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Efficacy of *Moringa oleifera* seeds in purifying metal-contaminated water

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ABSTRACT

Access to clean, potable water is a critical challenge, particularly in resource-limited regions. This study investigates the potential of *Moringa oleifera* seeds as a cost-effective, sustainable solution for purifying metal-contaminated water. Through a series of experiments, we examined the seeds' coagulation properties and their efficacy in reducing concentrations of specific metal ions, such as lead, cadmium, and arsenic, in contaminated water samples. The results demonstrate that Moringa seeds can effectively reduce metal contaminants to safe levels, making them a viable alternative to conventional chemical treatments. This natural purification method offers a scalable and eco-friendly approach, particularly suited to underdeveloped and developing regions where Moringa plants are abundant. Our findings suggest that leveraging locally available natural materials like Moringa could significantly address the global water crisis, providing affordable and sustainable purification options for communities most in need.

Introduction

Water is one of the most precious resources in our planet because all living things need water. However, 97 % of the Earth's supply is salty water from the oceans, roughly 2% is frozen in ice glaciers, and only about 1% is suitable for human consumption (EWD, 2009). Despite water's importance, globally, 2 billion people lack access to safely managed drinking water and 3.6 billion people lack access to safely managed sanitation (World Bank, Water Group). This tragedy can be experienced firsthand when visiting several places around the world, from the southeast region of Tamil Nadu, India to the parts of Africa, such as Ethiopia and Chad. People living in these regions have to rely on nearby muddy and filthy ponds for all of their water-related daily needs such as cooking, drinking, etc. Nowadays, bottled water is accessible to many of these places. However, the underprivileged majority still have to rely on these muddy water ponds for their needs. Over the years, several solutions were proposed to address these crises. Some of these include germicidal tablets (Perlman 2017) which need to be constantly replenished and the obtained filtered water is prohibitively expensive for the poor living in these villages. Another solution is the LifeSaverⓇ Bottle (Magento Commerce, 2017) which contains a carbon filter with 15 nm holes to prevent even the smallest virus from passing through. The reality of the situation was that these solutions were impractical because of their cost and logistics involved in getting those technologies to the people in need. Therefore, a true solution to this crisis would have to be simple to operate and would have to use the material easily available to the people living in these locations. Such solution would not only provide drinkable water for their everyday life but also empower them with technology they can readily use by themselves.

Water, as stated before, is a dwindling resource. A large portion of the clean water once available to humans is now contaminated, including lakes, ponds, and rivers. There are many pollutants in water, such as detergents, insecticides and herbicides, volatile organic compounds (VOCs), perchlorate, fertilizers, industrial chemical waste, heavy metals (Casper Ohm (2017). Biological contaminants, such as pathogens, salmonella, *E. coli* bacteria, norovirus, and many parasitic worms, are also a major issue (EPA, 2017). The presence of any of these substances in drinking water has the potential to cause serious damage to the consumer's health and well being.

Moringa oleifera seeds have shown promising results in purifying metal-contaminated water. Studies have demonstrated their effectiveness in removing heavy metals such as cadmium, copper, chromium, lead, and zinc, with removal rates ranging from 50% to 90% (Nand et al., 2012).

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The seeds' coagulation efficacy is comparable to conventional methods like alum, achieving turbidity removal efficiencies of up to 96.7% (Sangodoyin, 2013). Moringa seeds also exhibit antimicrobial properties, reducing *E. coli* content in water samples (Sangodoyin, 2013). The seeds' adsorption capacity is attributed to amino acids present in their composition, which facilitate metal ion exchange or complexation (Apori et al., 2020). Factors affecting heavy metal removal include pH, biosorbent dosage, and contact time (Apori et al., 2020). Multiple studies have concluded that *Moringa oleifera* seeds are a cost-effective, biodegradable, and environmentally friendly alternative to conventional water treatment methods, particularly suitable for rural and peri-urban areas in developing countries (Sangodoyin, 2013; Amagloh & Benang, 2009).

Moringa oleifera (Moringa) species is common in the regions of India which has been long used for many traditional food and treatment (Islam et al., 2021). The plant consists of many nutrients, and is a common part of the South Indian diet. The material inside the seeds is not soluble in water yet show meshy structural features. We envision that this material from Moringa seed could be effective in removing contaminants from water. In this project, we set to demonstrate using Moringa seedy materials to remove several typical contaminants, including Cr3+, Fe3+, Ni2+, and Cu2+ ions [6], from “standard waste water”.

Materials and Methods

Moringa seed Preparation

The *Moringa oleifera* seeds, purchased from Amazon.com, were de-shelled and ground into a fine powder by using a mortar and pestle as shown in figure 1. Each seed produced approximately 0.3g of powder.

Figure 1: Moringa powder extraction

To make enough powder for experimentation, approximately 50 Moringa seeds were de-shelled, crushed into a fine powder, and stored away in a sterile jar for use during experiments.

Plant Water

Along with the chemical contaminations discussed in the next section, pre-treatment water was provided from a water treatment plant to test the abilities of Moringa on the water that water treatment plants deal with. We focused on two parameters: turbidity and residue after evaporation. For residue after evaporation, 10g of the pre-treatment water is placed into 3 glass containers, then 10g of deionized sterile water is placed into 2 other glass containers for Comparison. These 5 glass containers are placed onto a hot plate as shown in Figure 3 until all of the water in all 5 containers have evaporated. The weight before and after water removal are recorded. The before and after treatment with Moringa solutions are then compared using a turbidity meter and recorded. The obtained results are discussed in section 3.2 below.

Chemical Preparation

The metal ions that were chosen to test were Ferric Ion (Iron (III)), Chromic Ion (Cr(III)), Nickelous Ion (Ni(II)), and Cupric Ion (Cu(II)). To better handle and control these chemicals, Iron Chloride (FeCl3), Py(ClCrO3H), Nickel (II) Acetate (Ni(OAc)2), and Copper sulfate (CuSO4) were used. “Standard waste solutions” based on these chemicals were prepared by dissolving them in deionizing water and their concentration of the contaminants are between 100ppm to 200ppm. To do this, the 100ppm and 200ppm boundaries were calculated and a proportioned amount of each substance in the 100ppm to 200ppm range was placed into 50g of water using a spatula and then stirred until completely dissolved.

Moringa Experimentation

For consistency, the ratio 0.3g of Moringa per 10g of water was used throughout the experimentation. Each test tube used for experimentation was to hold approximately 5g of water which meant that 0.15g of Moringa was used in each test tube.

First, 5g of the FeCl3 solution is introduced to the test tube. A proportionate amount of Moringa

(0.15g) is added to the test tube. The test tube is capped and then shaken vigorously by hand for 10 seconds. The test tube is then placed in the centrifuge for 2 minutes to speed up the coagulating and settling process. After the time elapses, the test tube is then gently placed in the test tube rack. With the Moringa and the contaminants coagulated settled to the bottom of the test tube, a pipet is used to carefully extract the water at the top of test tube and place it into a glass container as seen in Figure 2.

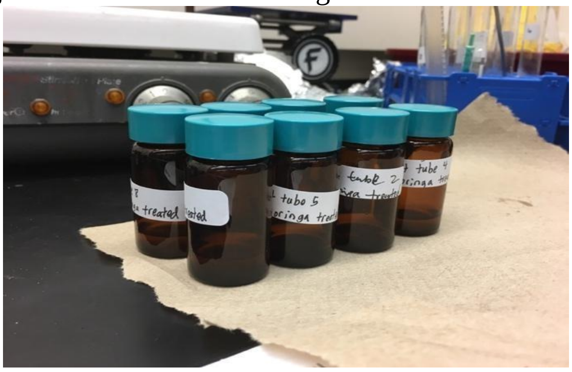

Figure 2: Moringa processed solutions to be tested for turbidity

This process is repeated for the other solutions with two trials each.

The metal ion contaminations before and after the Moringa treatment were then measured using an atomic absorptions spectrometer and the results are discussed in section 3.3 below.

Results and Discussion

Characteristics of Moringa seeds

Moringa seeds are cheap and readily available in tropical regions that are coincidently facing a water crisis (Klimek-Szczykutowicz et al., 2024). These seeds are soft and nutritious. We tested the solubility of these seedy materials in various solvents, and they are not cross-linked network. FT-IR spectrum shown in Figure 3, obtained from a Bruker FX 70 FT-IR system in ATR mode shows complicated structural features. While it is difficulty to elucidate the detailed structures, some typical functional groups, including hydroxyl and amine groups, are clearly shown.

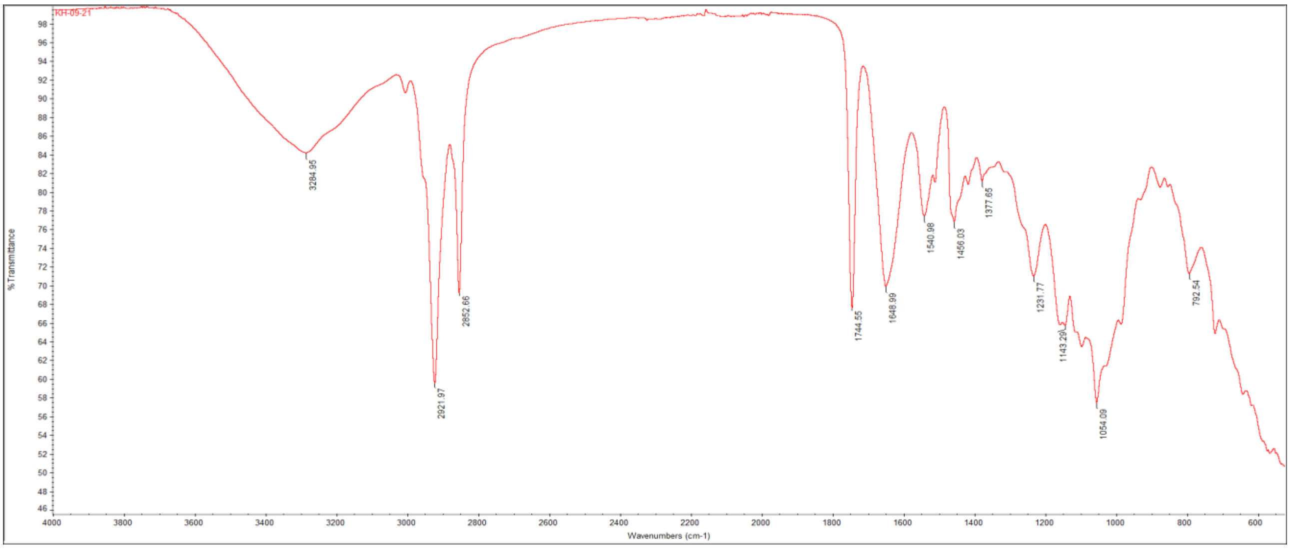

Figure 3: FT-IR spectrum of Moringa seeds

The presence of amine groups shows that the Moringa has potential to remove biological contaminants such as bacteria from contaminated water (Figure 5).

Effectiveness of Moringa in treating plant water

Table 1: pH and turbidity of plant water before and after treatment

Plant Water	pH	Turbidity(NTU)
Before treatment	5.87	17.0
After treatment	6.34	1.9
%change	+8.00	-88.8

Table 2: Residue of the plant water before and after treatment

Plant Water	Residue	Control (DI water)
Before treatment (ppm)	277.7	~5
After treatment (ppm)	63.6	~5

The pretreatment plant water is acidic and also carried at turbidity of 17 NTU. With the use of the Moringa seed powder, the pH of the plant water increased by 8%. The pH after Moringa treatment was closer to 7 than before the Moringa treatment. This demonstrates and proves Moringa's ability to remove the acidic components from plant water. Also there is a significant reduction in turbidity (88%), which proves Moringa's effectiveness on the removal of particulates in contaminated water. In addition, Moringa seed is also effective in removing solid sediments as indicated in the residue test in Table 2, through coagulations.

Effectiveness of Moringa in removing metal ions

Table 3: Effectiveness in removing metal ions calculated from prepared solutions; measured with atomic absorption spectra

	Cr	Cu	Ni	Fe
Before (ppm)[a]	149.6	92.5	157.9	141.8
After (ppm)[b]	14.1	21.0	17.9	9.2
% removed	90.6	77.3	88.7	93.5

The metal ions studied are common contaminants in the water of developing countries (Chowdhuryj et al., 2016). Using a single Moringa treatment it can be noted that Moringa is effective in the removal of the metal ions from water. All of the sample had more than 75% of the total metal ion contamination removed. In the Iron (Fe) solution, 93.5% of the contamination in the original solution were removed with the Moringa treatment. The Chromium (Cr) solution had 90.6% of the contamination in the original solution removed with the Moringa treatment. The Nickel (Ni) solution had 88.7% of the contamination in the original solution removed with the Moringa treatment. Then the Copper (Cu) solution had 77.3% of the contamination in the original solution removed with the Moringa treatment. This data proves Moringa is a reasonably effective purifying agent for metal ions. The possible mechanism is a combination of chemical absorption and physical coagulations.

Conclusion

Moringa seed powder could be an effective natural water purification material for the developing world. It effectively removed a significant percentage of an array of metal ions from contaminated water. Moringa can also remove acidic substances to bring it closer to pH neutralization. Moringa can effectively reduce the turbidity in grey water.

Detailed studies are needed to explore the effectiveness of Moringa as an antimicrobial agent. Other common contaminants such as pesticides and fertilizers require detailed studies to validate and expand Moringa's abilities as a natural purifying agent. With the development and validation of Moringa as natural purification agent, a larger percentage of the world will now have access to potable water.

References

(EWD) Earth's water distribution. United States Geological Survey. 2009. Available online: http://ga.water.usgs.gov/edu/waterdistribution.html (accessed on 15 May 2009)

Amagloh, F. K., & Benang, A. (2009). Effectiveness of Moringa oleifera seed as coagulant for water purification. African Journal of Agricultural Research, 4(1), 119-123.

Apori, S. O., Atiah, K., Hanyabui, E., & Byalebeka, J. (2020). Moringa oleifera seeds as a low-cost biosorbent for removing heavy metals from wastewater. STED Journal, 2(1), 45-50. https://doi.org/10.7251/STED2002045O

Casper Ohm (2017). Chemical water pollution « Water Pollution Guide. http://www.water-pollution.org.uk/chemical.html.

Chowdhury, S., Mazumder, M. A. J., Al-Attas, O., & Husain, T. (2016). Heavy metals in drinking water: Occurrences, implications, and future needs in developing countries. Science of The Total Environment, 569–570, 476–488. https://doi.org/10.1016/j.scitotenv.2016.06.166

Egbuikwem, P. N., & Sangodoyin, A. Y. (2013). Coagulation efficacy of Moringa oleifera seed extract compared to alum for removal of turbidity and E. coli in three different water sources. European International Journal of Science and Technology, 2(7), 13.

EPA (2017). National Primary Drinking Water Regulations. EPA. July 11, 2017. Accessed October 17, 2017. https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations#Microorganisms.

https://www.worldbank.org/en/topic/watersupply

Islam Z, Islam SMR, Hossen F, Mahtab-Ul-Islam K, Hasan MR, Karim R. Moringa oleifera is a Prominent Source of Nutrients with Potential Health Benefits. Int J Food Sci. 2021 Aug 10;2021:6627265. doi: 10.1155/2021/6627265

Klimek-Szczykutowicz M, Gaweł-Bęben K, Rutka A, Blicharska E, Tatarczak-Michalewska M, Kulik-Siarek K, Kukula-Koch W, Malinowska MA, Szopa A. Moringa oleifera (drumstick tree)-nutraceutical, cosmetological and medicinal importance: a review. Front Pharmacol. 2024 Feb 2;15:1288382. doi: 10.3389/fphar.2024.1288382.

Magento Commerce. Accessed October 17, 2017. http://www.lifesaverbottleusa.com/.

Nand, V., Maata, M., Koshy, K., & Sotheeswaran, S. (2012). Water purification using Moringa oleifera and other locally available seeds in Fiji for heavy metal removal. International Journal of Applied Science and Technology, 2(5), 125.

Perlman, USGS Howard. “The World’s Water.” Where is Earth’s water? USGS Water-Science School. Accessed October 17, 2017.

World Bank, Water Group

https://water.usgs.gov/edu/earthwherewater.html.