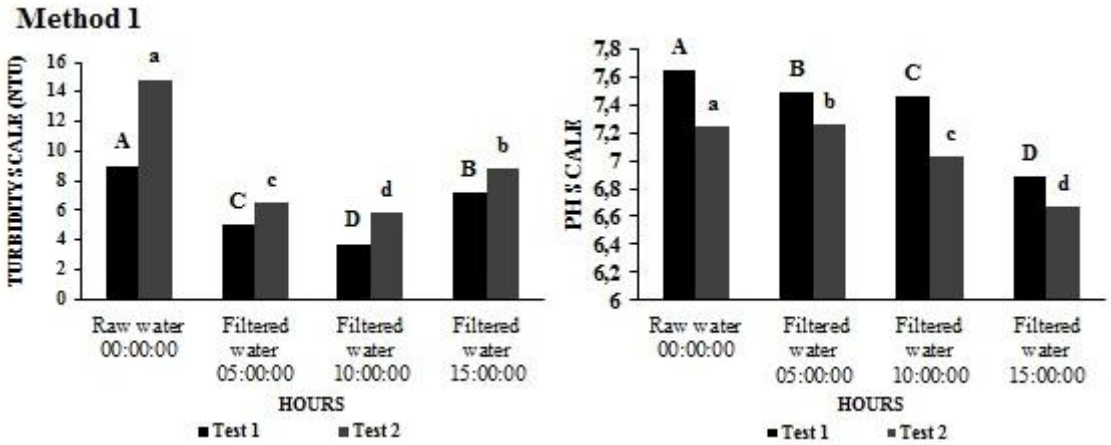

Image 3. Results of the physicochemical analysis of method 1 (efficiency of the biological filter for the clarifying of raw water)
Different uppercase letters indicate statistical differences between the times of the test 1. Different lowercase letters indicate the statistical differences between the times on test 2. Statistical analysis Turkey ($p<0,05$)
Source: The authors.

As for the second evaluated method, the *Moringa oleífera*seed was showed to be efficient as a biological coagulant in relation to the turbidity of the raw water. It is known that the seed contains functional groups such as the amino acids, fatty acids, vitamins, nutrients and phenolics that are able to absorb suspended materials and metallic ions (Moraes, 2004; Yin, 2010).

In reference to the physicochemical results of the analyzed tests, associating treated water with biological filters caused the turbidity levels to drop even lower, getting close to zero in 10h00min of filtration for both tests. In that case, the turbidity index went down to 0.75 on test 1 and 0.98 on test 2. The pH levels as well in that filtering time were stable, being the main research data that corroborates with the research of Gallão et al., (2006) and Pritchard et al., (2010).

The parameters observed in 15h00min of filtration had similar effects to the first evaluated method, due to the increase of turbidity to 5.02 and reduction of the pH to 6.38 in the first test and the increase of turbidity to 6.48 and reduction of the pH to 6.90 in the second test (Image 4). The filter showed to be efficient of a determined period of time, meaning that a long time filtration would interfere with the quality of the water

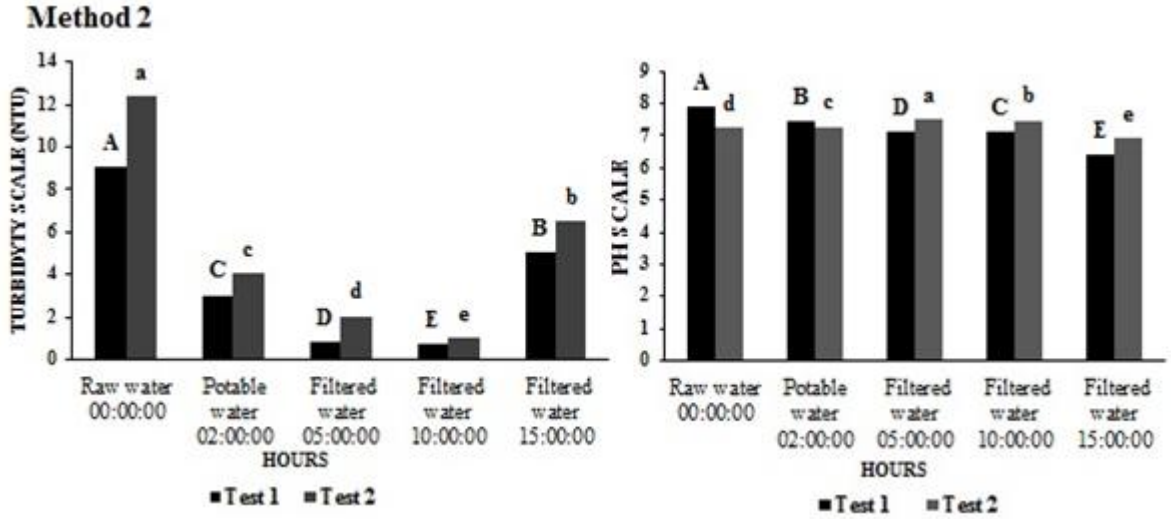

Image 4 Results of the physicochemical analysis of method 2 (efficiency of the Moringa seed and biological filter for the clarifying of raw water)
Different uppercase letters indicate statistical differences between the times of the test 1. Different lowercase letters indicate the statistical differences between the times on test 2. Statistical analysis Turkey ($p<0,05$).
Source: The authors.

With that we can consider that the Moringa seed is classified as an excellent vegetable for the clarifying of turbid water, and so, when associated with slow filtering, if favors even more the physicochemical quality of the water (Formentini-Schmitt et al., 2014), as shown on Image 5.

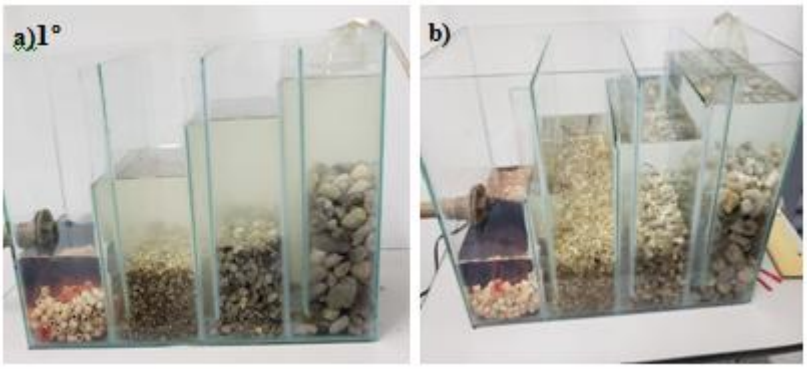

Image 5 a) Water treated with Moringa seed added to the filter
b) Water treated after 5 hours in the filtering means.

Source: The authors.

Conclusions

1. The biological filter presents efficiency clarifying the raw water and when the water is treated with the *Moringa oleífera* Lam seeds the physicochemical qualities are favored.
2. The treatment of the raw water through a vegetable coagulant and biological filter can be an alternative method for clarifying, being needed to control the filtration period, as the study shows that 10h00min of filtering is the best time to reduce turbidity and stabilize the pH.

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