RCMOS – Multidisciplinary Scientific Journal of Knowledge.
ISSN: 2675-9128. São Paulo-SP.

Year V, v.1, n.1, Jan/July 2025. | submission: 2025-02-03 | accepted: 2025-02-05 | publication: 2025-02-07

USE OF MORINGA OLEIFERA SEEDS IN THE TREATMENT OF TURBID WATER, COLLECTED DIRECTLY FROM THE BÚZI RIVER FOR HUMAN CONSUMPTION

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Summary

Drinking water can be defined as water suitable for human consumption, that is, free of pathogenic substances and organisms that can cause diseases, in addition to having no color, taste or smell..Turbidity in the water can be caused by erosion of the banks of the Buzi River during rainy seasons, due to the lack of vegetation fixing itself to the soil. Sewage and various industrial effluents and mining activities that sometimes occur along the river also cause increases in water turbidity. One of the major challenges for the scientific community is to seek methodological processes that reduce the harmful impact on human health. Moringa oleifera seeds contain proteins with low molecular weight when their powder is dissolved in turbid water, acquiring positive charges that attract negatively charged particles such as clays and silts, forming dense flakes that settle. In this context, the study aimed to evaluate the amount of Moringa oleifera seed powder needed, the time for sedimentation and removal of turbidity, and the effect on the pH of the water collected from the Buzi River for consumption by the population of the regions it flows through. The experiment was carried out with samples of 50, 100, 150, and 250 mg of moringa powder in 500 ml of water; and only one sample of 500 ml of water did not have moringa powder added. The results of the research show a decrease of up to 95% in turbidity at the concentration of 50 mg as well as optimization of pH.

Keywords: Moringa oleifera seeds. Natural coagulant. Turbidity. Human consumption.

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Abstract
Potable water can be defined as water suitable for consumption, that is, free of substances and organisms that can cause diseases, 1 and also without color, taste, or odor. The turbidity of water bodies can be caused by the erosion of river banks during the rainy season, resulting from the misuse of the soil, such as the lack of vegetation fixation. Sanitary sewage and various industrial effluents and mining activities also cause increases in water turbidity. One of the great challenges for the scientific community is to seek methodological processes that reduce the impact on the environment. Moringa oleifera seeds contain low molecular weight proteins, which, when their powder is dissolved in water, acquire positive charges that negatively attract charged particles such as clays and silts, forming dense flakes that sediment. In this context, the study aimed to evaluate the ideal amount of Moringa oleifera seed powder and the best sedimentation time for the removal of turbidity and its effect on the pH of water from the Búzi River consumed by the population of regions whose only source of acquisition of the precious liquid are rivers. The experiment was carried out with 50, 100, 150, and 250 mg of powder/500 mL and another 500 mL of water to which no Moringa powder was added. The research results show a reduction of up to 95% in turbidity at a concentration of 50 mg, as well as optimization of pH.
Keywords: Moringa oleifera seeds, natural coagulant, turbidity.

1. Introduction

Water is the source of life. All living beings, without distinction, depend on it to survive. However, despite its importance, people continue to pollute rivers and their sources, forgetting how essential they are for the permanence of life on the planet.

Water to be consumed by humans cannot contain dissolved substances at toxic levels nor carry in suspension pathogenic microorganisms that cause diseases, which is why it is important to analyze its potability qualities before being consumed.

The present research entitled "**use of moringa oleifera seeds in the treatment of turbid water, collected directly from the Búzi River for human consumption",**It was conceived through the study with the samples collected on the banks of the Búzi River, as it was this water resource that attracted attention for the present study to be carried out, hence the study was developed along the banks of this river, specifically in the town headquarters of the Chibabava District, crossed to the north by this river.

The research lasted ten (10) months, that is, from November 2016 to September 2017.

The present work had the general objective of evaluating the effectiveness of the moringa oleifera seed in clarifying turbid water that is consumed by communities along the Búzi River;

And as a specific objective it aimed to:

✔ Determine the ideal amount of moringa seed powder for clarifying the cloudy water;

✔ Check for changes in organoleptic, physical-chemical and microbiological data from water treated with powder from Moringa oleifera seeds;

✔ Analyze the degree of turbidity and pH of raw water and treated water with seed powder. moringa oleifera.

The population living along the banks of the Búzi River has untreated water as a source of acquisition for their consumption, even though it poses health risks due to its non-potability. Given this assumption, the following research question was raised:**:**

✔ ***"How much Moringa Oleifera Seed Powder is needed for clarification of the turbidity of water collected from the Búzi River for human consumption?"***

In addition to this question, the following was also considered as an auxiliary research question:

✔ ***"What benefits come from using Moringa oleifera seed powder in treatment of water from the Búzi River for human consumption?"***

To achieve the objectives of this work, the following methodology was used:

✔ Bibliographical Consultation

✔ Experimental Method

2. THEORETICAL FRAMEWORK

2.1. Important Concepts

2.1.1 Drinking water

According to Afonso and Domingos (2009) water suitable for drinking must be colorless, odorless, tasteless and free from pathogenic bacteria or microorganisms.

According to Souza (2014), drinking water can be defined as water free of substances and microorganisms that can cause diseases, in addition to having no color, taste or smell. For water to be considered drinkable, we must therefore analyze its physical, chemical, biological and even radioactive characteristics..

Many people think that crystal clear water is drinkable and therefore does not need to be treated. However, color and odor alone are not enough to guarantee that water is safe for consumption, since sub-microscopic pathogenic organisms can be present.

present and cause serious harm to health. Therefore, drinking water cannot be assessed only visually, and potability tests are essential.

According to Souza (2014), river and lake water is not normally suitable for human consumption, and it is essential that it undergoes specific processes in water treatment plants. After treatment, it is important that analysis tests are carried out to confirm whether the treated water meets the potability standards required by the Ministry of Health. If it meets the standards, the water can be sent to the population.

Among the standards required by the Ministry of Health,highlights include the analysis of fecal coliforms, monitoring of*Escherichia coli,*analysis of turbidity and chemical substances present, including cyanotoxins and verification of pH, taste, odor and radioactivity. (Souza, 2014)

The World Health Organization estimates that around 748 million people worldwide do not have access to safe drinking water and approximately 1.8 billion people use contaminated water. This means that a large portion of the population is at risk of contracting diseases that can even lead to death. (WHO, 2006)

The lack of drinking water in the world has several causes, with pollution and the lack of planning in the distribution of this resource standing out..Therefore, it is important that policies be created urgently to ensure the conservation of water bodies, the decontamination of rivers and that water distribution occurs in an appropriate manner. Constant investment in sanitation is also essential, as this ensures that sewage is disposed of properly and that quality water reaches the population. (WHO, 2006)

It is important to highlight that drinking water is a valuable asset that deserves attention not only from governments. Each person, by wasting water in their homes or polluting a river, for example, is contributing to a reduction in the amount of drinking water. Doing our part is ensuring quality of life for our generation and future generations.

2.1.2 Quality standards

Substances in water can be classified according to their specific properties (inorganic, biological, radiological) or according to other characteristics associated, for example, with their uses and functions. (Alves, 2007).

Quality standards are the quantitative instrument that expresses the minimum characteristics that water intended for human consumption must comply with (Alves, 2007).

According to Alves (2007), each country must stipulate its legal criteria taking into account the following objectives:

● Absence of chemical substances in toxic and micro-toxic concentrations. pathogenic organisms;

● Absence of characteristics that are detrimental to the maintenance of the system supply;

● Be colorless, odorless, fresh, have a pleasant taste and be free of microorganisms.

2.1.3 Raw water sources

According to Suluda (2012), the main sources of raw water are four (4), namely:

● ***rain water***are those that result from rainfall, they are water for the Human consumption, but they lack dissolved salts and are saturated with oxygen and nitrogen;

● ***Surface continental waters***are those that are found on the surface terrestrial and can be classified from the point of view of their origin into three (3) classes:

● Á***mountain water***(lotic waters);

● ***River waters***(lentic waters);

● ***Waters of lakes and reservoirs***.

2.1.4 Quality of water for human consumption

According to Paulos (2008), the concept of quality presents, simultaneously, great ambiguity and great diversity. For this author,*Quality*is not, therefore, a word whose meaning is objective and univocal. This concept of quality is relative, since it is based on the objectivity of the user, or the purpose for which the water is intended. Water that is suitable for drinking may not be suitable for other purposes (agriculture, industry, etc.), and vice versa. For example:

● Distilled water, which is almost pure, is not suitable for drinking, or, more strictly speaking, its consumption would eventually lead to the death of the consumer, due to the loss of minerals that would be removed from the body;

● Water for human consumption is not suitable, for example, for bleached paper pulp industry, as it contains a certain amount of iron, an element essential to life, which would cause rust stains on the paper.

Therefore, there is no water whose quality, in absolute terms, is suitable for all purposes.

According to Paulos (2008), for the direct consumer, water quality is assessed, at first glance, by its organoleptic properties. In order for it to be drunk, unconditionally and without repugnance, it must be clear (colourless), odourless (without smell) and not have any unpleasant taste. However, water that presents these characteristics may not be suitable for human consumption, as it may be contaminated with pathogenic organisms, for example. In order for it to be consumed without restrictions, it must meet many other requirements, which cannot be assessed sensorially.

It can be concluded that water for human consumption has the following quality requirements: not to pose a risk to health, not to cause damage to distribution systems and to have organoleptic characteristics that do not negatively affect its acceptance by the consumer.

2.2 Organoleptic characteristics

Organoleptic characteristics include color, smell and taste. The origin of the color presented by natural waters is due, individually or in combination, to the following causes:

● Natural inorganic origin, due to the presence of metallic compounds, mainly iron and manganese;

● Organic, animal or vegetable origin;

Industrial origin, due to the discharge of industrial effluents (textiles, paper pulp, refineries, chemical industries). (Paulos, 2008),

It is common to define two types of color: apparent and true. Apparent color is the color of the water as it appears, that is, with all suspended matter. True color is the color that the water presents once suspended matter has been removed. The fact that water is not clear does not mean that it is free of toxic or dangerous products.

Smell, according to Rodier et al., (2011), can be defined as:

● The set of sensations captured by the sense of smell when in presence of certain volatile substances;

● The quality of each particular or individualized sensation caused by each one of those substances.

The existence of smell and taste in water can be, as in the case of color, a sign of pollution or the presence of decomposing organic matter.

2.3 Physicochemical characteristics

The characteristics that are considered most relevant to this study will be addressed, which are the following:

2.3.1 Hydrogen Potential (pH)

The pH expresses the concentration of hydrogen ions; its value for pure water at 25 ºC is equal to 7.0, less than 7.0 in an acidic medium and greater than 7.0 in an alkaline medium. It is naturally altered by the dissolution of rocks, photosynthesis or anthropogenic means through domestic and industrial waste. It is important for the environment, since chemical reactions are strongly affected by its value (Silva, 2012).

According to Loriatti and Matheus (2009), pH is an important parameter that can provide clues to the degree of pollution, the metabolism of consumers or even impacts on an aquatic ecosystem. Natural waters have a pH between 4 and 9, influenced by the dissolution of CO_2, which results in low pH values. In general, when the pH approaches 9, it is because carbon dioxide has been removed from the water by algae during the process of photosynthesis.

2.3.2 Turbidity

Turbidity, according to Cordeiro (2008), is evidenced by the presence of particles in suspension and in a colloidal state, presenting a strong relationship with biological contamination.

Henning (2011) reinforces this information when he states that turbidity can cause harm to health, especially when it is anthropogenic, as microorganisms that cause various waterborne diseases and toxic compounds aggregate in the particles.

According to the WHO (2006), turbidity is a characteristic of water due to the presence of particles in a colloidal state in suspension, finely divided organic and inorganic matter, plankton and other sub-microscopic organisms. It is expressed by the interference of the passage of light through the liquid being measured in a turbinimeter or nephelometer and is expressed in nephelometric turbidity units (NTU).

Turbidity is therefore an expression of the optical property that causes light to be scattered and absorbed through the sample rather than transmitted in a straight line. The clarity of a natural body of water is one of the main determinants of its condition and productivity. (Parron, 2011).

Turbidity in water bodies can be caused by erosion of riverbanks during rainy seasons, resulting from poor soil use, such as lack of vegetation on the land. Sewage and various industrial effluents and mining activities also cause increases in water turbidity. The first cause shows the systemic nature of pollution, when interrelations or transfers of problems from one to another occur in the environment, such as from soil to water (Piveli, Kato, 2006).

Raw water from surface sources presents variations in its turbidity between rainy and dry periods; when it is dammed, the turbidity is reduced due to the sedimentation of particles. In raw water, it is considered one of the main parameters for selecting treatment technologies and controlling treatment processes (WHO, 2006).

When the presence of turbidity causes a reduction in the intensity of the light rays that penetrate the body of water, it influences the characteristics of the ecosystem present and when the particles settle, they form mud banks where anaerobic digestion leads to the formation of methane and carbon dioxide gases, mainly, in addition to gaseous nitrogen and hydrogen sulfide gas, which is foul-smelling (Piveli, Kato, 2006).

The increase in this variable unbalances the trophic chain, causing changes in the biodynamic cycles, interfering in the speed and intensity of photosynthetic action, which is harmful to fish (Alcântara, 2006).

The sources that are most vulnerable to sources of contamination and susceptible to seasonal variations in water quality are, respectively, surface sources, unconfined (phreatic) and confined (artesian) water tables. Regarding suspended particles (turbidity) and sedimentable pathogenic organisms (e.g. protozoa), dammed groundwater, natural lakes or dams in general, have better quality than running water, but they can eutrophicate, accentuating the color due to the proliferation of algae and cyanobacteria. Groundwater is protected, as it is only subject to natural sources of pollution or contamination, resulting from soil characteristics, such as iron, manganese, arsenic and fluorides (WHO, 2006).

In filtered water, turbidity is considered a health indicator, its removal through filtration indicates the removal of suspended particles, cysts and oocysts of protozoa.

2.3.3 Hardness

In general, hard water is defined as water that requires a large amount of soap. to produce foam or which cause scale build-up in hot water pipes, pans or other equipment in which the water temperature is high. This forms what is commonly referred to as "pan stone". Although with the advent of detergents the problem of hardness, in terms of soap consumption, has lost its impact, the same cannot be said about incrustations. (RODIER, et al, 2011)

The hardness of natural water varies considerably from place to place, with surface water generally being less hard than groundwater. The hardness of water reflects the nature of the geological formations with which it has been in contact. (Piveli, Kato, 2006).

Hardness (usually expressed in mg/L of calcium carbonate $CaCO_3$) of water is due to the presence of divalent metal cations mainly calcium ions (Ca^{2+}) and magnesium (Mg^{2+}). Hard water is water that contains large amounts of calcium and magnesium. These divalent metal ions are generally associated with the bicarbonate anion (HCO_3^-), sulfate (SO_4^{2-}), chloride (Cl^-) and nitrate (NO_3^-). (RODIER, et al, 2011)

However, it is common to distinguish between temporary (or carbonated) hardness and permanent (or non-carbonated) hardness. The former is due to calcium and magnesium that are bound to bicarbonates and are eliminated when the water is boiled. Permanent hardness is due to calcium and magnesium that are associated with sulfates, chlorides, nitrates, etc. and are not eliminated when the water is boiled. (RODIER, et al, 2011)

2.3.4 Conductivity

Conductivity is a numerical expression of the capacity of water to conduct electric current. Depending on the ionic concentrations and the indicated temperature, the amount of salts present in the water column, and therefore represents an indirect measure of the concentration of pollutants. In general, levels above 100 mS/cm indicate impacted environments. (RODIER, et al, 2011)

Conductivity also provides a good indication of changes in the composition of a water, especially in its mineral concentration, but it does not provide any indication of the relative amounts of the various components. As more dissolved solids are added, the conductivity of the water increases. High values   may indicate corrosive characteristics of the water. (Piveli, Kato, 2006).

2.4 Sources of Water Pollution

According to Cesan (2011), during its circulation on the Earth's surface, water can be contaminated by humans and animals. This happens mainly in cities, where sewage from homes, hospitals and factories is released without treatment into rivers, lakes and seas.

Contaminated water is a powerful vehicle for disease transmission. Water-related diseases have diverse origins and are mainly caused by bacteria, viruses or parasites. Cesan (2011),

2.5 Standards of water used in Mozambique (maximum and minimum admissible limits)

According to MISAU (2004), water is considered drinkable when it is free of total coliforms, fecal coliforms and cholera vibrio, has a tasteless, colorless taste, P_H in the range of 6.5 to 8.5, turbidity not exceeding 5 NTU and low concentrations of chemical parameters. However, for untreated public water supply, a fecal coliform parameter not exceeding 10 can still be considered.

2.6 Water Treatment

It is common for river water to have a muddy, cloudy appearance before being treated (raw water) and a color that ranges from yellow or light purple to dark purple. The turbidity of the water is caused by particles of material that are suspended (clay, sand, microalgae). The color of the water is caused by dissolved or finely divided organic substances. At the water treatment plant, these substances are removed in order to make the water suitable for human consumption. (Heller, et al., 2006),

The purpose of water treatment is to ensure its potability, that is, to protect public health by making it as pleasant to the eye and taste as possible, and to avoid the destruction of materials in the water supply system.

According to Heller, et al. (2006), two main mechanisms of disease transmission through water are observed: by biological agents, the ingestion of water contaminated by pathogenic microorganisms, and transmission due to lack of hygiene due to a decrease in the quantity of water. Although it is common to say, from a technical point of view, that any type of water can be made potable (make drinkable), the health risk and costs involved in water treatment contaminated water can be very high, requiring the use of increasingly costly and sophisticated techniques, such as water disinfection using chemical products (chlorine and ozone) or even ultraviolet light. For this reason, priority should be given to actions to protect water sources, that is, where, according to Heller (2006, p. 55), "treatment begins with the choice of raw water collection".

Depending on the climate, geological and biological characteristics and existing anthropogenic activities, the characteristics of water and its treatment needs vary (Ribeiro, 2010). According to CESAN (2011), water treatment occurs in stages and involves chemical and physical processes. The addition of chemical products contributes to making water drinkable.

Water Treatment Steps and Chemical Products used are:

1st Stage: Sieving: At the raw water collection point there is a screening system that does not allow the passage of leaves or large solid waste, which can clog the pumping and treatment system.

2nd Stage: Coagulation

Chemical added:Aluminum Sulfate or Polyaluminum Chloride (PAC) **3rd Stage: Flocculation**

Chemical added:cationic, anionic or neutral polymer. **4th Stage: Decantation or Flotation**

No chemicals are added at this stage of the treatment. **5th Stage: Filtration**

No chemicals are added at this stage of treatment either. **6th Stage: Disinfection (Chlorination)** ***Chemical added:****Chlorine (Cl_2)* **7th Stage: Fluoridation**

Chemical added:Fluosilicic Acid (H_2SiF_6)

8th Step: Neutralization or pH correction

Chemical added:Hydrated Lime (Ca(OH)2)

Hydrated lime or calcium hydroxide is a chemical product used in water treatment to correct the pH (hydrogen potential). During treatment, the water comes into contact with chemicals that give the water acidity and this needs to be corrected. (Cesan, 2011).

2.7 Advantages of Using Biological Coagulants Over Chemical Coagulants

The use of a natural coagulant produced on site at low financial cost can alleviate the problems associated with the consumption of non-potable water and the discharge of untreated wastewater into receiving water bodies. Coagulant/flocculant has demonstrated advantages over chemical coagulants, specifically in relation to biodegradability, low toxicity and low rate of production of residual sludge (Monaco et al. 2010).

Natural polymers, such as cassava and potato starches, have proven their use as flocculation and/or filtration aids. In addition to starches, which are widely used as flocculation and/or filtration aids, other biopolymers can be used for the same purpose, such as okra and moringa (Scariotto, 2013).

One of the studies carried out is the use of biopolymers from Moringa Oleifera seeds in the water treatment process, as it promotes the coagulation of organic matter with a smaller fraction than that of chemical coagulants, reducing the formation of sludge, not altering the pH of the water, reducing turbidity and color, and also contributing to the removal of up to 90% of bacteria, as most of them are found aggregated to particles disseminated in the water, thus reducing the amount of chlorine in the disinfection process, making the process biodegradable (Santos, 2013).

Yarahmedi et al. (2009) experimentally showed, when comparing the coagulation efficiency of aluminum chloride and moringa seed extract, that the final pH of the water sample was not altered with moringa extract, while aluminum chloride caused a reduction in the same.

2.8 The seeds of the Moringa oleifera

Seeds, when compared to leaves, pods and bark, have better coagulation/flocculation potential. According to the experimental results, the active proteins are contained only in the seeds, therefore, to ensure effectiveness in water treatment, it is ideal to use recently harvested Moringa oleifera seeds, since the coagulation efficiency decreases with the storage time of the seeds. However, they are considered highly active because they produce high reductions in turbidity of raw water for a maximum period of 18 months, significantly reducing its potential and becoming inefficient after 24 months, especially for raw water with turbidity below 100 NTU (Valverde et al., 2014).

Moringa oleifera seeds contain low molecular weight proteins; when their powder is dissolved in water, they acquire positive charges that attract negatively charged particles such as clays and silts, forming dense flakes that sediment (Valverde et al. 2014).

Table 1–**Proximate chemical composition of moringa oleifera seeds**

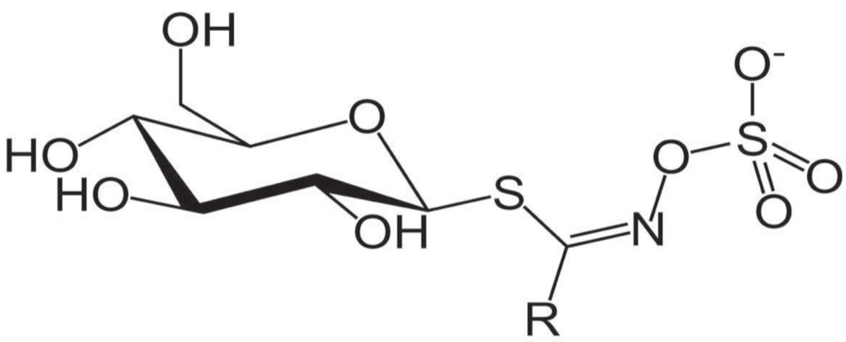
Centesimal composition (in g)	***Seeds (100g)***
Humidity	3.27
Inorganic matter	3.09
Proteins	25.14
Lipids	22.17
Organic matter	46.33

Source: FERNANDES, et al. (2012)

2.8.1 Structure of the coagulant substance present in the moringa seed

Active substances with three main components are found in the cotyledons of the seeds: flocculants – which are polypeptides (proteins), substances that have not yet been clearly identified, and antimicrobial substances, which in the water purification process can reduce the bacterial load by up to 97% in a short period of time (Almeida, et al. 2008).

Figure 1:**Structure of the coagulant substance present in moringa seeds (Glucosinolate)**



Source:https://upload.wikimedia.org/wikipedia/commons/1/13/Glucosinolateskeletal . Accessed at: May 14, 2017

2.9 Importance of proper water treatment

Water is an essential element for life, but it must be of good quality. According to the World Health Organization (WHO, 2006), many children die every year from diseases related to contaminated water.

According to Miranda (2007), the coagulation-flocculation process aims to remove organic or inorganic turbidity that does not settle quickly, the true and apparent color, eliminate bacteria, viruses and pathogenic organisms that can be separated by coagulation, destroy algae and plankton in general and remove phosphates, which serve as nutrients for the growth of algae, eliminate substances that produce flavor and odor and chemical precipitates.

3 MATERIAL AND METHOD

3.1. Research methodology

According to Gil (2008, p.8), a method is “a set of intellectual and technical procedures” necessary for scientific research. Since scientific knowledge is based on reason, it needs to be systematic, so that it can be tested and proven by other members of the scientific community, hence the need for the method.

To achieve the objectives of this work, the following methodology was used:

3.1.1 Bibliographical Consultation

Based on this technique, information and relevant ideas were collected from certain bibliographic works related to the topic, such as articles, books, bibliographic works, etc. The theoretical basis for this investigative work was written from these sources.

3.1.2 Experimental Method

The experimental method consists, especially, of subjecting the objects of study to the influence of certain variables, under controlled conditions known by the researcher, to observe the results that the variable produces in the object (Gil, 2008).

This work is merely experimental and consisted of the execution of several activities from sample preparation to the analysis of water quality parameters. Based on this method, an experiment was carried out related to the clarification of turbid water using Moringa oleifera seeds, physical-chemical analysis of the water in which the pH, electrical conductivity, turbidity, amount of calcium ions, total hardness of the water before and after treatment were determined, as well as microbiological parameters such as total coliforms, fecal coliforms and cholera vibrio.

3.2 Data collection instrument

3.2.1 *Direct Observation*

Data collection technique, which does not consist of just seeing or hearing, but examining the facts or phenomena that one wishes to study, a basic element of scientific research. (Lakatos and Marconi, 1991).

Using this data collection technique, it was first observed that the water from the Búzi River was very turbid, and yet the population consumed it because it was the only water available. The turbidity was more pronounced during the rainy season. After collecting the sample, the organoleptic, physical-chemical and microbiological aspects of the water from the Búzi River were observed before and after treatment with powder from the seeds of the Moringa oleifera, which allowed us to determine the appropriate amount of this powder in the treatment of water for human consumption.

3.2.2 *Carrying out the experiment*

The experiment of water clarification using the seeds of moringa oleifera was carried out in the Chemistry laboratory of the Pedagogical University – Beira Delegation, as this laboratory has the minimum conditions for this purpose. Due to a lack of materials for carrying out chemical and microbiological analysis, these were carried out in the Water and Food Hygiene Laboratory.

the) ***Materials***

- ✔ Test tubes
- ✔ Funnel
- ✔ Filter paper;
- ✔ Spatula;
- ✔ watch glass;
- ✔ Beakers;
- ✔ Mortar and pestle; Empty 500mL
- ✔ water bottles

mineral.

b) ***Devices***

- ✔ Analytical balance with precision of 0.0001g Denver Instrumental,

model XE-100;

- ✔ Electrometer;
- ✔ pH – meter.

w) ***Reagents and solutions***

- ✔ Moringa oleifera seed powder;
- ✔ Water from the Búzi river (sample).

3.2.2.1 Sample collection and preparation

The water sample under study was collected from the Búzi River, specifically in the Chibabava region, in the town of..... To collect the sample, a 5-liter container was carefully washed and then the water was drained by placing the container directly into the river, closing it and taking it to the Laboratory where the analyses were carried out.

3.2.2.2 Procedures

- The seeds of the Moringa oleifera were collected, left to dry in the sun and shelled;
- Then, with the help of a mortar and pestle, the seeds were crushed.

seeds until they form powder;

- The powder was stored in a plastic container with a lid to prevent exposure

to humidity;

- 50, 100, 150 and 250 mg of the powder were weighed separately;
- 500 ml of turbid water from the Búzi River was added to each dose of powder;
- The mixture was stirred very well and left to rest for 1 hour;
- At the end of this time, the mixture was filtered;
- Finally, with the filtered water, the physical-chemical analyses were carried out and

Microbiological.

The physical-chemical and microbiological analyses were carried out in the water and food hygiene laboratory in the city of Beira.

3.2.3 Analysis of samples carried out in the water and food hygiene laboratory

In order to verify the effectiveness of the results of the experiment of treating water with powder from Moringa oleifera seeds, the following analyses were carried out in the Water and Food Hygiene Laboratory: turbidity, coliforms (total and fecal) and Vibrio cholerae, calcium and total hardness. For this purpose, five (05) samples were taken to the laboratory, being untreated water from the Búzi River, water treated with 50, 100, 150 and 250 mg of powder from Moringa oleifera seeds respectively. The reports of the analyses at the LHAA are included in the annex to this work.

4 Results and discussion

Water is a limited resource, but it is indispensable and essential. Humans need to consume around 2 to 3 litres of water daily, directly and indirectly. This water must have quality characteristics that guarantee its potability, so as not to become a vehicle for diseases and pollutants.

The objective of this work is to determine the appropriate amount of Moringa oleifera seed powder for the treatment of turbid water.

For this purpose, a comparative method was used, which consisted of analyzing the water quality parameters of the samples treated with Moringa oleifera seeds at different doses. Therefore, the efficient quantity was considered to be that whose parameters were closest to those established by MISAU for drinking water.

The seeds of moringa oleifera were crushed in a pestle and mortar shortly before application, and added directly to the turbid water in four different doses.

In this section, the data are presented and discussed in a table or graph of P_H, turbidity, fecal and total coliforms of the five samples, four of which were treated with moringa oleifera seeds, at single doses of 50, 100, 150 and 250 mg/0.5L respectively, and one untreated 500 ml sample.

4.1 Physical and organoleptic characteristics

Regarding organoleptic characteristics, turbidity was determined using the Turbidimetry method at the LHAA, and the following results were obtained per sample:

- For raw water (untreated) 41.64 NT were obtained;
- Sample $A_1$2.09 NTU was obtained, sample $A_2$2.43 NTU, $A_3$2.66 NTU and $A_4$3.05 NTU

THE**Table 2**It contains an outline of the results of the analysis of the physical and organoleptic characteristics of raw water and water treated with Moringa oleifera seeds in single doses of 50, 100, 150 and 250 mg/0.5L respectively.

Table 2: Physical and organoleptic characteristics (turbidity) of the samples

Sample	***Turbidity Value (in NTU)***
Raw water	41.64
THE_1	2.09
THE_2	2.43
THE_3	2.66
THE_4	3.05
WHO maximum permissible limit	05

Source: Beira Water and Food Hygiene Laboratory, 2017.

(***Sample A_1***) – sample treated with 50 mg/0.5L; (
Sample A_2) – sample treated with 100 mg/0.5L; (
Sample A_3) – sample treated with 150 mg/0.5L; (
Sample A_4) – sample treated with 250 mg/0.5L.

The term turbid water is applied to water containing suspended matter that interferes with the passage of light through the water. Turbidity can be caused by a wide variety of suspended matter, of organic or inorganic origin, ranging from colloidal particles to solids of certain sizes.

In the case of waters originating from the Búzi River, its turbidity is due to colloidal particles and particles of a certain size. According to (Piveli, Kato, 2006), the turbidity of the waters can be caused by erosion of the river banks during rainy seasons, resulting from poor land use, such as lack of vegetation fixation. The same can be observed along the banks of the Búzi River.

The results of the research showed a significant reduction in the turbidity of water treated with Moringa oleifera seeds compared to the turbidity value of raw water. According to (Valverde et al. 2014), this reduction in turbidity was due to the fact that Moringa oleifera seeds have proteins with low molecular weight, and when their powder is dissolved in raw water acquire positive charges that attract negatively charged particles such as clays and silts, forming dense flakes that settle.

4.2 Chemical Analysis

In the chemical analysis the following parameters were determined: pH by the potentiometer method; Electrical conductivity, by the electrometric method; Calcium (mg/L of Ca^{2+}) by the titration method with silver nitrate ($AgNO_3$) and total hardness (mg/L of $CaCO_3$) by the EDTA Titration method.

The results of this analysis are presented in the table below:

Table 3: Comparison between the results of the chemical analysis of raw and treated water with the parameters recommended by the WHO.

Sample	**pH**	**EC (mS/cm)**	**Calcium (mg/L Ca^{2+})**	**Total hardness (mg/L $CaCO_3$)**
Raw water	7.9	0.06	5.6	56
THE_1	7.6	0.07	7.2	52
THE_2	7.5	0.08	7.2	60
THE_3	7.6	0.09	8.0	52
THE_4	7.7	0.14	8.0	66
Parameters recommended by WHO	6.5 to 8.5	0.050 to 20	50	100

EC–*Electrical conductivity*
Source: Beira Water and Food Hygiene Laboratory, 2017.

4.3 Potential of Hydrogen (pH)

Observing table number 03, it can be seen that the Hydrogen potential (pH) did not undergo major changes, this is due to the property that the coagulant has of not altering the pH of the aqueous fluid, leaving a neutral range. This property gives this coagulant a very large advantage when compared to chemical coagulants, such as Aluminum Sulfate, which alters the pH, therefore requiring its correction, as stated by (Monaco, et al. 2010).

4.4 Electrical Conductivity (EC)

Conductivity provides a good indication of changes in the composition of water, especially its mineral concentration, but it does not provide any indication of the relative quantities of the various components. According to Lima (2015), as more solids dissolved substances are added, the conductivity of the water increases. The same was observed by the author, as illustrated by the data in table 3, referring to the results of the chemical analysis of the water.

4.5 Calcium and Hardness

According to Sousa (2001), hardness (generally expressed in mg/L of calcium carbonate $CaCO_3$) of water is due to the presence of divalent metal cations mainly calcium (Ca^{2+}) and magnesium (Mg^{2+}). Hard water is therefore water that contains large amounts of calcium and magnesium.

According to the analysis data presented in Table 3, there is an increase in calcium ions as the quantity of Moringa oleifera seeds applied increases, however these values are in accordance with those established by MISAU, which according to the legislation of this body the maximum value permitted for drinking water is 50mg/L.

Regarding total hardness, a non-linear variation is noted as the quantity of Moringa oleifera seeds applied increases, as illustrated in the values in Table 3. However, these are values accepted by MISAU for water for human consumption, as the maximum value permitted according to this body is 50 mg/L. It should be noted that this hardness is temporary (or carbonated), as the calcium and magnesium that are bound to the bicarbonates are eliminated when the water is boiled.

4.6 Microbiological Analysis

In this analysis, total and fecal coliforms were determined using the multiple tube method and Vibrio Cholerae (Cholera vibrio) using the plate seeding method.

Table 4: Results of Microbiological Analysis of Total and Fecal Coliforms Vibrio Cholerae

Sample	Total Coliforms	Coliforms Fecal	Vibrio Cholerae
Raw water	9	< 3	_
THE_1	≥ 2400	< 3	_
THE_2	≥ 2400	< 3	_
THE_3	≥ 2400	< 3	_
THE_4	≥ 2400	< 3	_
Maximum and minimum limits recommended by WHO	Absent	0 10	Absent

(–) – Absent.
Source: Beira Water and Food Hygiene Laboratory, 2017.

Agreeing with Souza (2014), the presence of fecal coliforms in the water analyzed indicates that the water had been contaminated with fecal material from humans or other animals, which gives an indication that there may be pathogenic microorganisms in it.

In relation to table number 04, a drastic increase in total coliforms was observed after applying the powder from moringa oleifera seeds to samples $A_{.1}$up to A_4. This increase is due to the degradation of organic matter (moringa oleifera seed powder) that served as food for the microorganisms in the water. In summary, it can be concluded that moringa seeds do not eliminate total and fecal coliforms, as the results show that they only reduce turbidity to the standards recommended by the WHO, while fecal coliforms remained.

5 Final Considerations

This section presents the conclusions and recommendations of the research entitled "***Use of Moringa oleifera seeds in the treatment of turbid water, collected directly from the Búzi River for human consumption***"The aim of the work was to find the best quantity of moringa seed powder that offers the best results in treating turbid water. Water to be consumed by humans cannot contain dissolved substances at toxic levels nor carry pathogenic microorganisms in suspension that cause diseases.

The way to assess its quality is through physical-chemical and microbiological (bacteriological) analyses carried out by specialized laboratories. Therefore, the following conclusions were reached:

✔ Carrying out the experiment of treating water with powder from moringa seeds oleifera presented satisfactory results, demonstrating its efficiency in the process of removing turbidity from water as a chemical coagulant, proving to be a viable alternative for use in its treatment, as the results obtained met the MISAU requirements (see table 03) with respect to the turbidity parameters, P_H, CE, Ca^{2+}, total hardness.

✔ All amounts of Moringa oleifera powder applied obtained reductions in turbidity, however, the dose that showed the greatest efficiency in treating water with turbidity is 50 mg of moringa powder in 500 ml of raw water.

✔ It was also observed in the experiment that Moringa does not influence other physical-chemical parameters such as pH, when it does not significantly change its value.

Therefore, it will not be necessary to use other chemical substances to correct the $P_H$up to the neutral range, thus reducing the treatment cost.

✔ Based on experience, it was also possible to show that as more dissolved solids are added, the conductivity of the water increases.

✔ One negative thing noted about moringa is that it encourages the reproduction of micro-organisms manifested by high numbers of total coliforms.

✔ The use of Moringa oleifera is a viable alternative for treating turbid water intended for consumption in rural areas, as it presents positive factors and is economically

viable, with a wide range of use, thus becoming sustainable, it does not pose a risk to humans or the environment, however, care must be taken to disinfect after reducing turbidity.

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