FABRICATION OF PORTABLE WATER PURIFIER USING RENEWABLE ENERGY

A Project Work submitted to

VISVESVARAYA TECHNOLOGICAL UNIVERSITY

in partial fulfilment of the requirements for
the award of degree of

BACHELOR OF ENGINEERING

in

MECHANICAL ENGINEERING

Submitted by

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CERTIFICATE

This is to certify that the project work entitled **"FABRICATION OF PORTABLE WATER PURIFIER USING RENEWABLE ENERGY"** *is a Bonafede work carried out by*

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in partial fulfilment for the award of ***Bachelor of Engineering*** *in* ***Mechanical Engineering*** *of* ***Visvesvaraya Technological University, Belagavi,*** *during the year 2023-2024. It is certified that all the suggestions indicated during internal assessment have been incorporated in the report and this report satisfies the academic requirement with respect to* ***Project Work 18MEP83*** *prescribed for the degree.*

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DECLARATION

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the students of ***BE VIII Semester (Mechanical Engineering)*** *declare that the project entitled* ***"FABRICATION OF PORTABLE WATER PURIFIER USING RENEWABLE ENERGY"*** *" is carried out by us as a partial fulfilment of academic requirement of degree under* ***Visvesvaraya Technological University.*** *The content in the report are original and are free from plagiarism and other academic dishonesty and are not submitted to any other University either partially or wholly for the award of any other degree.*

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Abstract:

Developments in sustainable water purification technology have been driven by the growing need for drinkable, clean water on a global scale. In order to solve water scarcity and environmental problems, the goal of this project is to fabricate an environmentally conscious water purifier that incorporates renewable materials and energy sources.

The suggested water purifier is built with renewable resources, with an emphasis on using biodegradable and environmentally friendly materials to reduce its negative effects on the environment. The filtration system uses sustainable and natural materials that have been shown to purify water, offering a practical solution while lowering dependency on non-renewable resources. To power the water purification process, the project incorporates renewable energy sources. The energy-intensive operations of the purifier are powered by solar energy, a commonly available and sustainable resource that lowers the system's carbon footprint and increases energy efficiency. This method, which encourages the use of clean and renewable energy for water treatment, is in line with the concepts of sustainability.

The objective of the project is to develop a sustainable and reasonably priced prototype that is simple to duplicate and modify in a variety of geographic locations, particularly those with restricted access to traditional energy sources.

The project's results in the development of environmentally friendly water filtration technologies that not only solve the urgent problem of poor water quality but also encourage responsibility for the environment. The suggested water purifier offers a comprehensive and environmentally beneficial solution for communities aiming to achieve long-term water sustainability by highlighting the use of renewable materials and energy sources.

Chapter 1

1.1 INTRODUCTION

Water is an essential element for life on Earth and is important to many aspect of human existence. Water is important for more than just staying hydrated; it's essential for agriculture, ecology, and human health. Water provides habitat to a vast array of organisms in the environment, thereby promoting diversification and preserving delicate environmental balances. It is also an essential resource for agriculture, boosting the development of crops that serve as the basis for our food supply. Water and human health are inseparable because it is necessary for body functions, cleanliness, and the prevention of disease. In addition, water powers a number of businesses, including transportation and hydroelectric plants. Water scarcity or contamination present serious problems that can result in harm to the environment and public health emergencies.

For human well-being, having access to portable drinking water is essential, particularly in light of the world's growing urbanization, frequent travel, and emergency scenarios. It's essential to have portable access to safe and clean drinking water in order to stay hydrated, avoid becoming sick from the water, and preserve general health. Since convenience and dependability are essential in today's busy and changing lives, the market for portable water solutions has grown dramatically. Having a portable, easily accessible source of drinking water is crucial for outdoor activities, travel, and disaster relief. Cutting-edge technologies, such small filtration systems and portable water purifiers, are essential in meeting this need because they give communities and people a sustainable and dependable way to meet their hydration needs under a variety of conditions. Promoting and funding the development of portable drinking water solutions is crucial because it advances public health and disaster preparedness objectives in addition to improving individual health.

1.2 Health problems due to non-availability of drinking water

Lack of access to drinking water can result in a variety of health issues and poses serious health hazards. Maintaining general health and preventing waterborne illnesses require having access to clean, safe drinking water. When people don't have access to a trustworthy source of drinkable water, they could end up drinking contaminated water from unreliable or harmful sources. Waterborne infections like cholera, typhoid, diarrhea, and other gastrointestinal ailments may spread as a result. Inadequate access to drinking water can lead to dehydration, which can have negative effects on health in addition to infectious infections. When the body loses more fluids than it takes in, dehydration sets in, resulting in symptoms including weariness, dizziness, and in extreme situations, organ failure. In addition, the lack of clean water makes it more difficult to maintain good hygiene, which raises the risk of skin infections and other health problems linked to poor hygiene. Inadequate water for household and personal use has an impact on sanitation as well, making it difficult to keep homes clean and facilitating the spread of illness. Water-related diseases can result in higher healthcare expenditures and reduced revenue, making people lacking access to safe drinking water especially vulnerable to a vicious cycle of poverty and ill health. As a result, guaranteeing the availability of clean drinking water is not only important for maintaining public health but also for ending the cycle of poverty and fostering general well-being in local communities all over the world.

Fig 1.1 Contaminated container

Fig 1.2 Contaminated tap water

1.3 Standard Requirements of Drinking water

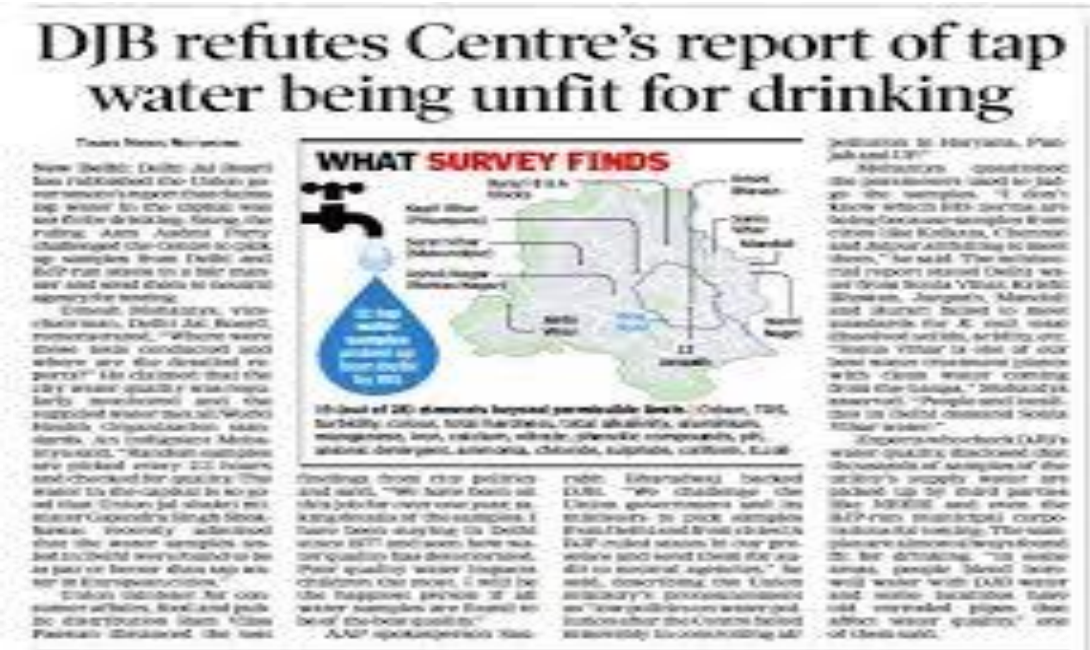
Treatment of Drinking water is must in order to remove the impurities and various bacteria's present. World health Organization (WHO) provides international standards on water quality in form of guidelines that are used as the basis for regulation and standards world-wide. These Guidelines for drinking-water quality (GDWQ) promote the protection of public health by encouraging the development of Water Safety Plans. The standards given are tabulated in the table 1.1

Parameters	Standards
pH	6.5-8.5
Total Alkalinity (mg/l)	120
Total Hardness(mg/l)	300
Total dissolved salts (TDS) (mg/l)	500
Calcium(mg/l)	75
Magnesium(mg/l)	30
Chloride(mg/l)	250
Nitrate	45
Sulphate	150

Table 1.1

1.4 Elements present in water that makes water unfit to drink

- Microorganisms: Bacteria, viruses, and parasites are common microorganisms that can contaminate water and cause waterborne diseases such as cholera, typhoid, and dysentery.
- Chemical contaminants: Water can be contaminated with various chemicals, including heavy metals (such as lead, mercury, arsenic), pesticides, fertilizers, industrial pollutants, and pharmaceuticals. These substances can have harmful health effects when consumed.
- Organic matter: Organic matter such as decaying leaves, algae, and other plant material can result in unpleasant tastes and odors. It can also serve as a breeding ground for microorganisms.
- pH Imbalance: Water with extremely high or low pH levels can be corrosive and cause damage to plumbing systems, and it may also affect the taste and quality of drinking water.


DJB refutes Centre's report of tap water being unfit for drinking

WHAT SURVEY FINDS

Fig 1.3 Report of tap water being unfit to drink

1.5 Water purification methods

Various water purification methods are designed to remove contaminants and make water safe for consumption. Different methods are suitable for different types of contaminants and water sources. Some common types of water purification methods are discussed below. Depending on the particular pollutants in the water and the required level of water quality, different purification techniques might be used. In special cases, a variety of techniques can be needed to completely purify the water.

- Boiling: Boiling water is one of the simplest and oldest methods of water purification. Bringing water to a rolling boil for at least one minute (or three minutes at higher altitudes) can effectively kill most bacteria, viruses, and parasites.
- Filtration: Filtration involves passing water through a physical barrier or filter that traps impurities. Common types of filters include activated carbon filters, ceramic filters, and membrane filters. These can remove particles, sediment, and some microorganisms.
- Distillation: Distillation involves heating water to create steam, then cooling the steam back into liquid form to remove contaminants. This method is effective at removing many impurities, including minerals, heavy metals, and certain organic compounds.
- Reverse Osmosis: Reverse osmosis is a water purification process that uses a semi-permeable membrane to remove ions, molecules, and larger particles from water. It is effective in removing salts, minerals, and many contaminants, providing high-quality water.
- UV Water Purification: Ultraviolet (UV) water purification uses UV light to kill or inactivate bacteria, viruses, and other microorganisms. It is a chemical-free method that can be effective against a broad spectrum of pathogens.
- Chlorination: Chlorination involves adding chlorine or chlorine compounds to water to kill or inhibit the growth of bacteria, viruses, and other microorganisms. This method is commonly used in municipal water treatment.
- Iodine Treatment: Iodine tablets or liquid can be used to disinfect water by killing bacteria and viruses. However, this method may not be suitable for long-term use or for individuals with iodine allergies.

- Activated Alumina Defluoridation: This method involves using activated alumina to remove excess fluoride from water. It is particularly relevant in regions where high fluoride levels are a concern.
- Chemical Disinfection: Chemicals such as chlorine dioxide, potassium permanganate, and hydrogen peroxide can be used to disinfect water. These chemicals are effective in killing pathogens but should be used with caution and in appropriate concentrations.

1.6 Various water purification methods and technologies that are available in the market

1. **Water Filters:**

- **Activated Carbon Filters:** Remove organic compounds, chlorine, and some contaminants.
- **Ceramic Filters:** Effective against bacteria and parasites, with some models featuring activated carbon.

2. **Reverse Osmosis (RO) Systems:**

- Uses a semi-permeable membrane to remove a wide range of contaminants, including salts, minerals, and microorganisms.

3. **Ultraviolet (UV) Purifiers:**

- Use UV light to disinfect water by inactivating microorganisms like bacteria and viruses.

4. **Distillers:**

- Heat water to create steam and then condense it back into liquid, effectively removing contaminants.

5. **Ion Exchange Systems:**

- Remove specific ions like calcium and magnesium, often used for water softening.

6. **Activated Alumina Defluoridation Units:**

- Utilize activated alumina to reduce excess fluoride levels in water.

7. **Chlorination Systems:**

- Add chlorine or chlorine compounds to disinfect water and kill pathogens.

8. **Ozonation:**

- Introduce ozone to oxidize and eliminate contaminants and microorganisms.

9. **Gravity-Based Water Purifiers:**

- Typically use a combination of filters and activated carbon to purify water without electricity.

10. **Chemical Water Purification Tablets:**

- Contain chemicals like chlorine or iodine to disinfect water, often used in emergency situations.

1.7 Comparison between various water purification methods available in the market

1. **Contaminant Removal:**

- **Reverse Osmosis (RO):** Effective at removing a wide range of contaminants, including heavy metals, salts, and microorganisms.
- **Activated Carbon Filters:** Excellent for removing organic compounds, chlorine, and improving taste and odor.
- **UV Purifiers:** Effectively inactivate bacteria, viruses, and other microorganisms but may not remove other types of contaminants.
- **Distillers:** Efficient in removing minerals, heavy metals, and some organic compounds.

2. **Energy Requirements:**

- **Reverse Osmosis (RO):** Requires electricity to operate the pump for water filtration.
- **Activated Carbon Filters:** Typically do not require electricity.
- **UV Purifiers:** Require electricity for the UV lamp.
- **Distillers:** Require electricity for the distillation process.

3. **Maintenance:**

- **Reverse Osmosis (RO):** Requires periodic replacement of the membrane and pre-filters.
- **Activated Carbon Filters:** Require regular replacement of the carbon filter.
- **UV Purifiers:** Require periodic replacement of the UV lamp.
- **Distillers:** May require periodic cleaning and replacement of components.

4. **Waste Generation:**

- **Reverse Osmosis (RO):** Generates wastewater as a byproduct of the filtration process.

- **Activated Carbon Filters:** Minimal waste generation.
- **UV Purifiers:** Minimal waste generation.
- **Distillers:** Generates waste in the form of concentrated impurities left in the distillation chamber.

5. **Cost:**

- **Reverse Osmosis (RO):** Initial setup cost can be relatively high; ongoing maintenance costs are moderate.
- **Activated Carbon Filters:** Generally more affordable, with lower maintenance costs.
- **UV Purifiers:** Moderate initial cost with lower maintenance costs.
- **Distillers:** Moderate initial cost; ongoing energy costs should be considered.

6. **Water Flow Rate:**

- **Reverse Osmosis (RO):** Generally has a slower flow rate compared to some other methods.
- **Activated Carbon Filters:** Usually maintain a good flow rate.
- **UV Purifiers:** Have a high flow rate but depend on water clarity.
- **Distillers:** Can have a slower flow rate.

7. **Effect on Water pH:**

- **Reverse Osmosis (RO):** Tends to reduce water pH.
- **Activated Carbon Filters:** Typically do not significantly impact water pH.
- **UV Purifiers:** Do not alter water pH.
- **Distillers:** May slightly decrease water pH.

8. **Environmental Considerations:**

- **Reverse Osmosis (RO):** Wastewater generation and energy use can have environmental impacts.

- **Activated Carbon Filters:** Generally considered more environmentally friendly.
- **UV Purifiers:** Environmentally friendly with minimal waste generation.
- **Distillers:** Energy consumption may have environmental implications.

Table: Comparison of different water purification Method.

1.8 Water purification methods with its benefits and drawbacks

Water Purification Method	Key Features	Contaminant Removal	Maintenance	Energy Requirements	Suitability
Boiling	Simple, no equipment needed	Bacteria, viruses, parasites	None	Requires heat source	Emergency, small quantities
Filtration	Removes particles, sediment, some microorganisms	Varies by filter type	Regular filter replacement	None (gravity-based filters) to moderate (electric filters)	Portable, household, outdoor activities
Reverse Osmosis (RO)	Highly effective, removes a wide range of contaminants	Salts, minerals, bacteria, viruses	Periodic membrane replacement	High (electric pump required)	Home, commercial use
Ultraviolet (UV) Purifiers	Chemical-free, effective against bacteria, viruses	Bacteria, viruses	UV lamp replacement	Moderate	Portable, household, camping
Distillation	Removes minerals, heavy metals, organic compounds	Most contaminants	Cleaning and periodic descaling	High (requires heat)	Home, small-scale systems
Ion Exchange Systems	Softens water by removing specific ions	Calcium, magnesium	Regeneration of resin beads	Moderate	Home, water softening
Activated Alumina Defluoridation	Reduces excess fluoride levels	Fluoride	Periodic replacement	None	Areas with high fluoride in water

Chlorination Systems	Disinfects water by adding chlorine	Bacteria, viruses	Regular chlorine addition	Low to Moderate	Municipal water treatment, emergency use
Ozonation	Oxidizes and eliminates contaminants	Bacteria, viruses, organic compounds	Ozone generator maintenance	Moderate	Commercial water treatment
Gravity-Based Purifiers	Portable, no electricity needed	Varies by filter type	Filter replacement	None	Outdoor activities, emergency
Chemical Water Purification Tablets	Portable, no equipment needed	Bacteria, viruses	None	None	Emergency, camping
Smart Water Purifiers	Monitoring, alerts, connectivity	Varies by technology	Filter replacement alerts	Low to Moderate	Household, tech-savvy users
Point-of-Use Purifiers	Installed at specific water points	Varies by technology	Filter replacement	Low to Moderate	Household, under-sink units
Whole House Filtration Systems	Treats water at point of entry	Varies by technology	Filter replacement	Low to Moderate	Entire household water supply

Table 1.2 Water purification methods with its benefits and drawbacks

1.9 Water purifiers available in market

Some popular brands of water purifiers in India include Kent, Aqua guard, Pureit, Livpure, Blue Star, and AO Smith, among others. Prices may vary based on factors such as capacity, purification technology, and additional features.

Brand	Technology	Notable Features	Approximate Cost (INR)	Disadvantages
Kent	RO (Reverse Osmosis) + UV/UF	Mineral RO technology, TDS control	8,000 - 20,000	High annual maintenance cost, electricity usage for RO.
AquaGuard	RO + UV/UF	Mineral Guard, Advanced Mineral Guard Technology	7,000 - 18,000	Regular maintenance required, can be expensive.
Pureit	RO + UV/UF	Advanced RO+UV technology, TDS removal	6,000 - 15,000	Consumables replacement costs, periodic filter changes.
Livpure	RO + UV/UF	7-stage purification process, Taste enhancer	7,000 - 16,000	Regular filter replacement, occasional leakage issues.
Blue Star	RO + UV/UF	Aqua Taste Booster, Copper Impregnated Activated Carbon	9,000 - 20,000	Higher initial cost, RO purifiers may waste water.
AO Smith	RO + UV/UF	MIN-TECH (Mineralizer Technology), Hot Water at the press of a button	10,000 - 25,000	Higher initial cost, regular filter replacement costs.

Table 1.3 Water purifier available in market

Chapter 2

Literature review

Many researchers have carried out experiments to on various water purification methods like using activated charcoal, UV, fibers, physical and chemical filtrations. These research articles are discussed below.

2.1 Portable water filter

Arshad Mulani. et al [1] fabricated a portable water filter as shown in the figure 2.1 and this filter has been successful in eliminating the harmful bactericidal entities present in the source water used for testing the filter. Water testing results show that the filter has remarkably reduced many different types of dissolved solid impurities along with some chemical entities implying that combining hollow fiber filters and coconut carbon fiber is valuable and efficient. The filter clearly demonstrates its use in purifying water on the go with its portable and easy to use design making it a smart choice for everyone deprived of clean drinking water irrespective of their financial background. Even with the use of all the components used in the filter, the user will experience an uninterrupted flow of water effortlessly in an instant.

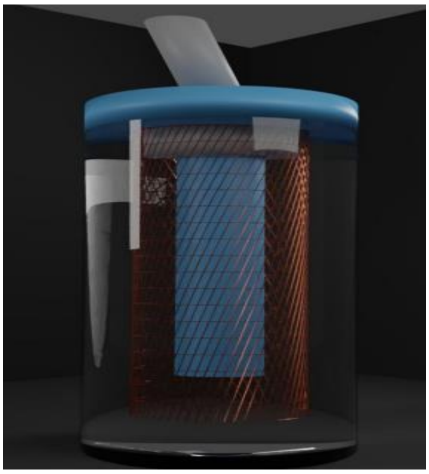


Fig2.1 Diagrammatic representation of the device

Fig 2.2 Coconut carbon fiber embedded on copper mesh

Mohanad, et al, designed dual purpose handy water filter.This model provides state-of-the-art information on the feasibility of using this technology and on design, construction, and operations to best achieve desired production and performance. An efficient and easy way to make small sized dual purposes handy water filter has been proposed in this paper. The water filter comprises a cylindrical container for holding a quantity of liquid to be treated including, a filter tube to filtrate the water and heating element to heat the filtrated water. The filter tube is connected to the upper end of the cylindrical case and the heating element is connected to the lower end of the cylindrical container. The designed filter provides an easier way to get safe, clean, and healthy and hot water. The water from this dual-purpose handy filter has been tested using various tests to prove that the quality of water is meeting the standards.

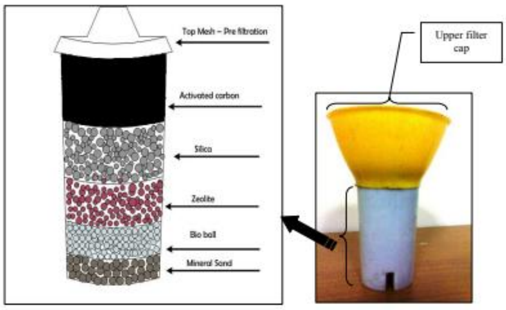


Fig 2.3 Filter Cartridge and its Layers in the Model designed.

Shivani conducted a study to design a portable antimicrobial water filter which is both economic and easy to use. A prototype was made following the designing of the water filter was constructed. Layers of sand, cloth, activated charcoal, and cotton containing compartments were built for carrying out water analysis. The Vellore Institute of Technology Lake water was tested compared with that of filtered water. Complete water analysis was done, and the sand filter layer was observed to be responsible for a maximum of the antimicrobial action of the filter. The results showed that the proposed design of water filter is efficient in removal of turbidity, odor, and microbial content of lake water along with decreasing the acidity of water.

a) stages of Filteration

b) Activated charcoal layer and cotton layer compartment

c)Sand and gravel layer and cloth layer compartment

Fig 2.4 Purification system setup

Water purification can be defined as the act of processes for removal contaminants from untreated water to produce the potable, safe and pure enough water for human consumption. During this process, an appropriate membrane will be removed the contaminant substances such as suspended solids, bacteria, algae, viruses, minerals such as iron, and other chemical pollutants like fertilizers. World Health Organization (WHO) has issued several guidelines for drinking water quality requirement that are generally can be followed in order to have an access to safe drinking water for consumers. During the late 1800s, scientists gained a greater understanding of the sources and effect of contaminants drinking water. In 1855, epidemiologist Dr. John Snow proved that cholera was waterborne disease that linked with a contaminant. In the 1880s, Louis Pasteur explained microscopic organisms could transmit disease through media like water. In 2014, unexpected severe flooding has been occurring in the East Coast region such as Kelantan, Terengganu and Pahang with the number of victims is more than 100,000 people. During or post disaster situation, the difficulty to get a clean and safe water will increase because the water treatment plants are damaged and water cannot be supplied to the disaster area. Beside that an electricity supply also will be lost if it was decided for safety purposes or infrastructure has been destroyed. In an emergency case, an active person needs to drink at least half gallons or 2 liter of water each day. However, children and illness person will require even more. An estimation of clean water usage at least 1 gallon or 3.8 liter per person, per day and the rest were for food preparation and hygiene. After the flood disaster occurs, people are too difficult to find a source of water supply and if the condition persists, it will harmful to the public health. In other conditions, flood victim need to get water from tanker and need have to wait for hours to get better water for survival.

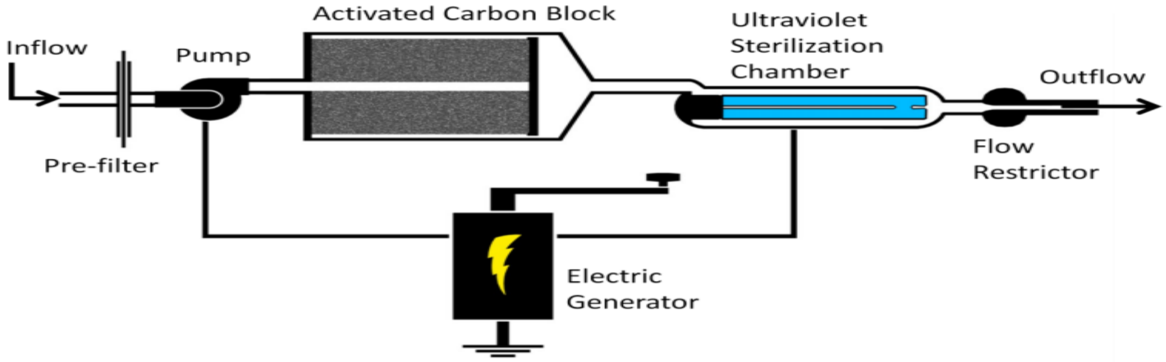


Fig 2.5 Spatial arrangements of components

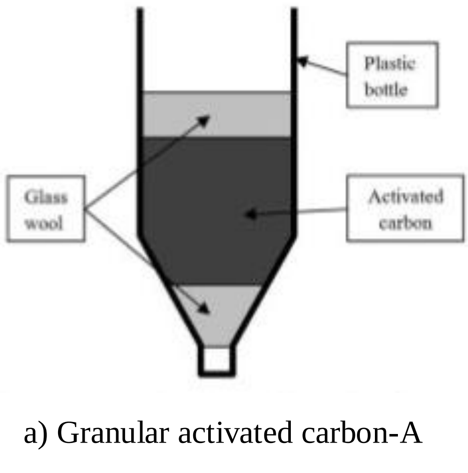
The overall goal of the project discussed herein was the development of a portable, continuous flow water purification system for use in regions of the world which lack potable water. Though the water purification market is very broad, within the humanitarian and aid environment there is still a need for a small to medium volume water filtration and purification system. The course to completion of the project included the conceptual system development, specific part selection and design, and initial prototyping of a practical and effective system. Specifically, the main objective of the project can be broken down into a number of smaller goals, each of which has a particular set of constraints based upon the needs of the market for the product. In terms of the importance of the criteria, three main categories can be considered: functionality is the most critical followed by portability second and marketability third. Thus, while many criteria played into design considerations, when trade-offs occurred they did so with deference to the relative importance of each category to the value of the final product. This project centered upon the development of a prototype water purification system. The process began with system development in which the initial filtration method was determined. Next, the design phase included the location of specific components, parts, and materials for the actual system. Prototype construction and testing followed at the end of the project. Each stage of this development path was extensive and each will be addressed in turn as the process is explained. Once the history of the project has been illuminated, the attributes of the final product will be summarized and various important features of the process and design can be discussed. Finally, the conclusion will offer insight into the valuable lessons learned during the course of the venture as well as suggestions for next steps should others wish to improve or further develop the system.

Fig 2.6 Experimental setup of portable water purifier

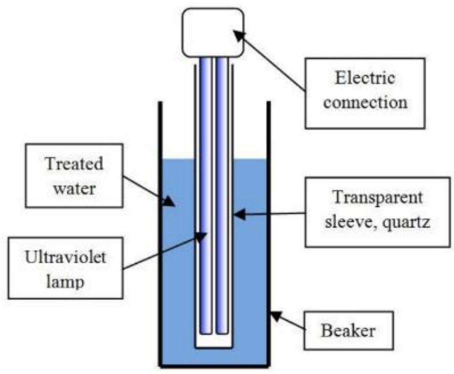
The portable filter has been constructed by continuous fixed-bed adsorption principle. The construction of filter shows how the different parts are connected. 5 g of 1 cm length of thiol functionalized aloe vera fibres are stuffed into porous tube and the packing density is maintained as 0.3. The electrospun PAN nanofibre web is wrapped around the tube. Now the filter is ready for experiment. The specifications of filtration set up are shown in table 1. Aqueous solution containing heavy metal ions such as cadmium and lead at concentrations of 30, 50, and 70 mg/L has been prepared, and each concentration of both metal ions mixture has been filled in the input tank and passed through the filter, as shown in figure 1. The heavy metal ions have been adsorbed by the functional groups present in the aloe vera fibre and the water passes through the PAN nano fibre web then it has been collected from out let for analysis. Each experiment has been conducted for 60 minutes.

2.2 Activated Charcoal for Water Filtration

Siong et al studied the Performance of Activated Carbon in Water Filters. Activated carbon is commonly used in water treatment to remove water contaminants from tap water and well water. Activated carbon is used in home water filtering system due to its excellent adsorption capacity. In this research, two types of granular activated carbon are used; one granular activated carbon-A (GAC-A) and the other granular activated carbon-B (GAC-B) to study their performance in the filters. Ultraviolet radiation system is used to purify water without leaving any harmful chemicals. Prototype is being made by using activated carbon and ultraviolet radiation system for water treatment. Surface area and porosity analysis is done on two activated carbons. Scanning electron microscopy (SEM) is used to obtain the magnified image of GAC-A and GAC-B for comparison between the surface morphology. Two types of water samples, the tap water and well water, are analyzed before and after the water treatment. The water samples were analyzed using pH test, turbidity test, total suspended solid examination, biochemical oxygen demand (BOD) test and chemical oxygen demand (COD) test. The results obtained from the water analysis shows that the GAC-A performs better than GAC-B in reducing turbidity, total suspended solid, BOD and COD. However the ultraviolet radiation reduced the BOD and COD of the water.



a) Granular activated carbon-A (GACA)



b) Ultraviolet disinfection treatment.

Fig 2.7 Portable activiated charcoal Water Filter

Awal Musa et al, evaluated the contaminant removal efficiency of an improvised charcoal filter. The filter had four layers with 6.3, 2.0, 1.18 mm sized, and powdered charcoal responsible for the filtration process. The water sample was collected from river Challow from the region believed to have the highest concentration of contaminants. The physicochemical and bacteriological characteristics of the water sample before and after filtration were determined and evaluated. Although testing for coliform bacteria in the samples before and after filtration read positive, the charcoal filter showed very high turbidity removal efficiency (i.e., up to 98%) after a seven-number repeated filtration runs. It also showed high odor, artesian chloride removal efficiencies. However, an increase in conductivity was observed in the filtered samples which maybe correlated to the ability of charcoal to enrich the water with elements like sodium and potassium. In addition to these the pH value of the sample before filtration was acidic (i.e. 5.7) but increased to 7.7 after filtration which is suitable for drinking water. Hence, it is recommended here that charcoal filters can be used to produce high-quality water as tabulated in the table 2.1 below.

Parameters	Recommended Limits Set by Agencies	Before Filtration	Assessment	After Filtration	Assessment
Temperature (^{0}C)	25	24.5	Suitable	24	Suitable
Turbidity (NTU)	5	353.7	Un suitable	6.21	Un Suitable
Total dissolve solid (TDS) (mg/L)	500	485	Suitable	96	Suitable
Odor (Un objectionable)	Un objectionable	Objectionable	Un suitable	un objectionable	Suitable
Conductivity (µS/cm)	1000	291	Suitable	633	Suitable
pH	6.5 - 8.5	5.67	Un suitable	7.7	Suitable
Acidity (mg/L)	NIL	150		--	
Alkalinity (mg/L)	200	--		182.5	Suitable
Hardness (mg/L)	500	302.6	Suitable	129.94	Suitable
Iron (mg/L)	0.3	0.028	Suitable	0.016	Suitable
Chloride (mg/L)	250	114	Suitable	76	Suitable
dissolve Oxygen (mg/L)	NIL	2.3		2.54	
Coliform Bacteria (cfu/100ml)	0	Present	Unsuitable	Present	Unsuitable

Table 2.1 Showing water quality results before and after filtering

Jiang et al studied the Application of Activated Carbon in Water Treatment and found that activated carbon is a very good adsorbent in water treatment, and itself is a green and pollution-free material. Its loose porous environment and high specific surface area provide it with excellent purification ability. Because activated carbon not only has good adsorption performance and low price, but also can recycle and other excellent performance, it is widely used in water treatment. Foreign water treatment technologies developed earlier than ours and China started relatively late. The application of activated carbon is not good enough, which shows that there is still a long way to go. Activated carbon can be used either alone or in combination with other water treatment technologies. In order to maximize the adsorption capacity of activated carbon in water treatment, better service for water treatment, saving cost, reducing energy consumption and improving efficiency become a basic research criterion. In the modification of activated carbon, combined with microbial properties and microwave-activated carbon research, the application performance of activated carbon in future water treatment will be higher.

2.3 Hollow Fibres for water Filtration

As per article in Snyder Filtration Hollow fiber filtration utilizes thousands of long, porous filaments ranging from 1-3.5mm wide that are potted in place in a PVC shell. Each filament is very narrow in diameter and flexible. Hollow fiber can find uses in all types of filtrations, ranging from microfiltration to reverse osmosis. Hollow fiber filtration works on the same principle as tubular and capillary configurations but utilizes a small tube diameter which allows for flexibility. Common applications for hollow fiber membranes include MBR, RO pretreatment, Industrial water/wastewater, juice processing, and biotech applications. Its Advantages are

Hollow fiber membranes feature a very high packing density because of the small strand diameter. Because of the flexibility of the strands, certain filter configurations are possible that cannot be achieved in other filtration configurations. They can also be back flushed from the permeate side and air scoured, and can process feed streams with high total suspended solids (TSS).

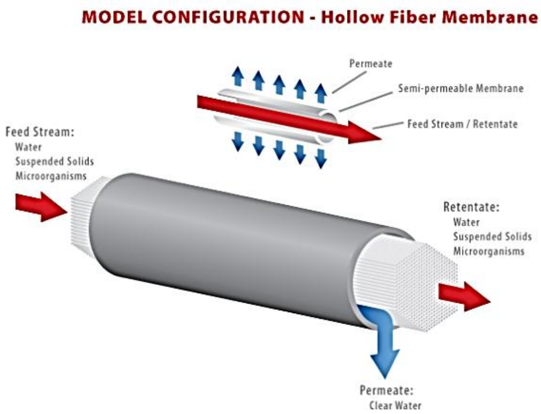


Fig 2.8 working of Hollow fibers for water filtration

As per the blog CNOC outdoors, Closed-loop hollow tubes with pores that are open towards the "incoming" side of the filter. Water is "pushed" into the hollow fiber. Water in the tubes is "pushed" through the pores. Bacteria, protozoa and cysts bigger than the pores remain in the fiber.

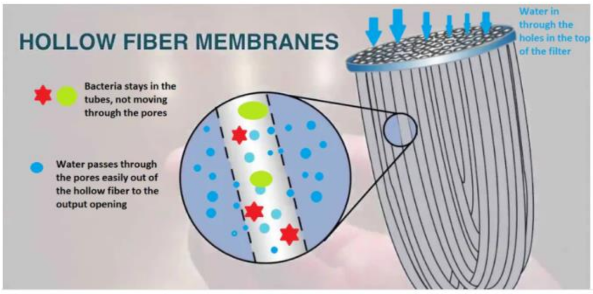


Fig 2.9 Mechanism of a Hollow Fiber Filter working

2.4 U V Light

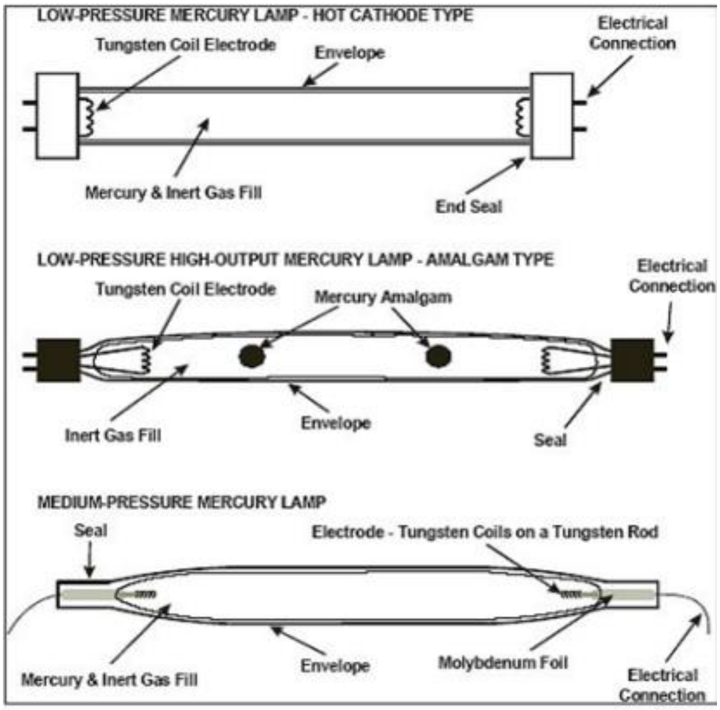


Fig 2.10 uv light and lamps drawings

In drinking water systems, UV lamps are contained in a UV reactor. UV reactors operate as either batch or continuous flow reactors. Several characteristics must be taken into account when designing, installing, and operating a UV reactor. Among them are water quality characteristics, distance between the lamp and the reactor wall, and the distribution of UV light. Additionally, continuous flow reactors must take into account hydraulic characteristics of water flowing through the reactor. Due to all these characteristics, all microorganisms will not receive the same UV dose. For example, UV lamp placement in a reactor influences UV dose delivery. If the distance between the lamp and the reactor wall is too large (i.e., a large amount of water between the lamp and the reactor wall), microorganisms furthest from the lamp will receive less UV intensity and subsequently a lower UV dose. Most UV-using water purification devices utilize a batch reactor system. UV light inactivates microorganisms by damaging deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). When DNA and RNA absorb UV light, dimers (covalent bonds between the same nucleic acids) are formed resulting in damage. Dimers cause faults in the transcription of information from DNA to RNA, which in turn results in disruption of microorganism replication.

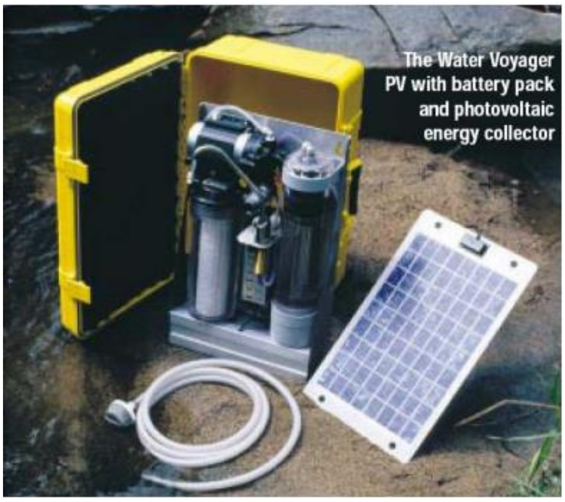


Fig 2.11 The water voyager

The mechanism of kill involves the absorption of photons of UV energy by the DNA, which fuses the DNA and prevents replication. DNA (Deoxyribonucleic acid) consists of a linear chain of nitrogen bases known as purines (adenine and guanine) and pyrimidines (thymine and cytosine). These compounds are linked along the chain by sugar-phosphate components. The DNA of most forms of life is double stranded and complimentary; the adenine in one strand is always opposite thymine in the other, and linked by a hydrogen bond, and guanine is always paired with cytosine by a hydrogen bond. The purine and pyrimidine combinations are called base pairs. When UV light of a germicidal wavelength is absorbed by the pyrimidine bases (usually thymine) the hydrogen bond is ruptured. The dimer that is formed links the two bases together, and this disruption in the DNA chain means that when the cell undergoes mitosis (cell division) the DNA is not able to replicate. The most effective wavelengths to achieve this effect are found between 263nm to 275nm, and the peak wavelength distribution is dependent on the target organism. Ultraviolet (UV) rays with a wavelength 254 nm will effectively kill bacteria, viruses, yeast, moulds and algae. The UV radiation breaks through the outer membranes of the organisms, destroying or inactivating the DNA (Deoxyribonucleic Acid) thus preventing them from reproducing. This safely and effectively purifies water without changing its pH, colour, taste, odour or temperature.

Fig 2.12 The Pilot Plant

Ultraviolet rays are widely used to disinfect microbial water. Disinfection is a treatment process for drinking water. UV disinfection is one of the physical methods used to kill bacteria and destroy cells. In most cases, the physical process immediately purifies drinking water without the formation of toxic substances. Therefore, there are no bacteria in the water, so that it can be cleaned constantly. This research aims to obtain environmentally sustainable drinking water in conditions where clean water is scarce, such as water shortage. The pilot plant was established to evaluate a ceramic filter's effectiveness in reducing turbidity, plankton, and anything else that could alter drinking water properties. As a result, some water purification stages, such as those used in water treatment plants, are reduced. To see how effective UV sterilization is in killing bacteria, especially faecal coliform and Escherichia coli bacteria. Work was done by taking samples from the well water from Al-Zaidan area in Abu Ghraib district. Before the sterilizer is inserted, this procedure works on water that meets specific requirements. Although it is a commercial filter, the ceramic filter is excellent at removing turbidity with removal efficiency (73~89) %, the removal efficiency of dissolved solids (100) %, the removal efficiency of iron (75~83) %, and the removal efficiency of bacteria (45~53) %, which is an excellent removal efficiency. The UV sterilizer's ability to remove bacteria has reached a removal efficiency of (100) %. This process is superior because it does not produce any secondary substances and has no effect on colour, taste, or smell. Because water samples are taken from Groundwater, it contains high TDS content.

Chapter 3

3.1 Gap

- From the literature it is observed that each of these filters fabricated uses only one filtering material.
- Maintenance and purchasing cost are high for portable filters available in market.
- The Water filters available in market are costly.
- Energy Consumption (RO and UV Purifiers)
- Removal of Essential Minerals (RO Purifiers)

3.2 Motive behind doing this project work

"Access to drinking water should not be a privilege for some . It should be a right for All"

3.3 Aim

"To Fabricate Portable Water Purifier using Renewable Energy"

3.4 Objectives

1. To build a prototype of a water purification system that eliminates impurities, salts, bacteria from water using natural elements.
2. To use renewable energy source to power the water purifier & assemble purifier system with powering unit.
3. To test the water purifier and validate.

3.5 Methodology

1. To build a prototype of a water purification system that eliminates impurities, salts bacteria from water using natural elements.

a) Collect the data on drinking water standards provided by World Health Organization [WHO provides international standards on water quality in forms of guidelines that are used as the basis for regulation and standards world-wide].
b) Conduct a survey on various water purifiers available and methods adapted to purify water.
c) To study various water treatment methods like Distillation, Filtration, Chemical Treatment and Irradiative Treatment
d) Study various methods of purifying water using various natural elements.
e) To build a water purifying system that satisfies the objectives of the project.
f) Test the quality of water.

2. To use renewable energy source to power the water purifier & assemble purifier system with powering unit.

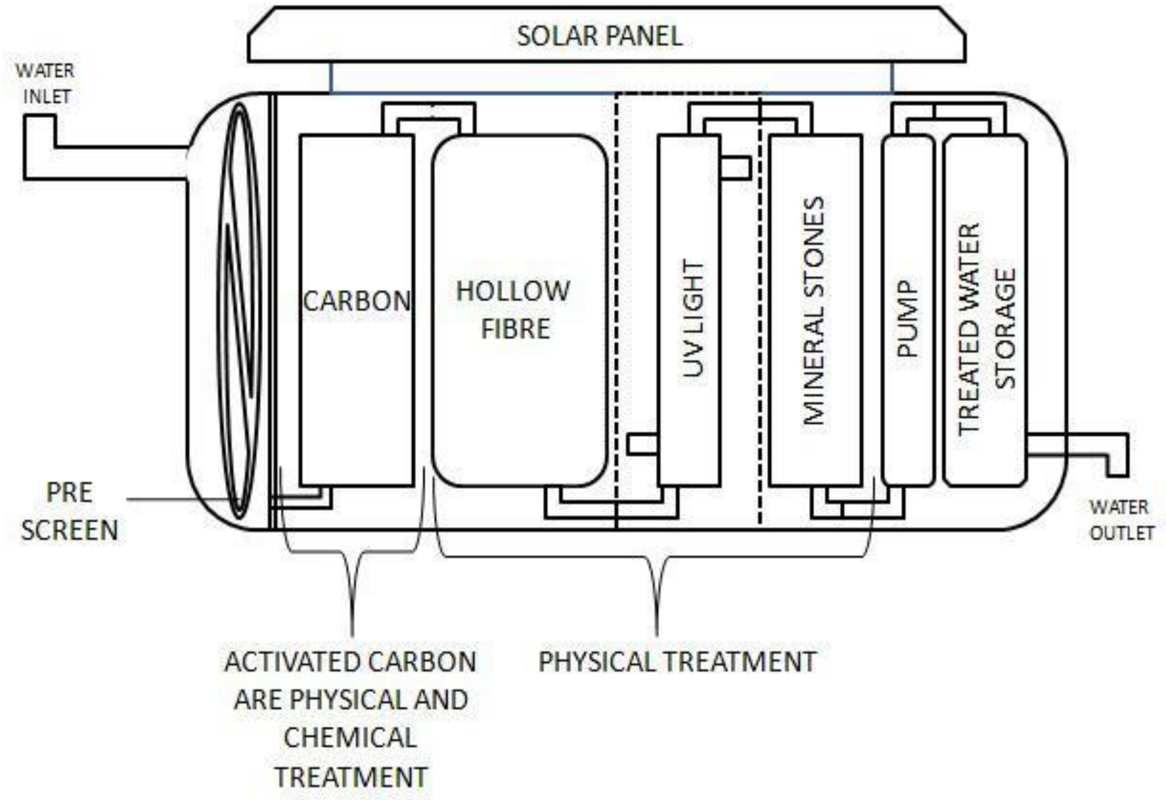
a) To study various and choose the best renewable energy methods to power the purifier
b) Calculate the power required to operate purifier
c) Connect the selected energy source to the water filtration system

3. To test the water purifier and validate

a) To test the quality of the water like pH, TDS, turbidity, hardness and presence of bacteria
b) To Compare the results with WHO standards and optimize

Chapter 4

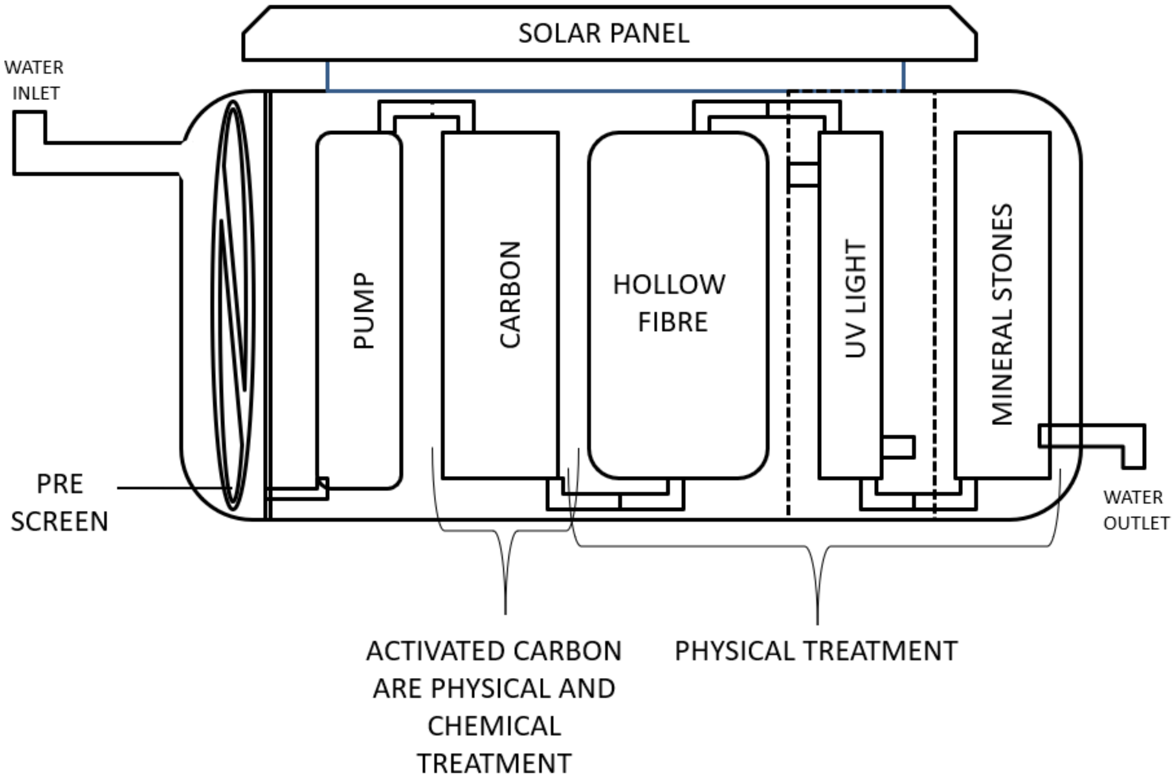
4.1 Design 1



Drawbacks of Design 1

- There was lot of air suction at the initial point which affected in the water flow.
- Due to the hollow fibers micro grain structure there was lot of air pockets building up in hollow fibers section.

4.2 Design 2



Outcomes

- There was no air gapes formation in the hollow fibers section as pump placed at the initial place.
- The flow of water was at the desired rate of flow.

4.3 Materials used

1.Activated Charcoal

Fig 4.1 Activated Charcoal

Activated carbon filters are effective at removing compounds that create bad tastes and odours from tap water, resulting in better-tasting water. Versatile: Removes or reduces a wide variety of different impurities in your tap water. As shown in the fig 4.1.

2.U V Light

Fig 4.2 U V Light

In a UV water filter system, UV (Ultraviolet) rays kill the harmful bacteria from the water. Hence the water is completely disinfected from pathogens. The UV water purifier is good for health because it kills all the harmful microbes present in the water without affecting the taste. As shown in fig 4.2.

3.Hollow Fibres

Fig 4.3 Hollow Fibres

Hollow fibre membranes feature a very high packing density because of the small strand diameter. Because of the flexibility of the strands, certain filter configurations are possible that cannot be achieved in other filtration configurations. Hollow-fibre membranes can be used to effectively treat contaminated surface water or groundwater. This filtration method will achieve rapid water purification without unnecessary wastages or mineral losses. As shown in 4.3.

4.Mineral Stones

Fig 4.4 Mineral Stones

These stones possess unique properties allowing them to filter out bacteria, viruses, heavy metals, and other impurities from water. By leveraging the mineral-rich compositions of these stones, it's possible to achieve high levels of purification while also enhancing the overall quality of your water. As shown in the fig 4.4.

5.Power bank

Fig 4.5 Power bank

A Power Bank is a portable charger designed to recharge your electronic devices when you're on the move. Ranging in size from slim, pocket-sized devices up to larger, higher-capacity Power Banks – they can be used to charge smartphones, tablets, earphones, smartwatches and other mobile devices. Here it is used to power the water purifier when there is no energy source from the solar panel. As shown in Fig 4.5.

6.Solar Panel

Fig 4.6 Solar Panel

Solar panels, sometimes also called photovoltaics collect energy from the Sun in the form of sunlight and convert it into electricity that can be used to power homes or businesses. These panels can be used to supplement a building's electricity or provide power at remote locations. As shown in Fig 4.6.

4.4 Bill Of Material

Sl.No	Items	Quantity	Cost
1	Activated charcoal	250gms	200
2	UV source	1	400
3	hollow fibers	1	350
4	Mineral stones	250gms	200
5	Bag	1	500
6	Solar Panel	1	500
7	Pump	1	700
8	Pipes and Clamps	1	150
Total Cost			**3,000**

Table 4.1 Bill of material

Chapter 5

5.1 Results and Discussion

Drinking water also known as potable water, is the water that is safe to drink and also can be used for preparing food. For healthy and safe living, water quality is most fundamental and by providing access to safe water, good health can be promoted. Water safety and quality are most important to human development and well-being. Providing access to safe water is one of the most effective instruments in supporting health and reducing poverty.

As the international authority on public health and water quality, WHO leads global efforts to prevent transmission of waterborne diseases. This is achieved by promoting health-based regulations to governments and working with partners to promote effective risk management practices to water suppliers, communities and households. In India, Bureau of Indian Standards (BIS) has set certain standards for quality of potable water (BIS 10500-1991). The standard was adopted by the Bureau of Indian Standards with the following objectives -

- To assess the quality of water resources, and
- To checks the effectiveness of water treatment which is supplied by the concerned authorities.

They apply to drinking water supplied by different Authorities/ Agencies/ Departments of State Governments and Central Government, wherever applicable in the country. They also apply to water supplied by Non-Government or Private Agencies for human consumption in any place of the country.

The various parameters covered include Colour, Odour, pH Value, Total Dissolved Solids, Hardness, Alkalinity and elemental compounds such as Iron, Manganese, Sulphate, Nitrate, Chloride, Fluoride, Arsenic, Chromium, Copper, Cyanide, Lead, Mercury, Zinc and Coliform Bacteria. The standard categories vary in characteristics as essential or desirable. It mentions the desirable limit and indicates its background so that the implementing authorities may exercise their discretion, keeping in view the health of the people, adequacy of treatment etc. All essential characteristics should be examined in routine.

In the present work, following parameters which influence water quality are considered and studied

1. **Total Coliforms**: Coliforms belong to a broad class of bacteria. These bacteria are found freely in our environment. The feces of humans as well as other warm-blooded animals are a source of these bacteria. Coliforms are primarily used as a method for indicating water quality. When coliform bacteria are detected in drinking water; it may be indicative of the potential presence of other harmful, disease-causing organisms. Testing for bacteria is the only way to know if your water is safe. Just by look, taste, or smell of the water, we cannot detect if disease-causing organisms are in it or not.
2. **pH Value:** The pH value is a good indicator of whether the water is hard or soft. The pH of pure water is 7. In general, water with a pH lower than 7 is considered acidic, and with a pH greater than 7 is considered basic. The normal range for pH in surface water systems is 6.5 to 8.5, and the pH range for groundwater systems is between 6 to 8.5. Alkalinity is a measure of the capacity of the water to resist a change in pH that would tend to make the water more acidic. The measurement of alkalinity and pH is needed to determine the corrosiveness of the water.
3. **Turbidity**: Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. The more total suspended solids in the water, the murkier it seems and the higher the turbidity. Turbidity is considered as a good measure of the quality of water.
4. **TDS**: TDS stands for total dissolved solids, and represents the total concentration of dissolved substances in water. TDS is made up of inorganic salts, as well as a small amount of organic matter. Common inorganic salts that can be found in water include calcium, magnesium, potassium and sodium, which are all cations and carbonates, nitrates, bi-carbonates, chlorides and sulfates, which are all anions. High concentration of dissolved solids is usually a health hazard.
5. **Total Hardness**: The water hardness is the amount of dissolved calcium and magnesium in the water. Hard water is high in dissolved minerals, both calcium and magnesium. Hard water also contains bi-carbonates and sulfates but Calcium and magnesium are the most abundant minerals in hard water. The hardness of the water mainly depends upon the concentration of the calcium & magnesium in the water. If the concentration of the calcium is less than or equal to 160 ppm (Parts Per Million) then water is referred as soft water but

if the concentration of the calcium in water is above 160 ppm then it is regarded as hard water.

For all the parameters discussed above, BIS has set quality standards as shown in the table below and values measured for the water should be within the limit, if not water is not recommended for drinking.

Sl.No	Parameters	Before Purification	After purification	IS 10500-2012 Specifications
1	Total Coliforms	2 MPN/100ml	Not detected	-
2	Turbidity NTU	<1	<1	1-5 NTU
3	Total Dissolved solids mg/l	20 mg/l	20 mg/l	<500 mg/l
4	P^H value	6.99	6.8	6.6-8.5
5	Total hardness as CaCo3 mg/l	151	156	<200
6	Calcium mg/l	32	35	75-200
7	Magnesium mg/l	15	16.5	30-100
8	Chloride mg/l	31	36	25-1000
9	Sulphate mg/l	28	23	200-400
10	Fluoride mg/l	0.18	0.23	0.1-0.3
11	Copper mg/l	<0.05	<0.05	0.05
12	Iron mg/l	0.073	0.073	0.3

Table 5.1 Results of chemical analysis of the untreated and treated water.

Power Calculations

1 minute = 500ml

Power Bank Capacity = 10000mah

2 hrs Power supply

Solar

7.2 volts

3 ampere

375 mA

In the present work, water is purified at different stages with different materials

1. Activated charcoal

Also known as activated carbon, is widely used in water purifiers due to its unique properties that make it highly effective at removing impurities from water. Here are the key reasons why activated charcoal is used:

- Adsorption Capabilities: Activated charcoal has a highly porous structure, which provides a large surface area for adsorption. Adsorption is a process where contaminants in the water stick to the surface of the charcoal, effectively removing them from the water. This makes activated charcoal particularly effective at removing organic compounds, chlorine, pesticides, herbicides, and volatile organic compounds (VOCs).
- Removal of Chlorine and Chloramines: Activated charcoal is excellent at removing chlorine and chloramines from water. These chemicals are commonly used to disinfect water, but they can cause unpleasant tastes and odors. Activated charcoal adsorbs these chemicals, improving the taste and odor of the water.
- Reduction of Heavy Metals: Activated charcoal can also help reduce the concentration of heavy metals such as lead, mercury, and cadmium. While it may not remove all heavy metals entirely, it significantly lowers their levels, making the water safer to drink.
- Chemical Neutralization: Activated charcoal can neutralize certain chemicals that might be present in water. It is particularly effective against a wide range of chemical contaminants, providing a broad-spectrum purification solution.
- Improving Taste and Odor: By removing organic compounds and chlorine, activated charcoal significantly improves the taste and odor of water, making it more pleasant to drink.
- Safety and Effectiveness: Activated charcoal is a safe and effective method for water purification. It does not introduce any harmful substances into the water, and it is capable of removing a wide range of contaminants without the need for complex chemical treatments.
- Microbial Removal: Although not as effective as specialized filters, activated charcoal can reduce the levels of some bacteria and parasites by trapping them in its porous structure.

2. Hollow Fibers

Hollow fibers are used in water purifiers for several key reasons, making them an efficient and effective choice for filtration. Here are the main advantages:

- High Surface Area: Hollow fiber membranes provide a large surface area for filtration due to their structure, which consists of numerous tiny, porous tubes. This allows for a high volume of water to be processed quickly and efficiently.
- Efficient Filtration: The porous nature of hollow fiber membranes can effectively remove contaminants such as bacteria, viruses, protozoa, and particulate matter from water. The small pore size (typically in the range of 0.01 to 0.1 microns) ensures high filtration efficiency.
- Low Pressure Requirements: Hollow fiber membranes operate efficiently at relatively low pressures compared to other filtration methods, reducing the energy requirements and operational costs.
- Durability and Flexibility: These membranes are made from robust materials such as polyethersulfone (PES) or polypropylene (PP), which are durable and resistant to chemicals and physical stress, enhancing their longevity and reliability in various water purification applications.
- Self-Cleaning Capability: Many hollow fiber membrane systems are designed to be backwashed, which helps to clean the pores and prolong the lifespan of the membrane. This self-cleaning capability reduces maintenance requirements and operational downtime.
- Compact and Modular Design: The structure of hollow fiber membranes allows for compact and modular design, making them suitable for both large-scale water treatment plants and small, portable purification units. This flexibility in design enables their use in a wide range of applications, from municipal water treatment to emergency water purification in disaster relief scenarios.
- High Permeate Flow Rate: Despite their fine pore size, hollow fiber membranes maintain a high permeate flow rate, ensuring that sufficient quantities of clean water can be produced in a relatively short period.
- These characteristics make hollow fiber membranes an ideal choice for modern water purification systems, offering a combination of high efficiency, reliability, and cost-effectiveness.

3. U V Light

UV light is used in water purifiers for its effectiveness in killing or inactivating harmful microorganisms without adding any chemicals to the water. Here are the main reasons why UV light is preferred in water purification:

- Effective Disinfection: UV light is highly effective at killing or inactivating a wide range of microorganisms, including bacteria, viruses, and protozoa. The UV-C spectrum (specifically at a wavelength of around 254 nanometers) penetrates the cell walls of these pathogens, damaging their DNA or RNA and preventing them from replicating.
- Chemical-Free: Unlike chlorination or other chemical disinfection methods, UV purification does not introduce any chemicals into the water. This means there are no byproducts, such as trihalomethanes (THMs), which can be harmful to human health.
- Maintains Water Taste and Quality: Since UV light does not use chemicals, it does not alter the taste, odor, or pH of the water. This is particularly important for maintaining the natural qualities of drinking water.
- Immediate Effect: UV disinfection works almost instantly. As water passes through the UV light, microorganisms are exposed and inactivated in a matter of seconds, making it a highly efficient process.
- Eco-Friendly: UV purification systems are environmentally friendly as they do not produce harmful disinfection byproducts and do not require the handling and storage of hazardous chemicals.
- Low Maintenance: Once installed, UV water purifiers typically require minimal maintenance. The main maintenance task is the periodic replacement of the UV lamp, which usually needs to be done once a year, depending on the model and usage.
- Compatibility: UV purification systems can be easily integrated into existing water treatment setups and are effective in treating water from various sources, including wells, rivers, lakes, and municipal supplies.
- Safety: UV light is a safe disinfection method as it does not involve the use of potentially dangerous chemicals. This reduces the risk of accidental exposure or chemical spills.

Overall, UV light is a highly effective, safe, and environmentally friendly method for disinfecting water, making it a popular choice for both residential and industrial water purification systems.

4. Mineral stones

Mineral stones are used in water purifiers for several key reasons, primarily related to improving the quality and taste of purified water, as well as enhancing its health benefits. Here are the main reasons why mineral stones are incorporated into water purification systems:

- **Mineralization:**
- Restoration of Essential Minerals: During the purification process, especially with methods like reverse osmosis and distillation, essential minerals such as calcium, magnesium, and potassium are often removed along with contaminants. Mineral stones help to reintroduce these beneficial minerals back into the water.
- Improved Taste: Water that has been stripped of its minerals can taste flat or bland. Adding minerals back into the water can enhance its flavor, making it more palatable and refreshing.
- **Health Benefits:**
- Balancing pH Levels: Mineral stones can help to balance the pH level of the water. Many purification processes can make water slightly acidic, and minerals can help to neutralize this acidity, producing water that is more alkaline and better for maintaining the body's natural pH balance.
- Bioavailability: Minerals in the water can be easily absorbed by the body, contributing to daily nutritional needs and supporting overall health, including bone health and metabolic functions.
- **Antibacterial Properties:**
- Natural Antibacterial Effects: Some mineral stones, like tourmaline, have natural antibacterial properties. These stones can help to inhibit the growth of bacteria within the water purifier, ensuring that the water remains clean and safe to drink.
- **Enhanced Hydration:**
- Micro-Clustering: Certain mineral stones can change the structure of water, creating smaller clusters of water molecules. This micro-clustered water is believed to be more easily absorbed by cells, potentially improving hydration levels more effectively than regular water.

- **Aesthetic and Practical Considerations:**
- Simplicity and Sustainability: Incorporating mineral stones into water purifiers is a simple and natural method to enhance water quality without the need for chemical additives. This makes the process more environmentally friendly and sustainable.

Overall, mineral stones in water purifiers provide a natural and effective way to enhance the quality of drinking water by reintroducing essential minerals, improving taste, and offering additional health benefits.

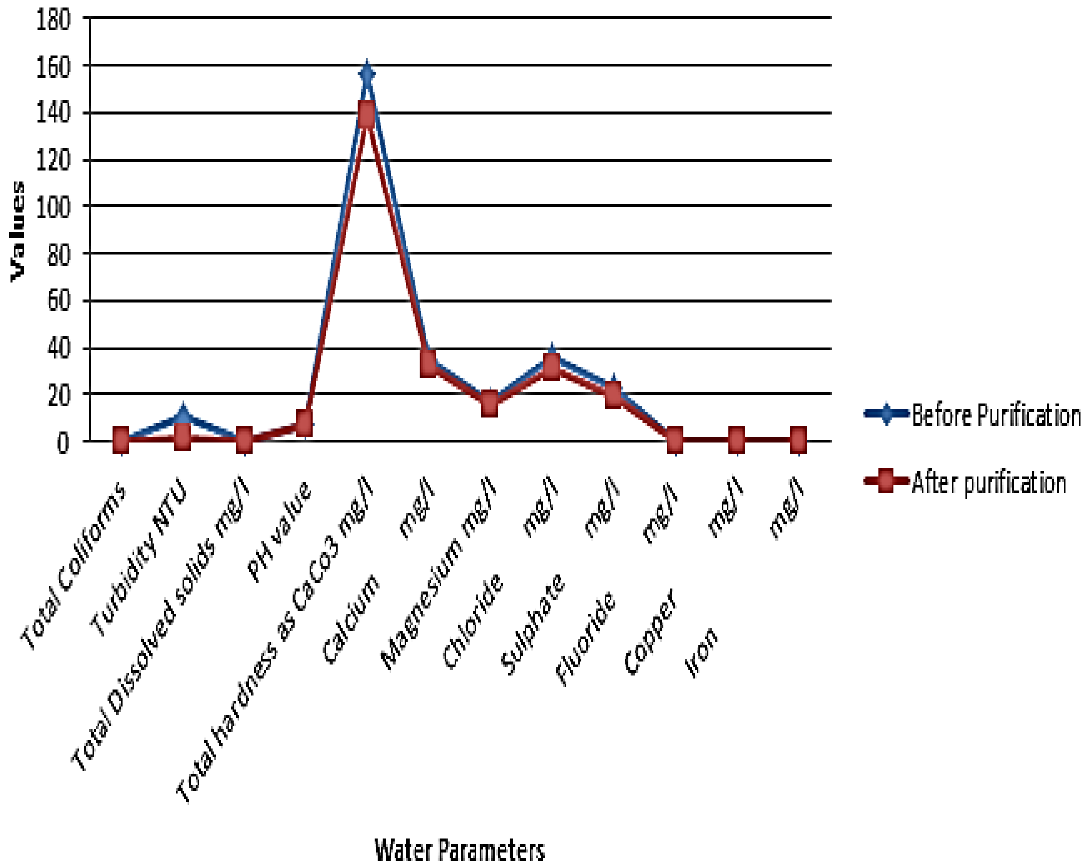


Fig 5.1: Graph showing various water parameters for untreated and treated water.

5.2 Conclusion

Water samples before purification and after purification were sent for analysis. The results showed that for Treated water

Total Coliform bacteria causing illness were completely absent

Parameters like TDS, pH, Turbidity has reduced from 309.8 mg/l, 7.4 & 10.8 NTU to 274.4 mg/l, 6.8, 1.2 NTU respectively and the values are within the standards set by the World Health Organisation (WHO).

Total hardness of the water is reduced from 156 mg/l to 109 mg/g and the values are with the limits (200 mg/L -600 mg/L) set by WHO

This is the cheapest water purification system that can be used by Military people/Travellers/ Rural areas as it is compact and is made of materials which are easily available at Low Cost.

5.3 Scope for Future Work

1. Higher capacity solar panel can be used to pump water even from underground, i.e. through bore wells.
2. Water high TDS values, Reverse Osmosis systems can also be implemented.
3. The Purification process can be modified further for reducing water hardness.

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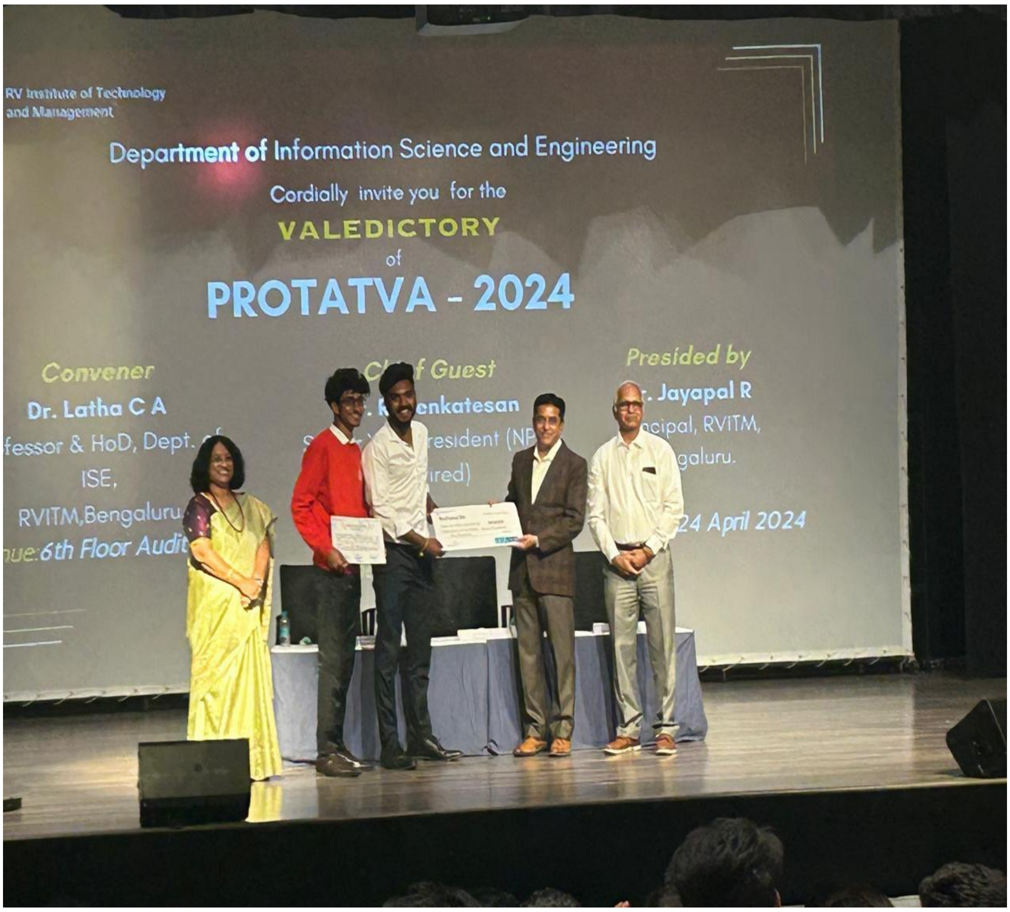
ACHIEVEMENT 1

CERTIFICATIONS AND AWARDS

PARTICIPATED IN IDEA PITCHING CONTEST WHICH WAS ORGANISED BY R V INSTITUTE OF TECHNOLOGY



ACHIEVEMENT 2

PARTICIPATED IN OUR COLLEGE PROJECT EXIBITION AND SECURED SECOND PLACE