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Design and Development of Portable Mini Water Bamboo Filter

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Abstract: This study aims to design and develop a portable mini water bamboo filter. Access to clean water is limited in the current era of globalization. Due to their remote location from cities, rural areas are more vulnerable. The goal of this study is to design and create a portable mini bamboo water filter that uses activated carbon as an adsorption mechanism to remove contaminants from the water supply. As addition, bamboo as natural plant is used as the major component in the canister development. Bamboo is a grass that can grow to 25 m in six months. When fully cultivated, it usually takes three to five years to grow to full strength. This research focuses on employing a cost-effective, environmentally friendly, renewable, and low-cost material to replace or reduce the materials commonly used today, such as plastics and metals. The second purpose is to evaluate the quality of the portable compact bamboo water filter that has been produced. The first way is to do a literature review on the features of both the carbon filter and the bamboo stem. Sketching is the following step, which is done when the literature review is completed. Several sketches are used in the design process to determine the best and most efficient water filter design. The design is then generated using SOLIDWORKS 2018 Cad modelling software. This study uses three water source parameters. Physical appearance and chemical testing are used to determine the quality of water. An activated carbon filter, according to the findings, can absorb and filter out most chemical pollutants.

Keywords: Activated Carbon, Portable Mini Water Bamboo Filter, Water Filter

1. Introduction

According to World Health Organization (WHO) in 2007, over 1 billion people lack access to clean water supplies. Natural water source contains microbial and chemical contamination. Water associated infectious diseases claim up to 3.2 million live each year, approximately 6.00 % of all deaths globally [1]. Not only should water be colorless, odorless, and tasteless, but it should also be free of germs and heavy metals. Generally, only 60.00 % of the country's population has access to

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clean and safe water for domestic use [2]. All living things, most notably humans, require water to survive. Humans can only survive for three to five days without water. The brain for example, will begin to shut down, resulting in a stroke or perhaps death [3]. The river, lake and groundwater sources are contaminated due to fertilizers, pesticides, antibiotics, dyes, heavy metals from the industry which result in diseases like cancer, skin defects, kidney damage, and liver problem [4]. Organic pollutants may also cause arteriosclerosis, heart diseases, hypertension, emphysema, bronchitis, and kidney and liver dysfunction [5]. A natural bamboo-based product and activated carbon are utilized to absorb and filter out hazardous contaminants and enhance water quality to lessen and overcome this problem. Bamboo is the common term applied to a broad group (1250 species) of large woody grasses, ranging to 10cm to 40m in height [6]. Because of its environmental benefits, bamboo is used in this study. When compared to plastic-based water filters, natural bamboo leaves no chemical traces. Plastic is derived from petroleum, whereas metal filters are derived from iron. Both product resources are non-renewable and will eventually be depleted.

Growing human population on planet in combination with an increase of consumption per capita, more and more pressure is put on global resources, causing three main interrelated environmental problem, depletion of resources, deterioration of ecosystems and human health [7]. To overcome these concerns, renewable resources are being developed actively all over the world. In addition to raw materials, renewable energy resources can be employed for food production and energy generation. Bamboo can be used to replace this natural resource in the manufacturing industry. Bamboo is strong and lightweight, and often be used without processing or finishing [8]. The project's purpose is to design and develop a portable mini water filter made of bamboo that is both environmentally friendly and simple to dispose. In recent years, a great deal of work has been put into developing acceptable, low-cost, and readily available materials for use in effective household filters.

The purpose of this research is to determine the water quality and filter out chemical contaminants using a portable mini water bamboo filter designed with bamboo as the primary material. In addition, the water filtering component is a catalytic activated carbon filter sponge layer. This study will examine the method of determining the physical appearance and chemical parameters of a water sample, which are the water local resources that decide quality testing. The purpose of this research is to examine the use of Solid Work 2018 for CAD modelling design. Chemical and physical appearance testing are performed to establish water quality. The search for potentially included articles was mainly through on-line bibliographic databases. In addition, Google Scholars were also used to capture articles which were unindexed. This study also checked the references list of identified studies for potential included articles. The citation of potential eligible studies retrieved was exported into the citation manager and duplicates were eliminated.

1.1 Bamboo

Bamboo is the common name of the perennial grass with a large woody stem or culm. Bamboo encompasses about 1662 species within 121 genera [9]. Bamboo is an important part of millions of people's daily lives in subtropical and tropical areas. Bamboo is a durable material. The outer coating of the stem is quite strong and durable. Bamboo is a flexible and elastic material. As a result, bamboo goods are exceptionally resilient and resistant to breaking when put under stress. Increased research during the recent years has contributed considerably to the understanding of these important arborescent grasses as well to an improved processing for wider users [10]. It is a quickly renewable, long-term resource with mechanical qualities like lumber. Bamboo takes only three years to develop. Bamboo is ready to harvest after three years. Worldwide, there is a growing interest in the development of bamboo product as a sustainable, cost-effective, and ecologically responsible alternative construction material [11]. Various mechanical properties of bamboo are required for its use as a structural material. Bamboo can be used as reinforcement in various structural members.

1.2 Activated carbon filter

Activated carbons are made from a natural organic component that contains a lot of carbon. Activated carbon is a form of absorbent that has a wide range of uses. It's a great way to get rid of chlorine, agricultural pesticides, and other contaminants. This not only improves taste and minimizes health hazard, but it also protects other water treatment units such as reverse osmosis membrane and ion exchange resin from possible damage due to oxidation or organic fouling [12]. High surface area, microporous structure, and high degree of surface reactivity contribute to the absorptive capabilities [13]. Heating organic components to pure carbon produces activated carbon. By eliminating pollutants, activated carbon may purify water and air. Chloramine and chlorine, tannins, and phenols are just a few of the dissolved pollutants that activated carbon can adsorb. Minerals, salt, and dissolved inorganics are not removed by activated carbon. Activated carbon binds to the contaminants it removes, rendering it saturated and unable to remove any more. It should be updated monthly at the very least.

As the time between replacements grows longer, carbon's ability to remove toxins from water will deteriorate. In this study, the catalytic activated carbon filter is used for filtering equipment. Catalytic activated carbon provides several advantages over normal carbons, including the fact that it is more effective. Its catalytic activity aids in a wide range of chemical processes. The result is less carbon and smaller equipment because of the speedier chemical process. The non-impregnated carbon also removes concerns regarding exothermic reactions, ignition temperatures, and toxic waste disposal. In addition, on-site regeneration reduces running costs and increases service life. Finally, catalytic activated carbon may be recovered and reused through thermal reactivation, which is the most essential benefit.

2. Materials and Methods

The study was carried out to test the quality of filtered water sample. Using Solid Work CAD 2018 software modelling as sketching design and using a suitable filtering testing standard. To achieve the completion of this project, strategic methods are important to get the desired results. Firstly, doing research on the related topic of this project is important to master all the knowledge and fully use the information from all past studies. This method will guide the project not to make any mistakes by assuming the facts. Next, the method that can be done after several studies in past research papers or from any other source is material selection. This step can be done after studies have been made thoroughly since wise decisions need to be made in this method. Furthermore, the next method is the preparation of the sample and material.

Samples will be tested which are the prototype of a portable mini water bamboo filter with activated carbon. The preparation of this portable mini water bamboo filter is very simple, where a simple cylinder chamber is fabricated with the addition of bamboo activated carbon as impurities-absorbing materials attached into it. This study used three different types of water samples. Tap water is the first water sample. A sample of tap water was collected from University Tun Hussein Onn Malaysia's Pagoh residential college. River water is the second type of water. This sample was taken from the Panchor River, which lies close by. The pond water is the final sample. The nearby Pagoh campus pond provides pond water. Because different locations of water sources have variable content and contaminants, three types of water samples are used. Furthermore, all samples are solely obtained inside the Pagoh area.

2.1 Materials

The portable mini bamboo water filter is made up of two major elements. The bamboo stem is the first important material employed in the development of canisters. The body of a portable mini water bamboo filter is primarily made of this material. Bamboo is a green material for sustainable development and has various advantages. The matured, largest measurement of diameter and length is used for the project to identify and know the sort of bamboo that is acceptable for use. This is

beneficial for inserting the activated carbon filter sponge into the bamboo. The catalytic activated carbon layer sponge is the second material utilized for filtering mesh inside the bamboo stem.

2.3 Sketching design

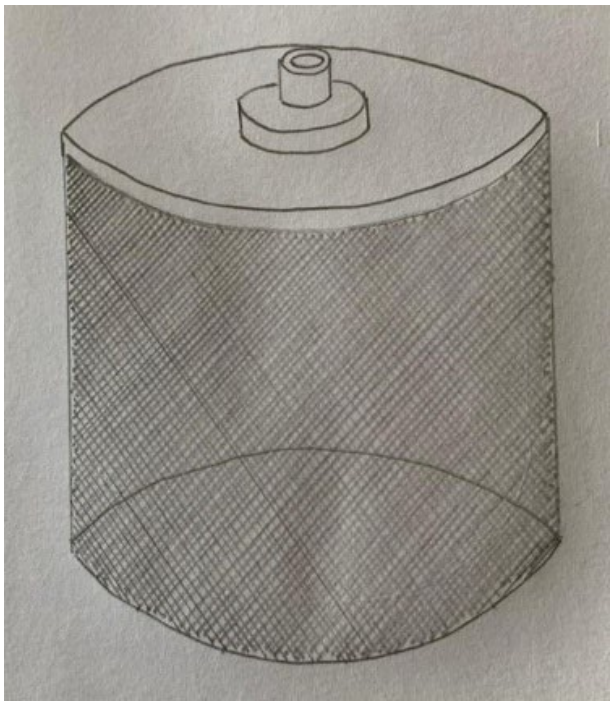

Figure 1: Sketching 2 (Cylinder Shape)

4 sketching designs concept are created for the study's reference design. Each concept has its technical requirements and characteristics. To use the best and most effective design for the water filter design, preliminary drawing is done. Because the surface or substance of filtering is wider and larger than other drawing designs, the cylinder shape design was chosen from the investigation. Sketching 2 was also chosen since it is simple to store and can be slipped into a bag pack when travelling. Then, sketching drawing 2 has the simplest assembly methods, which is advantageous during the assembly process. During the fabrication and assembly process, this can also save time and energy. The form is easy to install and disassemble due to the features and requirements of the mini water filter. Based on the size that was recognized and sketched, the actual portable mini water bamboo filter was built using the size and design of the sketching. Using the data acquired, the actual shape and picture may be successfully produced.

The observations will be based on a bamboo filter filtration performance test, with data collected and analyzed as a result. More features, such as a hole at the bottom of the filter to allow water to flow freely, can be added to this portable mini water bamboo filter for this type of design concept. University concepts can help produce an ergonomic design while simultaneously conserving the environment. To prevent the activated carbon from tearing during the filtering process. A sturdy canister is required in Solid Mechanics to prevent cracks or fractures caused by water flow. When maintaining a catalytic activated carbon filter, the shape of a cylinder type filter can be opened and disassembled using the sketching design. Catalytic activated carbon filter also can be maintained or replace yearly according to the usage of portable mini water bamboo filter.

2.4 Solid Work CAD modelling

Figure 2: AutoCAD design sketching (30.00 cm x 7.00 cm x 0.0 5cm)

SOLIDWORKS 3D, a solid modeling computer-aided design and computer-aided engineering program, is one of the most popular software options for mechatronics engineers. The SOLIDWORKS software solutions are used to form a connected design. The suite of programs is aimed at keeping all design in communication and able to respond to design needs or changes. Solid Work CAD software with the version 2018 was used to construct all the CAD model for sketching and design in this study. The properties of brass and wood were added in SolidWorks software. The dimension of CAD model of portable mini water bamboo filter is 30.00 cm in height, 7.00 cm in width, and 0.50 cm in thickness as illustrates in Figure 2. SOLIDWORKS application aids in increase productivity.

SOLIDWORKS 3D modelling allows designer to quickly simulate a design in 3D and make any necessary revisions. This boosts the designer's efficiency because the concept will not need to be rethink afterwards. SOLIDWORKS drawings also aid in the detection of inconsistencies and enable the designer to adjust models and sketches prior to completion. The next advantage is that the designer can create better designs. Manually recording numerous features of a mechanical component is a time-consuming operation that needs high degrees of precision in traditional drafting methods. It streamlines the entire process of documenting component designs because SOLIDWORKS 3D CAD models come preloaded with diverse documentation choices, such as documenting product geometry and dimensions, material specifications, bill of materials, and so on.

2.3 Equipment

From the fabrication process to the filtration process, there are seven pieces of equipment used in this investigation. The first piece of equipment is a 14.50 cm wide x 7.00 cm height bamboo stem. The water filter canister is made up of two parts of the same bamboo stem. This bamboo stem was sliced with a wood saw. The brass hose connector of 3.50 cm height x 3.00 cm wide at the top of the bamboo stem serves as the water inlet flow. The essential ingredients in the filtering process are then catalytic activated carbon filter sponges. The general-purpose contact adhesive glue is used to assemble the entire water filter. The catalytic activated carbon is cut into the desired size of filter sponge with a scissor. The water strip test kit and the offer table for the result quality of the water source are the final pieces of equipment.

2.4 Fabrication process

There are eight steps in the fabrication process. Cutting the bamboo stem is the first step. The bamboo stem is divided into four pieces using a wood saw. The project uses the matured, biggest diameter and length measurements to identify and determine the type of bamboo that is acceptable for

use. This makes insertion of the activated carbon filter sponge into the bamboo much easier. The second step is to dry the bamboo stems. This procedure is used to remove any germs or contaminants from the bamboo that may have an impact on the water quality. For 14 days, the bamboo stem is completely dried in direct sunlight. The washing of the bamboo stem is the third step. Microbial contaminants are removed both outside and within the bamboo stem. Drilling top bamboo stem is the fourth process. The drilling technique only uses a modest drill equipment since the bamboo inner nodal diaphragm is not very thick.

For installation of a brass hose connector, a 3cm wide hole is bored on the top side. The fifth phase is the same as the previous four, but with the bamboo components in a different location for the water outlet flow, which is accomplished by drilling the bottom bamboo stem. Drill 9 holes, each measuring 0.50 cm in diameter. Water can flow more easily out of the bamboo chamber if small holes are drilled into it. After the drilling operation, the sixth step is to assemble the brass hose connector. For the water inlet flow that is attached by a hose or direct water pouring, a brass hose connector is installed at the top bamboo stem. The insertion of an activated carbon filter sponge is the next step. For the optimum filtration results, a total of 15 layers of sponge are inserted. The gluing bamboo stem for assembly is the final step in the manufacture process. Water leaks from any connecting element are prevented by gluing both bamboo stems together tightly.

2.5 Final product

Figure 3: Final product

The final project following the fabrication process is shown in the illustration above. The final product is designed and developed in SOLIDWORKS AutoCAD software exactly according to the sketching. The durability and filtering process of the final portable tiny water bamboo filter have also been tested. There are no leaks throughout the filtering process. Water is pumped into the bamboo filter, which uses each layer of fine mesh to remove large particles like stones. Catalytic activated carbon elements are kept and retained in place by the mesh inside the filter. After water sample passing through the bamboo filter, the water is filtered twice and collected inside the bamboo canister.

2.6 Chemical testing

Chemical testing result is important to analyze and evaluate the quality of water. Water test strips kit are used to show the percentage of chemical concentration in water sample. This is for preliminary checks as their accuracy can hardly compared to professional analysis performed in laboratory conditions. Every process needs 2-3 seconds after immersed in water sample to obtain result. Ph

value, residual chlorine, hardness, total alkalinity, and total chlorine result is obtained after 15 second. For nitrite and nitrate, result is taken after 60 second.

2.6 Quality testing

Two types of quality testing are used in this study. Chemical testing is the first type of quality control. This test is used to assess the quantities of mineral and organic substances in the water. Chemical testing results are crucial in achieving regulatory requirements and following the safety measures required for pollutant-free water. This is a broad term that refers to a variety of methods for analyzing and evaluating water quality. Test strips were used to get the results of this chemical analysis. The color of these strips changes to reflect the chemical content in the water. These tests, on the other hand, are usually used as preliminary inspections because their accuracy is inferior to that of professional laboratory analysis. Physical appearance testing is the second type of quality control. This is done to show qualities that the senses can notice. The two sorts of characteristics used to determine the quality of a water sample are color and odor.

3. Results and Discussion

The results and discussion will be discussed based on the data obtained from the parameter of chemical and physical appearance testing.

3.1 Quality chemical result

i) Ph value

Figure 4 show the pH values for three types of water samples, both unfiltered and filtered. As a result of the filtering process, catalytic activated carbon shows a reduction in pH levels. The pH value of activated carbon can be reduced. Unfiltered water is represented by blue, whereas filtered water is represented by orange. After filtering tap water, the pH value drops somewhat. The second sample, pond water, has changed slightly after being processed. After filtering, the pH value of the third sample, river water, has decreased marginally. The result indicates that the Ph value is within the acceptable range for the user. Even though pH has little direct impact on water users, it is an important operational water quality criterion. pH management must be carefully monitored at all stages of water treatment to achieve appropriate water clarity and disinfection. For effective chlorine disinfection, the pH of the water should be less than 8.0. Failure to do so may result in water contamination, as well as detrimental effects on the flavor, odor, and appearance of the water.

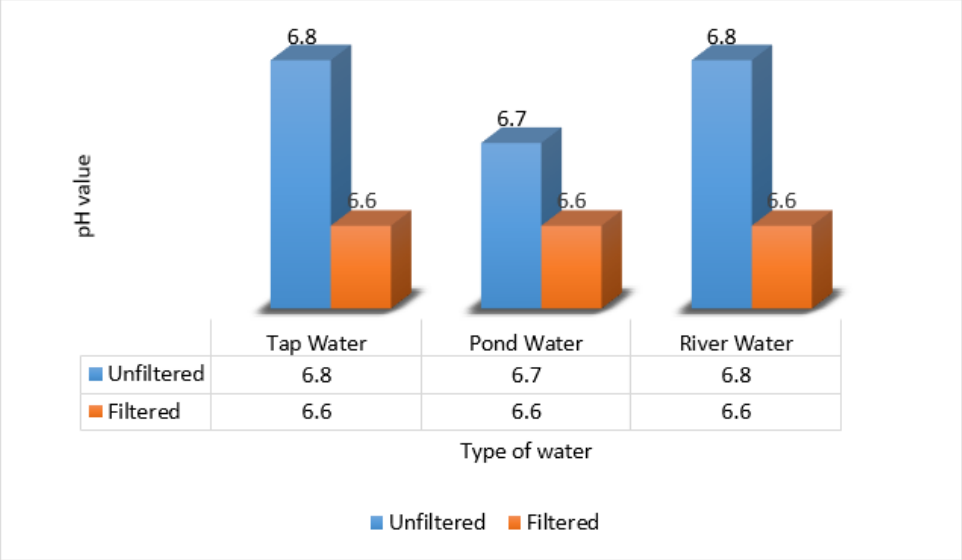

Figure 4: Measurement of pH value

ii) Nitrate (NO_3)

The presence of nitrate in water is shown in Figure 5. Nitrate levels more than 10mg may be harmful to human health. Nitrates can come from fertilizer or wastewater leaks, for example. The results demonstrate that the nitrate levels are within normal limits. The unfiltered result is shown in blue, while the filtered result is shown in orange. After filtering, tap water has the same amount. Activated carbon absorbs 50% of the nitrate in pond water. A catalytic activated carbon sample of river water shows a modest nitrate absorption. Although minor levels of nitrates may exist naturally in water, greater levels, which might be harmful to newborns, are occasionally discovered. When nitrate is reduced to nitrite, which can happen in the stomach or in the saliva, it becomes poisonous.

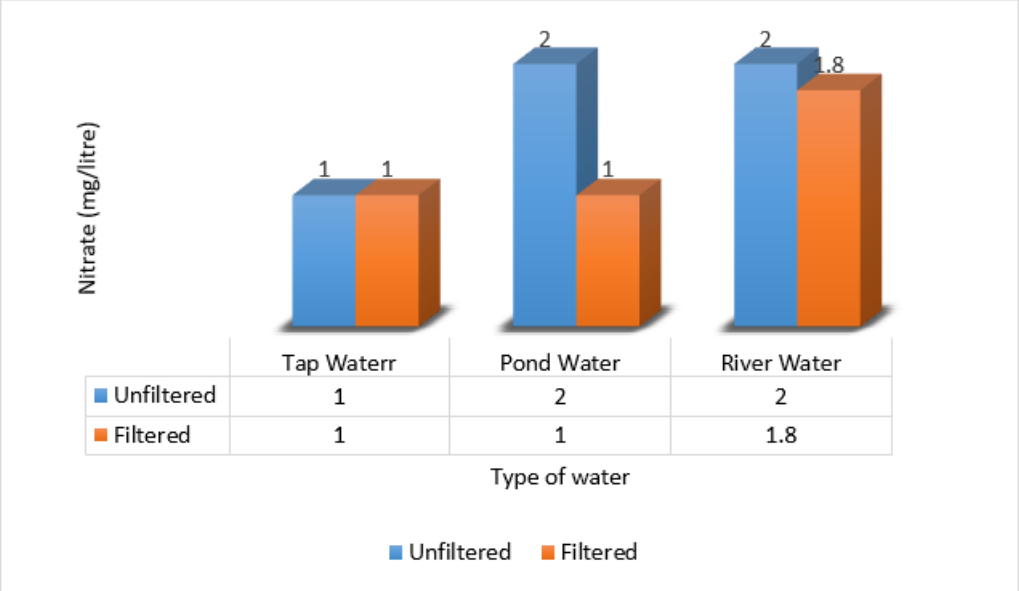

Figure 5: Measurement of Nitrate

iii) Nitrite (NO_2)

The result of the nitrite level in water is shown in Figure 6. In water and soil settings, nitrite and nitrate are common pollutants. When ammonium is biologically oxidized, nitrite is produced, which can subsequently be converted to nitrate. Soil, industrial waste, and groundwater all contain high levels of nitrite. Blue shows an unprocessed result, while the color orange denotes a filtered result. According to the tap results, activated carbon has absorbed 50.00 % of the nitrite pollutant. Nitrite levels have decreased slightly in both pond and river water samples. This is owing to the activated carbon filter's excellent absorption process.

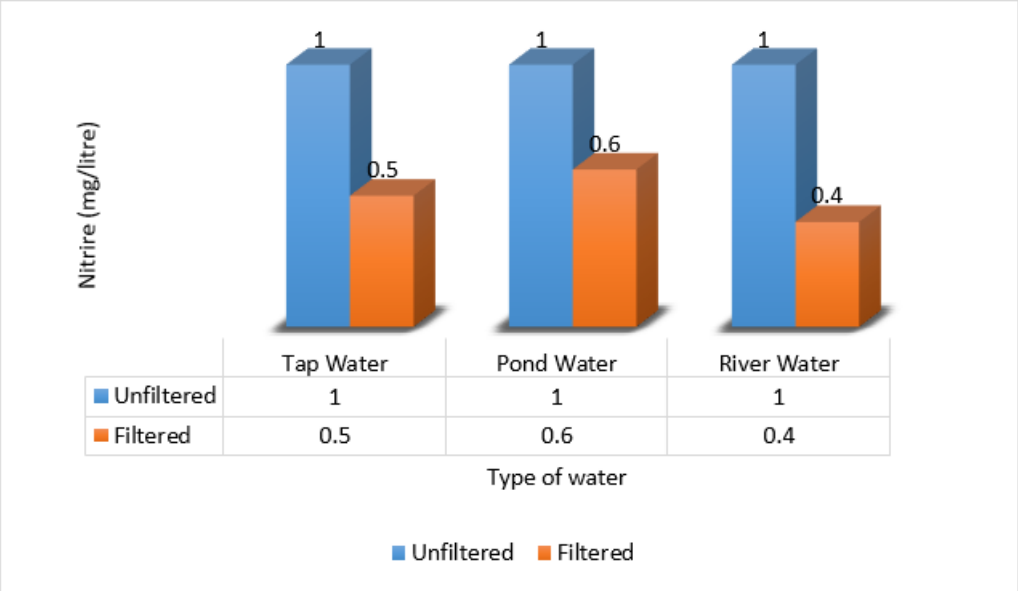

Figure 6: Measurement of Nitrite

iv) Residual Chlorine (CL_2)

Residual chlorine is a small quantity of chlorine remains in water after a contact time has pass after it was first applied. Chlorine provides protection against microbial contamination after water treatment. One of the most popular tests used by water treatment is residual chlorine testing. The residual chlorine test evaluates how much chlorine is left in water after it has passed all its tests and is ready to be released into the distribution system. Residual chlorine is a critical metric for preventing microbiological contamination. Figure 7 show the result of residual chlorine level in the water sample. Green color indicate unfiltered water sample and blue indicates filtered water sample. Based on the data, it can be concluded that the level of residual chlorine for all water sample has decrease, activated carbon's removal of chlorine reduces the chlorine to a non-oxidative chloride ion.

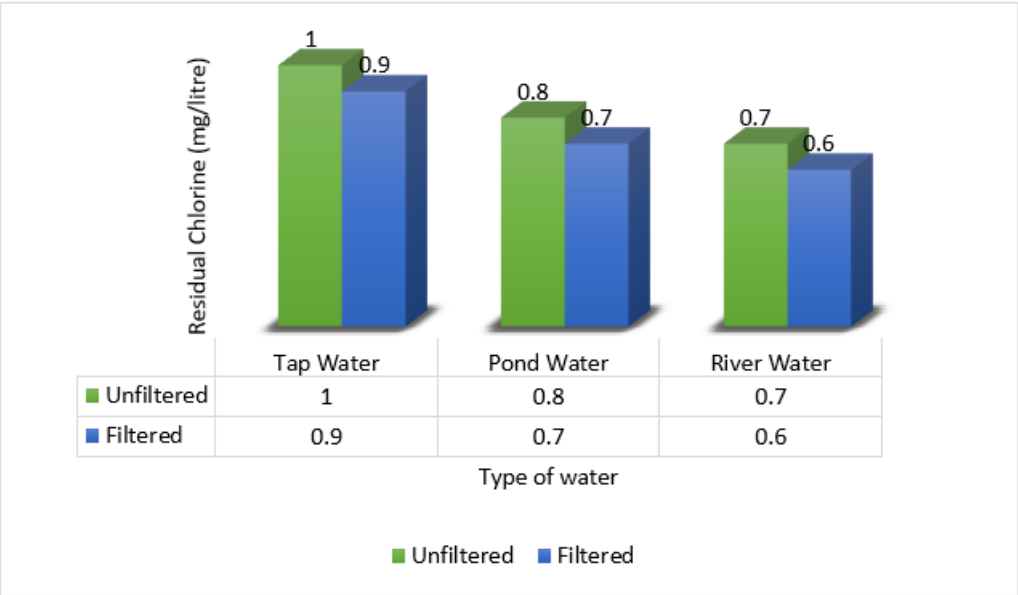

Figure 7: Measurement of Residual Chlorine (CL_2)

v) Hardness

Hardness refers to dissolved calcium and magnesium compound in water. Hard water containing more than 500 mg is not suitable for consumption in most household applications [14]. Figure 8 show the results before and after the filtering process. The hardness levels in the water sample reveal a reasonable level of hardness. Before and after filtering, tap water, pond water, and river water all have the same hardness level. The findings reveal that activated carbon is ineffective at absorbing and filtering hardness from the water sample.

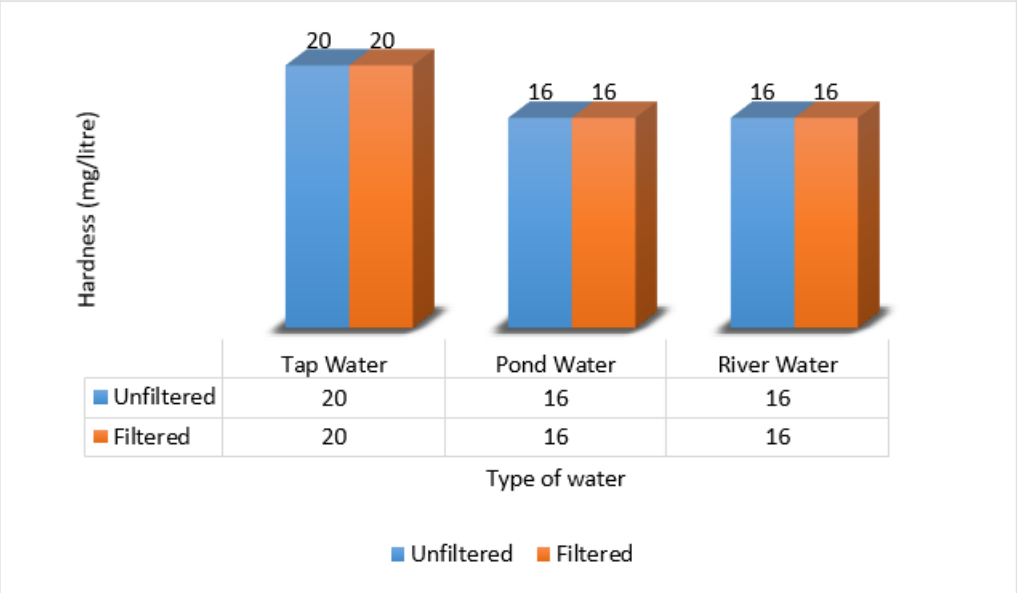

Figure 8: Measurement of Hardness (GH)

vi) Total Alkalinity (KH)

Total alkalinity is a measure of water capacity to neutralize acids. Higher amounts of CO_2 or other acids are required to lower pH because there is more available to neutralize or buffer the acid [15]. Alkalinity, often known as buffering, is a measure of the water's ability to resist fluctuations in pH. Maintaining a constant pH is critical for most applications. Alkalinity is made up of calcium and magnesium carbonates, bicarbonates, chlorides, and sulphates, however it's usually measured in milligrams per liter of water. M-alkalinity, commonly known as total alkalinity, is a metric that measures the total amount of hydroxide, carbonate, and bicarbonate ions in the body. Blue color indicates unfiltered result and orange color indicate filtered result. Figure 9 show activated carbon absorbs alkalinity efficiently during filtration process. The level result of alkalinity decreases for all water sample.

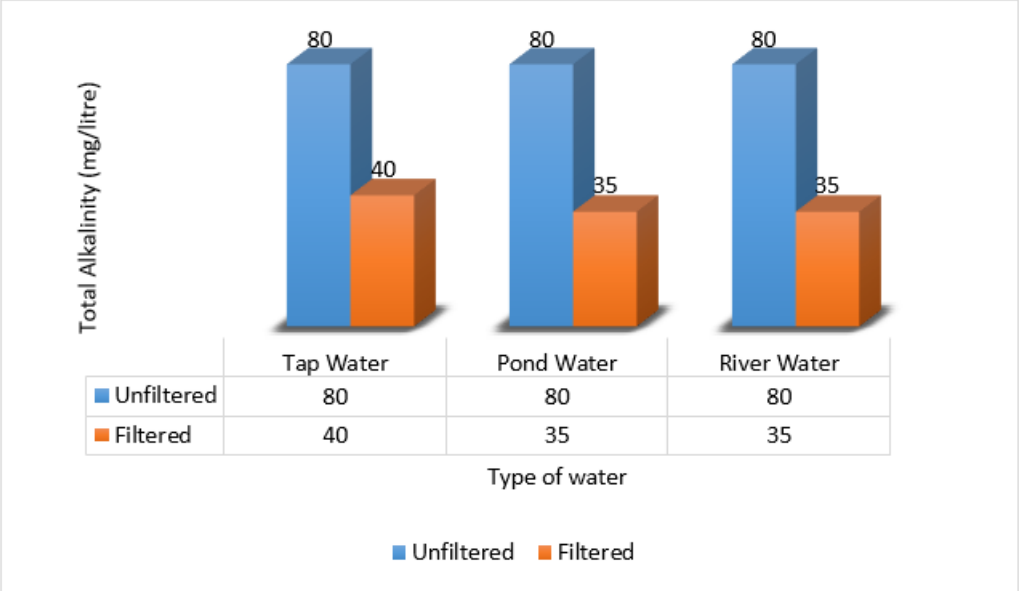

Figure 9: Measurement of Total Alkalinity

vii) Total Chlorine (TCL)

Total chlorine is the sum of combined and free chlorine. In all circumstances, total chlorine levels will be higher than or equal to free chlorine levels. Total chlorine is usually tested in wastewater after it has been treated. The light green color represents an unfiltered result, whereas the dark green color represents a filtered result. Activated carbon filters out chlorine efficiently throughout the filtration process, as seen in Figure 10. For all water samples, the overall chlorine level decreases marginally.

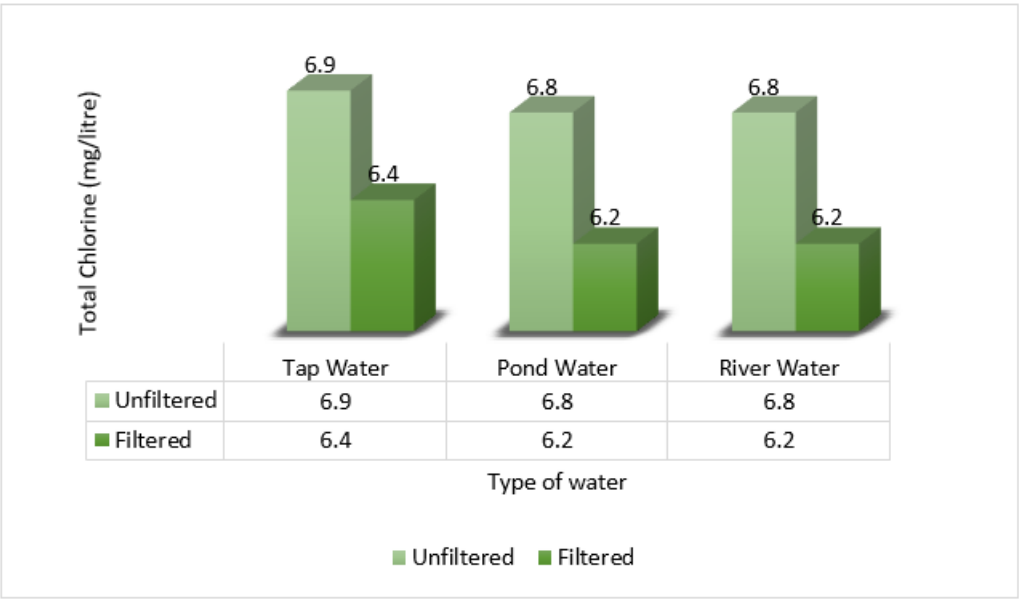

Figure 10: Measurement of Total Chlorine

3.2 Quality physical result

Physical properties analysis and testing is conducted by experienced chemists and scientists to proven, accepted industry and scientific protocols including ASTM and other industry and regulatory standards. The purpose of physical appearance testing is to uncover features that can be noticed by the senses. Color can be produced in water by the presence of minerals such as iron and manganese, as

well as plant-based substances such as algae and weeds. Color and odor tests indicate the efficacy of a water treatment system.

The results of the physical test are shown in Table 1 in their unfiltered form. The water in the tap is clear, but the water in the pond and river is hazy. This finding indicates that the water sample contains a variety of microbial and chemical components. Although tap water has no odor, pond and river water do.

Table 1: Unfiltered physical appearance result

Name	Color	Odor
Tap water	Clear	No odor
Pond water	Cloudy	Smelly
River water	Cloudy	Smelly

Table 2 shows the filtered physical appearance test results. The tap color remains the same after the filtering procedure. The color of pond and river water is also consistent. However, after the filtration procedure, pond and river water have a less odorous consequence. This demonstrates that activated carbon filters are ineffective at filtering the color of water. In terms of water quality, activated carbon filters are only marginally successful at removing odors.

Table 2: Filtered physical appearance result

Name	Color	Odor
Tap water	Clear	No odor
Pond water	Cloudy	Less smelly
River water	Cloudy	Less smelly

4. Conclusion and Recommendations

It has been determined that all the objectives have been successfully achieved. The results of past water quality testing and research articles were used to effectively design and build a portable mini water bamboo filter. The chemical solvent component in the water sample was satisfactorily absorbed by the portable mini water bamboo filter. CAD SolidWorks 2018 was used to create the prototype and actual project of a portable tiny water bamboo filter. If properly implemented, this study has the potential to reduce waste and pollution by lowering the amount of new raw material required. This advantage is that biodegradable materials, such as bamboo, need less energy to manufacture and are non-toxic because they contain no chemicals or poisons. The water quality results demonstrate that activated carbon is effective at absorbing chemicals but not so much at neutralizing the color and odor of the water. The results of the chemical hardness test demonstrate that the activated carbon filter sponge is unable to collect and filter out other contaminants in the water sample.

This research can be used to make a few recommendations for improving water quality. The first suggestion for future development is to create a fine bamboo mesh to increase water outflow flow. Further research into the balanced natural form of bamboo nodes can be used to improve water filter intake design. Although the water quality is high, it is recommended that you boil the water source before drinking it to destroy any bacterial remnant that may have remained in the system. Activated carbon only aids in the absorption and reduction of chemicals in the water system. Extensive experimental investigations with various types of water sources will be used to determine each filter's long-term effectiveness, such as ultraviolet light rays immersed in the water flow in a specialized chamber, which will reduce and kill all microorganisms present during the water flow through the specialized chamber.

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