Evaluation of A Dual-Stage Ceramic-Activated Carbon Water Purification System for Efficient Elimination of Broad Spectrum of Contaminants from Water

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ABSTRACT

The problem of access to clean drinking water persists as a global concern. It is estimated that more than 2 billion people lack access to securely managed supplies. According to the World Health Organization, contaminants such as bacteria, viruses, and chemicals pose a significant threat to health, especially in poor areas where conventional purification methods are not possible. This research presents a low-cost two-stage water purifier based on agricultural waste and natural antibacterial agents. The first stage uses activated carbon from cucumber peels to remove organic-compounds, chlorine, and odors while promoting waste management. The second stage uses ceramic filters made from clay and powdered lemongrass, utilizing the antibacterial properties of lemongrass and the structural integrity of clay. The system presents an environmentally friendly, biodegradable alternative to conventional filtration methods. Experimental evaluation found that the clay content of the filters had a moisture content of 10.54%, specific gravity of 1.74 g/cm³, and liquid limit of 32.84%. Initial water samples had a bacterial load of 230 CFU/100 mL, coliform bacteria of 450 CFU/100 mL, and E. coli at 104 CFU/100 mL. Coliforms were reduced by 98% after treatment and bacteria and E. coli completely eliminated. Nitrates and nitrites were reduced to 0.24 mg/L and 0.02 mg/L, respectively, from an initial level of 2.20 mg/L and 0.98 mg/L. This indicates potential improvements in water quality through purification that can be used practically, sustainably, and at a reasonably affordable cost in areas lacking access to clean drinking water.

Keywords: Activated Carbon, Affordable Solution, Ceramic Filters, Sustainability, Waste Utilisation, Water-Borne Diseases.

INTRODUCTION

Safe and clean drinking water is a major concern in this modern age, with over 2 billion people reportedly lacking access to uncontaminated water, according to the World Health Organization. Rife with harmful chemicals and bacteria, contaminated water poses serious health risks, especially in areas with limited infrastructure (H. Bairagi *et al.,* 2011). Increasing consumer concerns about environmental sustainability and health have led to the demand for economical and eco-friendly filtration systems. In the present study, a natural water purifier is described using clay ceramic filters incorporating lemongrass powder and activated carbon prepared from cucumber peels. Cucumber peel, a commonly discarded agricultural waste, contains biopolymers such as cellulose, hemicellulose, and lignin, which have the ability to chelate heavy metals (Gbenro *et al.,* 2022). The pyrolysis of CP can convert it into activated carbon with high porosity and surface area for the adsorption of organic molecules and heavy metals. The decomposition of CP also generates carbon with functional groups that help in contaminant removal (Pezoti *et al.,* 2016). Lemongrass, a lignocellulosic biomass and possessing antimicrobial and antioxidants, can also be valuable. Being cellulose-bearing, lemongrass is perfect for lightweight filter ceramics and, when burn with clay, it increases the pore size that enhances their effectiveness to remove sediments, pathogens (Sobsey *et al.,* 2008). The eco- friendliness of the element is being renewable and contributes to improving the antibacterial potency

of the filter. Both are capable of physically removing bacteria, protozoa, and sediments (Ben Mansour *et al.*, 2007). Moreover, activated carbon eliminates chemicals, chlorine, and organic pollutants, thus improving taste and odor of water. Put together, they form an ideal two-layer purification system in which both chemical and microbial contaminant removals are considered. Though proper design and maintenance are required for perfecting, this system provides a more effective, sustainable, low-cost solution for clean drinking water in resource-scarce areas, thus largely enhancing water safety and quality.

OBJECTIVE

- **Higher Efficiency in Filtration Effect:** This method offers two forms of protection in that it applies ceramic filters that can filter out pathogens and sediments, and activated carbon that removes chemical and organic compounds.
- **Provide Low-Cost Solutions:** Develop a friendly-environment and low-cost water filtration system suitable to communities where the infrastructure of water may not be set up.
- **Improve Health and Sanitation:** Raise the public's health level and decrease waterborne diseases cases while making safe, accessible.

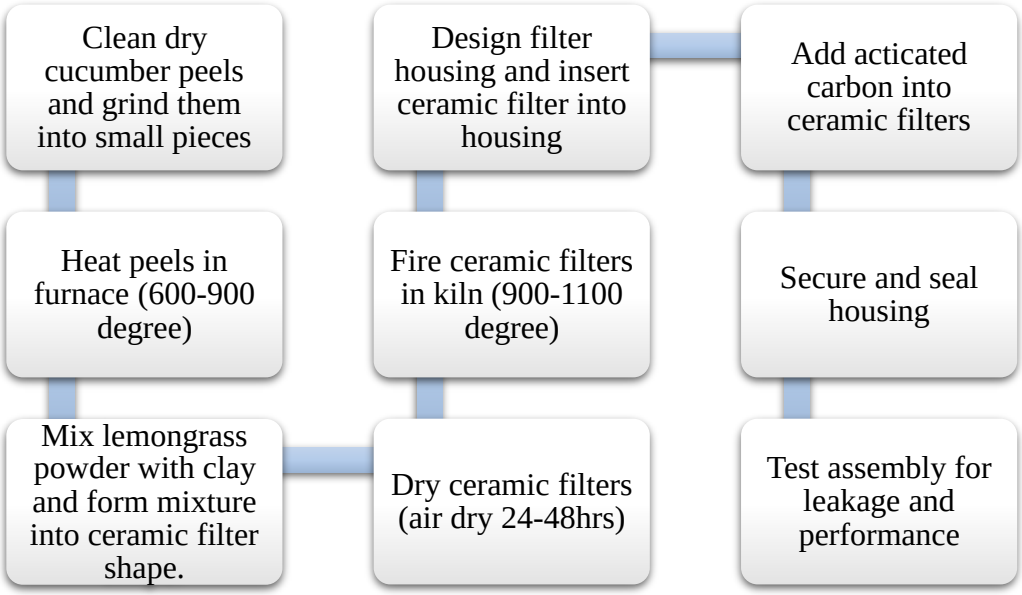
MATERIAL AND METHOD

Material Collection

Gather the ingredients from local market that include:

Cucumber peel, lemongrass powder, binding agents.

Product Development



RESULT AND DISCUSSION

Proximate Analysis of Cucumber Peel and Lemongrass Powder

Proximate analysis of cucumber peel based on AOAC (Association of Official Analytical Collaboration International) methods typically includes the determination of the following components:

Parameter	Methodology	Results of Cucumber Peel	Results of Lemongrass Powder
Moisture Content	Oven dry at 105°C	81%	5%
Crude Protein	Acid base digestion method	12%	4%
Crude Fat	Determined by soxchlet apparatus	0.1%	1%
Crude Fiber	Determined by acid base digestion method	7%	25%
Ash Content	By muffle furnace method at 550°C	5%	7%
Carbohydrate Content	Calculated by difference (100 – sum of other components)	1%	45%

Physical Properties of Clay

The clay was dark brown in color and crystalline in texture. Physical properties of the clay intended for the ceramic filter often determine the output of the filtering system, the following properties were carried out on the clay sample according to the analytical method described by (Niazi *et al.*, (2019), but slightly modified.

Parameter	Percentages%
Moisture Content	10.54%
Specific Gravity	1.74%
Dry Density g/cm	1.61%
Liquid Limit	32.84%
Shrinkage	12.70%

Bacteriological Analysis of Water Samples

The pour plate method was utilized to estimate bacterial counts in water samples before and after filtration, including Gram-positive and Gram-negative staining for coliform and E. coli estimation (CFU/100 mL). Contaminants such as Salmonella, Shigella, Vibrio, and E. coli were analyzed. Initial counts were 230 CFU/100 mL for bacteria, 450 CFU/100 mL for coliforms, and 104 CFU/100 mL for E. coli. The two-stage filter, namely cucumber peel activated carbon and lemongrass-clay ceramic, reduced coliforms by 98% and completely removed E. coli, hence showing its efficiency in the purification of contaminated water.

Physical Analysis of Open Stream Water Before and After Filtration

A dual-stage filtration system led to significant improvement in water quality. Turbidity dropped from 3.42 NTU to 0.98 NTU, thus improving the transparency of the water through suspended particle removal (Ebele *et al.*, 2014). Alkalinity decreased from 90.40 mg/L to 20.30 mg/L, aiding pH stability. Nitrate and nitrite reduced to 2.20 mg/L to 0.24 mg/L and 0.98 mg/L to 0.02 mg/L, respectively. Nitrite levels meet the

NSDWQ standards. Its major components such as silica 79 percent, sulfate 52%, iron 41%, with its total dissolved solids 89 % less content reduced greatly with stable magnesium levels.

Parameter	Instruments	Before Filtration	After Filtration
Turbidity NTU	Turbidity meter	3.42NTU	0.98NTU
pH	pH meter	4.3	6.5
Total Dissolved Solids	TDS meter was used to determine	65.20%	10.80%
Carbohydrate Alkalinity	Titimetric method	90.40%	20.30%
Total Hardness	Titimetric method	37.0%	19.50%
Nitrite	Spectrophotometer	0.98%	0.02%
Nitrate	Spectrophotometer	2.20%	0.24%
Total Iron Fe	Spectrophotometer	50.30%	20.50%
Magnesium	Spectrophotometer	0.89%	0.02%
Sulphate SO_4	Spectrophotometer	19.20%	10.20%
Silica SiO_2	Spectrophotometer	20.50%	4.30%
Calcium	Spectrophotometer	15.0%	9.8%
Total Coliform (cfu/100ml)	Bacteriological method	450(cfu/100ml)	60.0(cfu/100ml)
E.coli (cfu/100ml)	Bacteriological method	104(cfu/100ml)	0.00(cfu/100ml)

CONCLUSION

This experiment shows that a two-step water filter using activated carbon from cucumber peels with powdered lemongrass is effective. The system eliminates pathogenic bacteria such as E. coli and coliforms, and also has the added effect of significantly reducing turbidity, nitrates, nitrites, and heavy metals such as iron and silica. Ceramic filters laden with lemongrass work effectively in capturing particles and pathogens to minimize the problems of microbial and chemical pollution. In the meantime, activated carbon prepared from cucumber peels adsorbs organic chemicals and heavy metals efficiently. In regions without easy access to pure drinking water, this sustainable and cheap method has huge potential to improve public health, reduce waterborne disease, cut waste, and encourage environmental preservation.

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