IJAAR PUBLISHING®

Open Access Journal of Science Research | ISSN: 3027-1185
Vol. 1, Issue 1 (July-September, 2023) | www.ijaar.org

AGRICULTURAL WASTE TO HEALTH: WASTEWATER TREATMENT WITH BIOCHAR

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ABSTRACT

The protection of the environment is critical to the sustenance of all living things and should not be taken lightly because there are consequences, some of which are permanent. This research concentrated on the conversion of agricultural waste products to biochar, which is the solid carbon-rich product that remains after the pyrolysis process. It has a porous structure and a high surface area, making it suitable for heavy metal adsorption from waste water. Because of their toxic character, heavy metals contribute significantly to the deterioration of the environment as a result of man's daily actions for survival. Based on this, the effluent water from a hair salon was examined both before and after being treated with biochar processed from moringa seeds. However, after treatment, the values for copper (Cu) and iron (Fe) decreased from 12.61 + 0.055 to 1.23 + 0.005 mg/L and 15.10 + 0.039 to 0.99 + 0.009 mg/L, respectively. However, there was no discernible change in pH conductivity. Overall, Cu and Fe heavy metals were successfully removed; 15g of biochar made from moringa seed was sufficient.

KEYWORDS: Waste-water, treatment, Biochar, Processed, Moringa Seed

Published *28/08/2023*
Ekong, E., Ekong, J. & Oniwokpomayo, A. (2023). Agricultural Waste to Health: Wastewater Treatment with Biochar. *Open Access Journal of Science Research*, 1(1), 29-35.

INTRODUCTION

Wastewater, a byproduct of human activities such as domestic and industrial processes, needs to be effectively treated before being reintegrated into natural water bodies. This comprehensive examination explains the complexity of wastewater by examining its composition, historical setting, and associated environmental problems. The significance of wastewater treatment technologies, such as physical, chemical, and biological processes, is emphasized in order to lessen the detrimental impacts of untreated wastewater on ecosystems and public health. The research also emphasizes how crucial it is to use environmentally friendly wastewater treatment methods in order to safeguard aquatic ecosystems and the wider ecosystem.

Industrial wastewater can include a variety of pollutants, including heavy metals, organic compounds, and other harmful substances. It is produced by a variety of production processes. Depending on the type of industry and its unique procedures, the makeup of industrial wastewater might vary greatly. Agricultural wastewater, on the other hand, is produced during farming operations like irrigation, animal care, and crop harvesting and can contain high quantities of nutrients like phosphate and nitrogen as well as pesticides and other agricultural chemicals.

In addition, commercial wastewater is produced by industries like restaurants, hotels, and car washes and often includes large amounts of fats, oils, and grease in addition to cleaning agents and other impurities. Regardless of where it comes from, wastewater must be treated to remove toxins and make sure it complies with legal requirements before it is released into the environment or recycled.

In order to effectively treat wastewater, it typically goes through many phases, starting with primary treatment to remove particles, followed by secondary treatment to remove organic matter, and finally tertiary treatment to remove nutrients and other pollutants. In order to remove developing contaminants from wastewater, such as medicines and personal care items, innovative treatment techniques may also be used.

Due to its toxicity and possible threats to both humans and wildlife, copper is a common heavy metal that is found in natural water sources. As a result of its buildup in water bodies, copper poses a serious environmental problem. Both anthropogenic and natural causes, such as mine, industry, and agricultural practices, can lead to copper contamination of water (Liu et al., 2019). Additionally, copper from plumbing systems can contaminate water, especially in older structures with copper pipes (Siddique et al., 2021).

While excess copper can have harmful consequences on human health, including liver and kidney damage, anemia, and gastrointestinal issues, it is a necessary component for living things (Gupta et al., 2014). Additionally, copper can build up in aquatic habitats and have hazardous effects on aquatic life including reduced growth, reproductive failure, and mortality (Zhu et al., 2019).

There are many potential causes of iron contamination in water, including both natural and human-made processes. Iron can naturally dissolve in water derived from soil and rock formations as well as from groundwater sources that seep into surface water. Iron contamination in water can also be caused by anthropogenic activities such as mining, industrial discharge, and sewage treatment. One example of anthropogenic sources of iron contamination in water is the release of iron and other heavy metals into water sources through leaching or runoff from mining activities, as well as through discharge from industrial activities like steel production and chemical manufacturing (Liu et al., 2019).

The environment and human health may both be negatively impacted by iron contamination in water. High iron levels in drinking water can result in aesthetic issues such stains and discolouration of home furnishings as well as a metallic taste (Siddique et al., 2021). Developmental delays in children and gastrointestinal distress, as well as liver and kidney damage, have all been linked to exposure to high quantities of iron in drinking water (Bolton, 2017). Additionally, iron poisoning in water can encourage the growth of specific algae and bacteria, which harms aquatic life and depletes oxygen levels (Liu et al., 2019). Iron contamination in water distribution systems can also cause scale and deposits, which can restrict water flow and raise maintenance costs (Siddique et al., 2021).

To ensure that wastewater may be safely discharged into the environment, wastewater treatment is a crucial process. Physical, chemical, and biological methods are frequently used in the treatment process to eliminate pollutants. Large particles and debris are removed as part of the process's initial stage using physical techniques like screening and sedimentation (Bolton, 2017). After that, smaller particles and suspended materials are removed using chemical procedures including coagulation and flocculation (Wang et al., 2020). Then, organic debris and nutrients are taken out of the wastewater using biological treatment techniques such activated sludge or trickling filters (Bolton, 2017). Last but not least, disinfection procedures like chlorination or UV irradiation are utilized to eradicate any microorganisms that may still be present in the treated wastewater (Wang et al., 2020). After treatment, the wastewater can be safely discharged into a nearby body of water or reused for non-potable purposes such as irrigation or industrial processes.

The significance of wastewater treatment cannot be emphasized because it protects human health and the environment by avoiding disease spread and reducing pollution in our rivers (World Health Organization, 2018). Untreated wastewater can contain diseases and contaminants that are hazardous to one's health and the environment. Wastewater treatment is critical for protecting public health and the environment. Because of its propensity to bind pollutants together, Moringa seed oil has been recognised as a viable natural and sustainable solution for eliminating oil and grease from wastewater (Gomaa et al., 2020; Adeogun et al., 2019). This technology is a cost-effective and environmentally friendly alternative to traditional wastewater treatment procedures, with important implications for resource conservation and environmental protection (Singh et al., 2017). Given that it has been demonstrated to be efficient in treating a range of wastewater types, the use of moringa for wastewater treatment is an area of research that merits further investigation and development (Gomaa et al., 2020; Adeogun et al., 2019). We can take steps to manage wastewater in a way that is more sustainable and effective by investigating the possibilities of moringa seed oil for wastewater treatment.

Due to its high surface area, porosity, and chemical stability, biochar is a well-known and often used adsorbent for the removal of heavy metals from wastewater (Gupta et al., 2014). Agricultural waste, wood, and coconut shells are just a few of the biomass materials that can be used to create biochar (Girma et al., 2018). A potential precursor for the creation of biochar has been discovered in the agricultural waste known as moringa seed husk, which is high in cellulose, lignin, and hemicellulose (Goma et al., 2020; Wang et al., 2020). Previous research has shown that moringa seed husk can be used to make biochar and that it works well as an adsorbent to remove heavy metals from wastewater (Karadi et al., 2007; Wang et al., 2020).

The primary objective of this research is to evaluate the efficacy of utilizing biochar sourced from Moringa seed husk as a potential treatment solution for eliminating copper and iron from wastewater. The specific aim is to establish the adsorption capacity of the biochar in removing copper and iron ions from the wastewater matrix and to optimize the operating conditions to achieve maximum removal efficiency. The ultimate goal of this research is to present a sustainable and cost-effective treatment method for mitigating heavy metal contamination in wastewater. Moreover, the use of natural adsorbents, such as Moringa oleifera seed cake, was investigated by Ndibewu et al. (2011) as an alternative method for heavy metal removal in wastewater treatment and the study revealed that it was effective.

MATERIALS AND METHODS

Moringa oleifera seeds were obtained for this study from the Agric Road area of Ikot Ekpene Local Government Area in Akwa Ibom State, Nigeria. The seeds were taken to the Department of Science and Technology's Chemistry Laboratory at Akwa Ibom State Polytechnic, Ikot Osurua, Ikot Ekpene, for further examination, the waste water sample was gotten from a hair salon. The material was placed in a sterile bottle and promptly taken to the laboratory for analysis and treatment.

Laboratory equipment such as a beaker, conical flask, weighing scale, measuring cylinder, filter paper, funnel, heating mantle, retort stand, burette, and mesh sieve were utilized as experimental materials in this work. Distilled water, nitric acid, sulfuric acid, zinc chloride, and acetic acid were among the chemicals used. Before being dried in an oven and ashy in an electrical furnace, the Moringa oleifera seeds were pulverized in a grinder and put through a mesh sieve. With the use of graphite sand and an alumina boat, the resultant ash was examined. The active components from the seeds were also extracted and purified using a water bath. Following the procedure outlined by Metcalf et al. (1991), the quantities of copper and iron found in the wastewater prior to treatment were measured using an atomic absorption spectrophotometer (AAS).

Moringa oleifera pod shells were manually removed and the seeds were washed with tap water and then rinsed with distilled water (Shivani et al., 2008). The seeds were then oven dried for 24 hours, ground in a manual blender, and sieved through a 1mm sieve. To defat the sample, the seed powder was mixed in ethanol and mixed with a magnetic striver for 30-45 minutes. Subsequently, the residue was separated from the supernatant by centrifuging for 10 minutes at 400rpm. The supernatant was decanted and the residual solid was dried at room temperature for 24 hours to obtain the seed cake (Shivani et al., 2008).

Carbonization was performed in a tubular electrical furnace. The impregnated sample was placed in an aluminum boat and inserted into the middle of the furnace with a heating rate of 10°C/min until it turned to activated charcoal. The biochar was washed with distilled water until the filtrate reached approximately pH 6. The sample was dried in an oven at a temperature of 90-100°C, allowed to cool, ground into fine particles, and sieved to obtain a particle size of 1mm. The resulting sample was then stored in a desiccator prior to use in the wastewater treatment process (Peavy et al., 1988).

To begin the adsorption process, a retort stand was fixed with a burette and funnel, and a beaker was placed under the burette. Fifteen grams (15g) of activated charcoal were first poured into the burette followed by 20-90g of graphite sand. One hundred milliliters of wastewater was measured in a beaker and poured into the burette filled with biochar and graphite sand. However, it underwent the process called chemistry of adsorption before the water was treated (Karadi et al., 2007).

About 100 ml of the sample was measured into a conical flask, and 15 ml of nitric acid was added. The mixture was then heated with a heating mantle at a temperature of 70-90°C until the solution appeared colorless and reduced to 25 ml. The flask was allowed to cool sufficiently to avoid splattering before filtering with a filter paper. The filtrate was stored for the determination of heavy metals (Metcalf et al., 1991).

For the determination of heavy metals, a stock solution containing 100 mg/ml Cu was prepared by dissolving 2.682 g of CuCl2·H2O in de-ionized water and finally diluted to 100 ml. Standard solutions of concentrations 0.0, 0.5, 1.0, and 2.0 ppm were prepared from this stock solution (Girma et al., 2018).

Iron: A stock solution containing 1000 mg/mg of Fe was prepared from 1.0 g of pure iron wire. The wire was dissolved in 100 ml concentrated HNO3, boiled on a water bath, and diluted to 100 ml with distilled water. From this stock solution, a standard solution was prepared. The concentrations of copper and iron, present in the wastewater after treatment, were determined using an atomic absorption spectrophotometer (AAS) following the method described by Metcalf et al. (1991).

RESULTS AND DISCUSSION

The concentration of heavy metals prior to treatment, the concentration of heavy metals following treatment, and the WHO acceptable limit are all shown in Table 1.

Table 1: Comparison of sample concentration pre- and post-treatment

Heavy metal	**Concentration before treatment**	**Concentration after treatment**	**WHO permissible limit**
Copper(Cu)	15.10 + 0.039	0.99 + 0.009	0.00 ≤ 2.00
Iron (Fe)	12.61 + 0.055	1.23+ 0.005	0.00 ≤ 3.00

From Table 1 it can be observed that after treatment, the values for copper (Cu) and iron (Fe) significantly decreased from (12.61 ± 0.055) mg/L to (1.23 ± 0.005) mg/L and (15.10 ± 0.039) mg/L to(0.99 ± 0.009) mg/L, respectively which is within the WHO permissible limit as seen in Table 1. However, there was no discernible change in pH conductivity. Overall, Cu and Fe heavy metals were successfully removed with 15g of biochar made from moringa seed husk.

This result is consistent with previous studies conducted by Siddhuraju and Becker (2003) and Meneghel et al. (2013), which demonstrated the efficacy of biochar in removing heavy metals from wastewater.

Excessive levels of copper and iron in water can pose various health risks such as nausea, vomiting, diarrhea, gastric complaints, and headaches in the short term, and liver or brain damage over the long term. However, the concentration of copper and iron after treatment in this study was within the permissible limits, indicating that the water is safe for disposal into large water bodies.

Based on the findings of this study, we recommend the use of biochar as a natural adsorbent for the removal of heavy metals from wastewater. This could offer a sustainable, appropriate, effective, and robust water treatment means, particularly in developing countries where access to conventional water treatment methods may be limited.

Moreover, we recommend further studies to investigate the effectiveness of Moringa oleifera seed husk as a natural adsorbent for other heavy metals and pollutants in wastewater. Additionally, more research is needed to optimize the conditions for the biochar process from Moringa seed cake and to evaluate its economic feasibility for large-scale application.

Overall, the findings of this study suggest that the use of Moringa oleifera seed cake as a natural adsorbent holds great potential for the development of sustainable and effective wastewater treatment technologies.

ETHICAL ISSUES

This research does not require permission from any legal or special authority to be published.

CONFLICTS OF INTEREST

All authors declare that no conflict of interest exists in this work.

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