Surface Water Purification Using Resin and UV Light

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Abstract Access to safe and clean drinking water is a fundamental human right, yet millions of people worldwide continue to face the challenges of inadequate water quality and availability. In this context, the problem statement revolves around the need for portable water filters and an effective system for monitoring and maintaining drinking water parameters. The research aims to develop and optimize portable water purification technologies for the conversion of diverse source waters, including river water and other available water sources, into safe and potable drinking water. A charcoal filter employs different layers of sand, gravel, and charcoal to eliminate murkiness, unpleasant smell, and particles that are suspended in water. Afterwards, the water goes through an ion exchange membrane made specifically for removing dissolved solids and reducing water hardness. Ultraviolet lights are utilized to eliminate harmful microorganisms. The water then flows through a permeable hollow fiber device in order to eliminate bacteria that have been killed. The water quality is subsequently determined using resin technology. This procedure guarantees water that is not contaminated and is secure.

Keywords: charcoal filter, ion exchange, membrane, potable water filter, resin technology, ultraviolet light, water purification.

I. INTRODUCTION

Clean water is essential for a wide range of reasons, as it plays a critical role in maintaining the health and well-being of individuals, communities, and the environment. When we go outdoors for camping hiking or for various activities we mainly have a shortage of clean portable water where finding clean water is next to impossible, In places where there is lack of clean water a clean portable water filter can be used. We are going to design a portable water filter which can solve this kind of problem and will provide clean water. This filter will be convenient, travel friendly and easy to use. The filter has a capacity of 1litre and consists of layers such as various gravel size layers, charcoal layer, sand layer, cotton layer, resin layer along with UV lights. Due to the different layers various issues such as turbidity, ph, etc can be controlled. This filter will be in a shape of a normal bottle and have a small opening at the top from which the impure water can enter which will pass through the different layers and through UV radiations after which it will be clean and will exit through a tap which will be secured at the bottom of the filter.

II. PORTABLE WATER FILTER

A portable water filter is a compact and versatile water purification device that combines several key components, including sand, gravel, cotton, charcoal, aggregate, UV lights, and resins, to transform water from uncertain or compromised sources into clean and safe water for various purposes.

III. SOURCE

Collecting water samples from the Tulsi River within Borivali National Park for purification is a proactive step towards ensuring water quality. The meticulous collection process allows for accurate assessment of the water's condition and contaminants present. Implementing purification techniques, such as UVB light and ion exchange resins, can effectively address any identified issues, ensuring that the water meets quality standards for various uses.

IV. LITERATURE SURVEY

- Daniel Watson,[2023] Charcoal filtration is an effective and eco-friendly method for water purification due to its porous structure, which efficiently traps bacteria, chemicals, and some heavy metals. Types of charcoal used include activated charcoal, known for its high porosity and large surface area, and biochar.To create a charcoal filter, you'll need a container (plastic or glass with a lid), cloth or mesh to hold the charcoal in place, gravel or small stones for improved water flow, and sand to remove smaller particles. Alternatives like ceramic or activated carbon filters can also be used for effective water purification. In summary, charcoal filtration is an affordable and natural way to enhance water quality. Regular maintenance and replacement of the charcoal ensure the filter's continued efficiency.

- Stephanie Nielsen,[2023] The SpringWell UV5 Purification System is a top choice for home water purification, utilizing UV light to eliminate 99.9% of bacteria, viruses, and protozoa. With an impressive flow rate of 15 gallons per minute (GPM), it's suitable for most households. The system is compact (48 inches tall by 6 inches wide) and fits easily in a cabinet, servicing the entire home without altering water taste, color, or odor. The UV lamp should be replaced annually for optimal performance. Other notable systems include the Viqua D4 and Pelican UV Disinfection System with a peak flow of 16 GPM and NSF 55 Class B certification, and the Aquasana Rhino Whole House UV Filter System, praised for its combined filtration and UV purification capabilities.
- Randeep Singh , Vikranth Volli –[2023] Ion exchange resins, produced from polymers like phenol/formaldehyde, styrene divinylbenzene, and acrylonitrile, are modified through reactions such as halomethylation and sulfonation to create specific reactive sites for greater selectivity toward particular ions. These resins, typically in bead or granular form, offer chemical resistance and are effective catalysts, particularly in esterification, due to their enhanced selectivity and reusability. The catalytic efficiency of these resins depends on their degree of cross-linking, which affects their swelling and shrinking properties, thus controlling access to acid sites and overall reactivity.
- Fuhar Dixit , Pranav Chintalapati , Benoit Barbeau [2021]UV-based advanced oxidation shows potential for degrading cyanobacterial toxins in natural waters but is hindered by natural organic matter (NOM), which absorbs UV photons and scavenges hydroxyl radicals, requiring longer exposure times for effective microcystin reduction. NOM also leads to harmful disinfection by-products (DBPs) in treated water. Technologies capable of removing NOM are therefore desirable. A dosage of 1 mL/L can remove over 90% of dissolved organic carbon (DOC) and more than 80% of UV254 absorbing compounds. Pre-treatment with ion exchange (IX) can accelerate MCLR degradation via VUV photolysis by up to three times, with various intermediates observed during the process, including the destruction of the toxic ADDA moiety of MCLR.
- Wilma Bäckström Nilsson [2021] This study highlights the critical need to ensure safe drinking water amid rising demand and contaminants. It focuses on the treatment of natural organic matter (NOM) using carbon filters (CFs) in a drinking water treatment plant (DWTP). The research evaluated the impact of increased flow rates (190 L/s to 280 L/s) and extended empty bed contact time (EBCT) on CF efficiency. Parameters such as particles, UV absorbance, turbidity, conductivity, microorganisms, organic matter, chemical oxygen demand, and odor were analyzed. The results showed no significant effects from increased flow rates or EBCT on CF performance, indicating that CFs can handle future flow rate increases in DWTP expansions. The study recommends further comprehensive analyses of water to understand contaminant fluctuations and the long-term effects of increased flow rates on CF performance.
- Ankit Kotia, Aman Yadav, Tata Rohit Raj [2020] This study addresses the growing need for cost-effective and environmentally friendly water purification methods due to increasing water impurities and awareness of waterborne diseases. Carbon-based materials, such as activated carbon, carbon nanotubes (CNTs), graphene, graphene oxide (GO), reduced graphene oxide (rGO), fullerene, and carbon dots, are identified as promising candidates. The review critically summarizes advancements in water purification using these nanomaterials over the past decade, focusing on their thermophysical properties and fabrication techniques. It highlights the properties that make these materials suitable for water purification and analyzes 71 patents related to this field. Carbon-based materials offer scalable, eco-friendly solutions for water purification,

underscoring their growing importance in research.

- P. Akshay, S. Shreekanth, R. Rajesh, Geena Prasad [2020] The study explores a portable water purifier utilizing multiple filtration stages, including fabric, graphene oxide-coated sand, vetiver grass, and UV filtration, to remove contaminants effectively. It details the purifier's design, fabrication process, and results from water quality testing, alongside user preference surveys and multi-criteria decision modeling to evaluate filtration methods. Design failure mode and effects analysis (DFMEA) identifies potential design issues with preventive actions outlined. Testing shows significant reductions in contaminants, improving taste, odor, and color to meet consumer standards. This innovative, cost-effective, and eco-friendly purifier offers a convenient and efficient solution for regions facing water scarcity and contamination issues.
- Lifan Yue [2020] The study examines ion exchange resin, a synthetic polymer with functional groups that remove dissolved cations or anions from water through ion substitution. It details the resin's structure, function, and applications, especially in water filtration. Pre-treatment methods ensure water meets standards before ion exchange. The resin is vital in reducing water hardness from calcium ions, which can damage industrial equipment. Various resin types, like strong/weak acid cation and anion exchange resins, have different ion removal capacities. Resin regeneration with strong acids or bases restores functionality for reuse. In industries, ion exchange beds purify water, with cation exchange preceding anion exchange to prevent corrosion. Despite being relatively new, ion exchange resins show significant potential, particularly in metallurgy and electronics, for producing ultrapure water. Continuous regeneration is essential, and combining ion exchange with electrodialysis improves efficiency and regeneration.

V. CHARACTERISTICS OF WATER

- pH: Water with a pH range of 6.5 to 8.5 is considered safe for consumption and will not adversely affect the mucous membranes or water supply systems. Any deviation beyond this range can cause harm to mucous membranes and may negatively impact the water supply infrastructure. No relaxation of this standard is recommended.
- Turbidity: Turbidity, measured in NTU, is vital for water quality assessment. The accepted maximum level is 5 NTU, beyond which consumer confidence decreases. Elevated turbidity suggests the presence of contaminants, compromising water safety. Although the upper limit is 10 NTU, it still indicates compromised quality, necessitating remediation measures. Regular monitoring and treatment of turbidity are crucial for maintaining safe drinking water standards and protecting public health.
- Total Hardness: The maximum acceptable level for total hardness in water is 300 mg/L of calcium carbonate ($CaCO_3$). Beyond this, there's a risk of encrustation in water supply structures and adverse effects on plumbing systems and appliances due to mineral precipitation. Encrustation can lead to reduced water flow, clogging, and increased maintenance costs. Elevated hardness levels cause scaling on surfaces, impacting efficiency and longevity. While the upper limit is 600 mg/L, exceeding it significantly heightens adverse effects, emphasizing the importance of maintaining hardness within the recommended range for reliable and sustainable water supply systems.
- Chloride: The maximum acceptable level for chlorides in water is 250 mg/L (milligrams per liter). Beyond this limit, taste, corrosion, and palatability of water are affected. Chlorides contribute to a salty taste in water and can also accelerate corrosion of metal pipes and fixtures, leading to potential damage to plumbing systems. While the upper limit is set at 1000 mg/L, exceeding this level significantly heightens the adverse effects on taste and corrosion, underscoring the importance of maintaining chlorides within the recommended range for optimal water quality and consumer satisfaction.
- Dissolved Solid: The maximum acceptable level for dissolved solids in water is 500 mg/L (milligrams per liter). Beyond this limit, palatability decreases, and it may cause

gastrointestinal irritation. Dissolved solids can impart a salty or bitter taste to water, affecting its overall quality and consumer satisfaction. Moreover, high levels of dissolved solids can lead to potential health concerns, including gastrointestinal discomfort. While the upper limit is set at 2000 mg/L, exceeding this threshold significantly heightens the risk of adverse effects on palatability and health, emphasizing the importance of maintaining dissolved solids within the recommended range for safe and pleasant drinking water.

VI. TREATMENT OF WATER

The outlined research project presents a systematic approach to addressing the limitations of existing charcoal water filters and enhancing water purification methods. Beginning with the identification of problems in current filters, such as incomplete purification and high maintenance costs, the project sets clear objectives for proposing more efficient solutions. By considering the sources of water and the associated risks, particularly the formation of biofilms in stagnant water, the project establishes a foundation for selecting appropriate purification methods.

Furthermore, the collection of water samples from real-world sources like the Tulsi River and Sanjay Gandhi National Park provides practical context and ensures the relevance of the research. Rigorous testing of these samples for various properties, including microbial content and physicochemical parameters, forms the basis for designing an effective filtration system tailored to the specific challenges posed by the water sources.

The project outlines modifications to the filter design, incorporating charcoal filtration media, resin, and UV disinfection chambers to address identified limitations. Additionally, the insertion of additional materials such as carbon dioxide for pH regulation and ion exchange resin for heavy metal removal demonstrates a comprehensive approach to water purification.

Testing the treated water post-treatment is crucial for evaluating the efficiency of the prototype and ensuring that it meets the desired purification standards. Proper interpretation of the test results will be essential for drawing meaningful conclusions and determining the effectiveness of the developed filtration system.

Overall, the project showcases a thorough and methodical approach to addressing water purification challenges, emphasizing the importance of scientific research and experimentation in improving existing filtration methods. It underscores the need for meticulous documentation and adherence to standard research protocols to ensure the validity and reliability of the findings.

VII. CONCLUSION

The combination of resin filtration and UV light presents a highly effective method for surface water purification, removing various contaminants and pathogens efficiently. This approach offers numerous advantages such as minimal chemical usage, low maintenance, and environmental friendliness. However, its effectiveness can vary depending on specific contaminants and equipment quality. Nonetheless, it holds significant promise for addressing water quality challenges globally and ensuring access to safe water. Continued research and advancements in this field will further improve its efficacy and accessibility, leading to a healthier and more sustainable future.

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