TREATMENT AND RECYCLING OF WATER ABLUTION FOR IRRIGATION PURPOSE

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TREATMENT AND RECYCLING OF ABLUTION WATER FOR IRRIGATION PURPOSE

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ABSTRACT

A large amount of water is used in the ablution process, especially in musollas and mosques where greywater is permitted to stream freely and drain away. As quoted in the Hadith, Prophet Muhammad advised Muslims to avoid wasting anything, even when conducting the washing ritual or ablution before prayer. Most ablution systems in Malaysia consist of a row of water taps with a drainage through to take greywater to main drains. Because the tap is generally kept running, a lot of good water is squandered. In order to avoid wasteful waste, a simple recycling system may be developed to collect, purify, and reuse ablution water for non-portable water uses such as plant watering in a closed-loop system. This strategy not only introduces actual engineering solutions for encouraging sustainable living, but it also adheres to Islamic values of cautious use of natural resources. A research was done to create and test a conceptual model of the ablution water recycling system, named Eco-WUDHU, by referring to the University's own mosque. The Eco-Wudhu system, whether retrofitted or constructed from the ground up, represents a successful fusion of engineering know-how with religious principles for improved quality of life today and in the future.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Water has been over utilized in the industrial and urban sectors for decades owing to its low cost and large variety of application. As a result, the demand for fresh water has risen exponentially in a rising number of countries, making water a valuable asset and an important commodity in certain parts of the world. On the other hand, greywater is made up of waste from showers, kitchens, clothes washers, dishwashers and kitchen sinks but not from toilets. Greywater accounts from 50% to 80% of all wastewater produced in the home (Merriam-Webster Dictionary, 2021). The characteristic of greywater can be categorized by looking through the value of biochemical oxygen demand (BOD) and chemical oxygen demand (COD). BOD is representing the amount of oxygen absorbed by bacteria and other microorganisms when decomposing organic matter at a specific temperature under aerobic (oxygen present) conditions (Biological Oxygen Demand (BOD) and Water, 2019). Moreover, COD is defined as a second tool for calculating how much oxygen will be drained from a receiving body of water due to bacterial action. From data that have been collected from the households and the sample of greywater were collected in between December 2016 and February 2017, the result showed the water consumption from the household insider access around 74.16 % and external sources are 88.57 % (Oteng-Peprah et al., 2018).

As stated before, water is one of the important resources that existence is dependent on it, since it supports ecosystems and human societies. Food preservation, electricity supply, manufacturing, and sanitation are only a few of the ways we use freshwater in our everyday lives (National Geographic Society, 2021). The pollution that occurs involving water, especially pollution of rivers, seas and lakes is one of the causes of lack of water sources in a country no matter which country at all. So, it is the responsibility of every human being to use fresh water prudently so that there is no wastage. It is actually can cause a bad effect from wasting water to the environment. There are several reasons why is it actually bad wasting water to the environment.

Firstly, fresh water known as a limited resource for the survival of human population. Different nations have different freshwater supplies, and each has differing degrees of water depletion that must be tackled, based on their replenishment rate and consumption rate. Secondly, fresh water also essential for plants and animals. It is because plants and animals also resources of food for human if there is no fresh water for them it can threatened the population. Lastly, if we waste water and the human population and living things are increasing it will be the reasoned we need underground water intake. This is worrying because if the water from underground is also reduced it will affect all living things on this earth. Thus, the initiative that needs to be taken is to use water prudently and not waste the water. (US EPA,ORD, 2017)

This study will be conducted at Universiti Malaysia Pahang (UMP) Mosque, Gambang Campus. Basically, this study focused on how to recycle the greywater from the ablution that have been performed by Muslims who use the fresh water. Mosques in Malaysia use the same water system for ablution which is consists of a row of water taps connected by a drainage through that transports greywater to main drains. This system is also applied in UMP Gambang Campus mosque. Usually when we take ablution, the tap water will always be open and the excess water from it can still be used. The remaining greywater then can be treated and be reuse for other purposes. The concept of recycling the greywater are going to be applied in this study. Recycling is the practice of gathering and recycling items that may otherwise be discarded as waste and transforming them into new goods. Our society and the world will also benefit from recycling (recycling | Definition, Processes, & Facts | Britannica," 2021). Besides, recycled water is wastewater that has been recycled and disinfected at water treatment facility to remove solids and other impurities. In this concept, we use the filtration to treat the greywater from UMP Gambang Campus mosque. The treated ablution water will be reuse by distribute it for plants watering at UMP nursery that located behind the mosque.

The purpose of the recycled water ablution is to reuse it for plants watering at UMP nursery. Based on this purpose itself, there are many significant impacts of recycling and reuse of the greywater. First and foremost, water reuse conserves resources such as water, electricity, and money. In the arid west, where long-term drought conditions occur, decentralized water reuse systems are becoming more common. For several years, effective grey water services have been in use (Boano et al., 2020). By providing water for landscaping, they can reach up to 50% of a property's water needs. Grey water recycling conserves fresh potable water, decreases drainage flow to septic tanks and wastewater treatment facilities, and expands service capability for new consumers. In addition, it is also can help to prevent pollution from occur. It can be proven that because when untreated greywater and containing indirectly contaminated materials also contaminate crops when being used for plants watering. Moreover, recycling water also can save the energy. As we all know that water is a renewable resource. When we apply the concept of reusing water by treating greywater from ablution in particular can increase natural water resources and make water resources more and there is no wastage (Greywater Reuse - Greywater Action, 2018). To further this study, the water ablution recycling system is developed in order to treat the ablution water and reuse the treated ablution water for UMP nursery.

1.2 Problem Statement

Water pollution is one of the major environmental problems faced, because more than 70% of the Earth's surface is covered with water. Water pollution can be defined as pollution of rivers, streams, lakes, oceans or other waterways, deteriorating water quality and making it toxic to the environment and human. (Rahiza, 2020). Data in 2016 and 2017 show that most Malaysian river water quality is in the Class II and Class III Water Quality Index. Almost 98% of the Malaysia's fresh water supply comes from rivers. Thus, the status and quality of river water must be emphasized so that it is always in good condition and sustainable. River water quality and water supply crises are usually interrelated as rivers that are affected and polluted in large quantities will cause the Water Treatment Plant to cease operations temporarily and this is when the water supply crisis occurs. When water pollution occurs, the water supply to thousands and even millions of consumers will be affected, as is often the case in the Klang Valley (Haliza A.R, 2020). BOD, ammoniacal nitrogen (NH_3-N), and suspended solids (SS) are the primary contaminants in Malaysian rivers and lakes. Untreated or partly treated sewage from industrial and agro-based sectors adds greatly to elevated BOD levels.

Domestic sewage, animal production, and other liquid organic waste materials are the major sources of NH_3-N, while the main sources of SS are mainly earthworks and ground clearing operations, which are usually removed through sedimentation or water filters.

Statistics have shown that the average Malaysian uses about 210 liters per day, which is 27 % more than the United Nations (UN) recommended amount. Based on that, each Malaysian waste 45 liters of water per day or 16,425 liters of water per year (Sim L.I 2020). In UMP, the water wastage comes from various sources and among them is from ablution water at UMP's own Mosque. Muslims perform prayers 5 times a day and each time everyone will be consumed water ablution and the amount of water used in ablution in nearly 40 mosques and in the two holy mosques, and found it 3–7 L per person at a time (Zaied, 2017). The mosque in UMP uses tap water for ablution where the people just leave the tap open due to inconvenience and a simple ablution system consists of a row of water taps connected by a drainage trough that transports greywater to main drains. Because the tap is generally left running, a lot of good water is wasted. The highest amount of water ablution consumption is on Friday due to the number of pilgrims coming to the mosque will increase. In UMP's mosque, around 300 people will perform prayers at one time and an uncontrolled rate of water consumption will ensue. This can lead to wastage of clean water and exacerbate the situation when clean water is insufficient. In fact, only 2.5% of the total water on earth is readily available for human use. This water is in aquifers, lakes, reservoirs, rivers, streams, and rainfall. The increasing demand of clean water scarcity in some countries has become global issues (Beth H.Baker, et al., 2018)

The nursery plant located near the UMP's mosque receives clean water supply from the ump mosque water tank to perform daily watering activities. If the ablution water can be recycled, the rate of clean water consumption at nursery plant can be reduced because this recycled ablution water will be used for plant watering activities in the nursery plant. Thus, a simple recycling system for collecting and reusing ablution water can be devised (Zikri et al., 2020). Greywater from the ablution ritual is relatively clean because it contains no soap or solid impurities, although it does contain a small number of microorganisms, mainly from gargling. Due to the fact that ablution water is basically lightly polluted grey water, strategies for capturing and recycling another greywater could be applied to it as well. As a result, after capturing this mildly polluted water and undergoing basic treatment, the water can be recycled and reused in non- potable water applications. The treated water can be used outdoor applications include plant nursery. This example demonstrate how ablution water can be beneficially reused in a closed-loop water recycling system. Efforts to reuse ablution water have been confirmed by (Mamun, 2017).

The majority of current prayer facility design guidelines are primarily concerned with the appearance of the praying facilities, ignoring the proper design of supporting spaces such as the ablution area. (Aman, 2017). In mosques, the design of the water ablution area does not focus on the problem of water waste. Most designs only focus on appearance without finding a solution to design a system that can limit water use and recycle ablution water for daily use in the mosque itself. Most of the mosques will be produced a large amount of water that comes from water ablution. The ergonomic design is needed to developed the system that able to recycle the water, thus the water wastage can be prevented and the recycled water can be used for the daily usage in mosques (Julaila A.R. et al.,2020). The previous studies have been conducted in ump mosques but the construction could not be completed due to time constraints and current conditions due to covid-19. The agreement to carry out a renovation on the mosque from the Centre for Islam and Human Development University Malaysia Pahang (PIMPIN) is still under discussion. The recycled water supply will also be limited to watering a plan only and not for indoor use such as toilet flushing due to the amount of water used may not be enough to meet the water supply needs in the toilets plus the pandemic situation that hit caused the number of people in the mosque.

1.3 Objectives

1. To study characteristics of ablution water in UMP Gambang mosque.
2. To design and fabricate filtration and Eco-Wudhu system for irrigation plant.
3. To evaluate the performance of the Eco-Wudhu system by determining the water characteristics

1.4 Scope of Research

The study took place at the UMP Gambang Campus mosque that located between Kolej Kediaman 1 (KK1) and the nursery plant. It can hold at least 3000 people at any given time. Within the mosque, there are two ablution places, one for males and one for women. Outside the mosque, there is an additional ablution place for male Muslims. Stormwater is gathered in open drains surrounding the mosque, while ablution water is drained through covered pipe drains. The mosque, on the other hand, lacks its own water metre to keep track of how much water is used each month. The estimated average daily total number of individuals praying (excluding Friday) is around 900, according to Pusat Islam & Pembangunan Insan Universiti Malaysia Pahang (PIMPIN). Although water is inexpensive in Malaysia, it would be good to the environment and resource conservation if discarded ablution water could be recovered and used for various allowed campus activities. Samples of used ablution water were gathered from three major sites of the UMP Gambang mosque to measure the volume of water consumed and the quality of the water released to the drains. The used water from these sites is sent through the outflow. For two months, ablution water samples were collected and analysed, five samples from each station. TDS, turbidity, total suspended solids (TSS), chemical oxygen demand (COD), and total nitrogen (TN) were all determined. Standard Methods were used to determine the quality of the used ablution water before and after treatment with a sand filter.

The current research was carried out in this direction, with the goal of developing a workable model of the system, dubbed Eco-Wudhu, which satisfies the requirements of Islamic teachings while remaining viable from an engineering standpoint. The power and efficiency of the closed-loop water recycling system were then quantified using a basic ablution water performance prediction model. The Eco-Wudhu is made up of the primary components in general such as ablution water collection, retention tank, a filtration unit and a tank for collecting treated water. With the help of sensors and pumps in a closed-loop flow network, water circulation, whether handled or untreated, will be completely automated. Then the filtration system are design to provide acceptable quality recycled water with effective size range. The conventional filtration process is most important single unit operation of all water treatment. To supply water both inside the building and outside, the necessary pipes and fittings must be installed. The close-loop system has the benefit of reducing water waste through greywater discharge and also preventing pollution from outside source. A conceptual model for Eco-Wudhu was created to illustrate the water flow and components in the system, as well as the associated Islamic principles.

The idea was developed to work on both new and retrofitting programs. Development of the Eco-Wudhu was created by using engineering drawing software (AutoCAD). The scale of the design is measured from the suitable measurement of the pipes and fittings in water ablution area. The three-dimensional (3D) design was developed to analyze and improvise of the product created in order to give suitable design for the water ablution system. Retrofitting, on the other hand, necessitates further changes and improvements to meet internal plumbing configurations and room limitations. New installations appear to be simpler due to the simple application of a template layout, while retrofitting necessitates further adjustments and adaptations. The Eco-Wudhu system consist of two sections which is input and output. The used ablution water is directed into a catchment, which is then transferred to a retention tank with filtration process. The output section, on the other hand, channels the treated water from the retention tank to outdoor applications through piping network. The water treatment is done only using pre-treatment process which is pre- filter. Pre-filtration, also known as screening or coarse filtration, is a common method of removing large particles and debris form particles from membrane filtration system.

In the ablution area, the greywater from the ritual is stored in a temporary storage through underneath the washing bay. Before being poured into an elevated storage tank, the greywater is filtered to remove sediments and other small particles. Filtration is a necessary pre-treatment for removing large suspended solids and preventing clogging of the pump. Sedimentation will take place until the water was moved to the storage tank, further cleaning the water of smaller particles. The suitable size of pipes and fitting is installed for the uses of channel the water from input to output sections. The treated water is now ready to be distributed to nursery plants for various purposes. The storage tank that can hold 1000 gallons of water is used to store recycled water is enough to accommodate water use in nursery plants. The Eco-Wudhu scheme, whether retrofitted or built from the ground up, exemplifies a fruitful convergence of technical know-how and religious doctrines for better quality of life now and in the future.

Recycled water stored in storage tanks will be channeled to nursery plants for the purpose of watering the plants. Recycled ablution water can also reduce water wastage where wastage is something that is forbidden in Islam. The Holy Qur'an also reminds the Muslims to be moderate in whatever they do and never extravagant or wasteful, which is also valid for water use during ablution (Qur'an 17:26-27 and 25:67). By introducing Eco-Wudhu, water that was previously channeled to the drain by ignoring impending problems such as water crisis problems can be addressed with the existence of a system used to recycle ablution water. Although water is not expensive in Malaysia, it would be beneficial to the environment and resource conservation if used ablution water was recycled and reused on campus. Thus, this project will help the UMP's mosque to reduce waste of water from ablution where the water that flows into the drain can be recycled for various activities.

1.5 Significance of Research

The first objective of this study is to design Eco-Wudhu recycle ablution water system for long-term. Muslims do wudhu up to five times a day, and the volume of water spilled can be important. Shaving can consume up to 11 gallons of water per household, while developing an Eco-Wudhu can conserve a lot of water. Eco-Wudhu is one of the alternatives to save the consumption of freshwater. It is good to develop this system for all mosques around the world because it can help to reduce the usage of freshwater. This technology reminds us of the importance of 3R, namely reduce, reuse and recycle. Nowadays many have almost forgotten this slogan and also like to waste the water when performed the wudhu with let the tap water always open. So, Eco- Wudhu is very important to restore public awareness of the importance of reduce, reuse and recycle. From this slogan, clearly proves that Eco-Wudhu is important because we can reduce the use of freshwater. In addition, it is also one of the systems where we can recycle ablution water that has been used and also reuse it for other uses.

In addition, from Eco-Wudhu, we have also applied the concept of recycling. So, of course recycled water is also very important no matter to humans, flora and fauna. Simple definition of recycled water is wastewater that has been recycled and disinfected at a water treatment facility to remove solids and other impurities. Landscape and agricultural runoff, manufacturing operations, toilet flushing, and replenishing freshwater basins are just some of the uses for recycled water. As long as the water has been treated so we can use the recycled water. Other than that, when we recycled the water it can help to improves wetlands. Wetlands support the ecosystem in a variety of ways, including housing birds, reducing flooding, enhancing water quality, and providing a suitable spawning area for fish stocks. Recycled water may also be restored to dry wetlands to help them re-establish themselves as lush habitats.

Next, by using the recycled water can addressing the water shortage issues. If we are looking around the world, the water supply available in every country is not the same. Then, by using recycled water we can save and also ensure that the water supply is always adequate. Indirectly through this method we have helped those who are short of fresh water by not wasting the water that has been used and we also treat and reuse the water. Recycled water also had made a big impact to the environment by lowering the pollution risks. Untreated and recycled wastewater were often dumped into our vast bodies of water. Untreated wastewater does not decompose naturally. Instead, it pollutes our seas, waterways, and streams, degrading water quality and perhaps damaging the environment under which it is published. Recycling wastewater is the best way to prevent potential water shortages and reduce the environmental harm caused by water contamination.

Generally, Eco-Wudhu and recycled water have given many benefits to the humans, environment and also the world. This study focused on how these two things can give good impact to the UMP Gambang Campus mosque and UMP itself. Basically, the second objective of this study is to reuse recycled ablution water for UMP Nursery plants. It shows that this objective help UMP to gain many benefits from the aim of this work. Firstly, the nursery UMP does not have to take the freshwater in order to water the plants. They can use the recycled water from the mosque and simply use it for watering plants. From this method UMP can save up the money and also the energy to supply freshwater through the nursery. Secondly, the bills for electricity and water for UMP also can be reduce. Not only that, UMP's economic sector will also continue to grow.

1.6 Outline of Thesis

In Chapter 1 Introduction, the brief of the research background, problem statement, objective, scope of study, and important of study is identified. In research background, the general overview of water is elaborated. In problem statement, the four main issues are highlighted which are the water wastage in UMP’s mosque, dependency of nursery plants on clean water in mosque, water pollution that may occurs and current prayer facility design. The two objectives of the project are stated. The process used for Eco- Wudhu is determined in scope of study. The last part of chapter 1 is about the important of study to UMP mosque, the benefit of Eco-Wudhu and the importance of recycling water.

In Chapter 2 Literature Review, it briefs about the introduction of literature review, water usage for household, characterization of household water, the strategies for water management, separation process and conventional methods for water treatment, water treatment process engineering, water recycling and sustainability, impact of water treatment for recycling and reuse and the last part is summary of the literature review.

Next, in chapter 3 is the methodology of the research. Basically, in this chapter stated many questions through the research. There are also explanations about why it is important of the research. Then, have the description about the methods that have been developed in this research such as how the ablution water being treated and reuse for Nursery plants behind UMP Gambang campus mosque. Last but not least, in this chapter also have the description on the data and results obtained from the procedures that have been done.

CHAPTER 2

LITERATURE REVIEW

2.1 Water Usage for Household

2.1.1 Introduction

Increased population, water contamination, urbanization, industrial agriculture, climate change, and drought have all led to large gaps in the supply of high-quality water supplies and demand for use. For many countries, the key water problem is declining and unpredictable water quality in the face of rising usage. Water authorities understand the need to balance water demand when attempting to ensure potential water sources (Bradley Jorgensen et al. 2017). Lots of water sources are looking to increase supply (for example, by extending pipelines, building new dams, changing river storage capacity and recycling). Water management, on both the supply and demand sides invariably has major economic and social elements. Increasing water efficiency to reduce demand necessitates a better understanding about how water is used and how it can be preserved. The social and economic analysis on water demand control and water use reveals stumbling blocks to achieving this aim.

2.1.2 Issues with Water Demand Management

The success of household water demand management strategies is dependent on how well we understand how people think about water and water use. When people think there is a scarcity of water, they are more likely to save it. Believe that other users are conserving water as well for example, inter-personal confidence perceptions (Corral-Verdugo et al., 2017). Similarly, the price of water has a short-term effect on consumption. But it is unclear if knowledge of the marginal price, rather than the market system such as increasing block tariff or the duration of behavioral input processes for example water billing frequency (Olmstead et al., 2017). Furthermore, it is unknown if pricing influences water use over time directly or indirectly by shifts in public perception of water shortages and/or individual motivations. Water suppliers must understand how price knowledge is integrated into their customers' water usage decision-making and how it integrates with other considerations if price is to be an efficient means of controlling demand. If pricing is to be an efficient means of balancing demand, water utilities must understand how price knowledge is integrated into their consumers' water usage decision-making, as well as how it integrates with other considerations such as water constraints. Finally, while prices and water controls can help regulate household water usage when there is a perceived water scarcity, little is known about how effective these tactics would be if the water availability was expanded. If consumers assume that water is effectively regulated by pricing, regulations, and the development of new water supplies, water conservation motivations and behaviors can fade over time in households (Bradley Jorgensen et al, .2017).

Although a broad body of econometric analysis has examined the effect of price and non-price water policies on aggregate and household water use, the reasons for particular interventions' success or failure are often unplanned (Campbell et al., 2018). This may be attributed in part to a scarcity of social psychological evidence at the household level. Without the advantage of data on the complexities of water usage activity at the household level, off-setting habits (e.g., increasing shower duration after installing a low flow shower head) are believed to account for the ineffectiveness of household water saving technology, such as low flow shower heads. Furthermore, while water utilities strive for sustainable water conservation, the concept of equality and justice for various users and populations is often unknown (Atwood et al., 2007). Moreover, amid strong examples of the significance of spatial context, the relative availability of census data (e.g., housing density) rather than individual household characteristics related to real consumption limits interpretations of community effects and geographic variations in water consumption.

2.1.3 Water End Use Behaviors

Understanding domestic water use behavior is critical for determining an appropriate water monitoring strategy. According to a study, the introduction of smart water metering allowed for the monitoring of water use at an end-use level, resulting in the verification of individual water use activities such as baths, toilet flushing, tap use, or irrigation by the use of appropriate software. Furthermore, since total domestic water usage is made up of various water end use activities, understanding water use at the end use stage is critical. Some researchers believe that household characteristics play an important role in determining water usage, and that local knowledge on how to use and conserve water in the home should be included (S. Z. Daud et al., 2020). In Malaysia, even as the national reserve margin is at its lowest level since 2008, and leaking from pipelines continues, water demand has increased. According to the National Water Services Commission (SPAN), per capita intake in Peninsular Malaysia and Labuan increased to 230 liters per capita per day (LCD) in 2018, up from 226 LCD in 2018 and 222 LCD in 2017 while in Sabah and Sarawak were recorded 165 LCD and 108 LCD (Sim Leoi Leoi & Allison Lai, 2020). The daily water quota has been set at 165 liters per person per day by the United Nations. Johor, Kedah, Kelantan, Melaka, Terengganu, Perlis, and Selangor saw a rise in non-revenue water (NRW) in 2018 due to loss by defective and leaking pipes. The NRW ratio for the peninsula and Labuan remained unsatisfactory at 33.9%. NRW is caused by pipe leaks, storage reservoir overflows, and water theft. One of the main success metrics SPAN has set for operators is reducing NRW.

Nonetheless, as people's lifestyles have shifted toward overconsumption, many essential water end uses have expanded to include a broad discretionary portion, where usage can go well beyond what is necessary or deemed socially appropriate for the operation. Showering, for example, is now often misunderstood as a recreational or healing activity rather than a need. This behavioral shift reflects the ‘Human Exception Paradigm,' which holds that humans are superior to nature and therefore do not need to consider the world when using resources. While a certain amount of use is needed for basic sanitation in showers, clothes washing, and tap end uses, it is claimed that use above and below the practical sanitation requirement is discretionary. (S. Z. Daud et al., 2020).

2.1.4 Water Consumption in Malaysia

According to the Malaysia Water Association (MWA) Guidelines, water consumption per capita can be divided into three categories namely urban, suburban and rural. There are differences in usage clear water where urban areas have a population of over 10000 people, the average per capita water consumption per day is 230 Liter per capita per day (LPD) to 320 LPD (Phang Wai Leng et al., 2019). Average water consumption per capita in the periphery urban areas that cover between urban and rural areas are between 180 LPD to 230 LPD and rural areas where there are the population is slightly dependent on the type of land use. According to Abu Bakr Yang (2002), residential areas which largely located in urban areas will have more effects in water usage compared to rural areas. Nowadays, most people did not experience any difficulty in obtaining clean water supply because 92% of areas in Malaysia are supplied with tap water directly to residential areas without knowing the source of the water supply. Due to that reason water is easily available with such low tariff prices. In conjunction with that, domestic water consumers not appreciating it thus they continue to waste relentlessly and do not practice any austerity and cause per capita domestic water consumption in Malaysia continue to increase.

2.2 Characteristics of Household Water

2.2.1 Introduction

It is essential to characterize water and energy usage in order to develop techniques for their efficient use. The way these tools are used in households leading to the way for effective and reasonable management, which is interdependent. There are known to be major variations in water and energy use trends between rural and urban areas, with contributing factors to be found (Cristina Matos et al.,2019). Humans use water not only directly, but also indirectly through food processing, personal hygiene, sanitation, and a variety of other industrial and domestic applications that include energy use. Since water is such an important resource for a country's growth, it must be used efficiently to ensure not only its sustainability but also thermal, economical, and environmental savings. To propose water and energy saving measures, it's important to first classify domestic consumption and then gather data on the variables that may affect it, such as socio-demographic and housing characteristics, as well as household consumption habits (Antonio Cunha et al., 2019)

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Domestic water consumption in developed countries varies from 100 to 180 Liters per person per day, or 30–70% of what is needed in a city (Friedler and Hadari, 2006). This sum has risen in recent decades as a result of widespread and intense overexploitation, resulting in high levels of water stress, especially in Europe (Cristina Matos et al., 2019). Growth in the design and simulation of building drainage systems nowadays necessitates a more in-depth understanding of the use and characteristics of common household appliances (Friedler and Hadari, 2017). However, a few experts have significant reservations regarding the long-term viability of water supply and wastewater drainage system maintenance. In order to reliably assess the long-term viability of water and wastewater services, it is important to examine water usage and wastewater output at the household level.

2.2.2 Main properties of Household Water

A water molecule (H_2O) is made up of three atoms, one oxygen and two hydrogen atoms. The oxygen atom in of water molecule attracts more than its "equal share" of electrons (Pooja Arora, 2017). Water is polar because the oxygen end "acts" negatively while the hydrogen end "acts" positively, forming a single polar covalent bond. However, water is neutral as it has equal number of electrons and protons giving it a Zero Net Charge.

Freshwater that is clean, healthy, and adequate is essential for the sustainability of all living species as well as the smooth operation of habitats, societies, and economies. The basic physical, chemical, and biological characteristics of water that determine its suitability for life or human use are referred to as water quality. Water's suitable content varies depending on the intended application. The characteristics of water can be classified into three broad categories which is physical, chemical, biological characteristics. Physical characteristic includes temperature, color, odor, turbidity and total dissolved solids (TDS). Chemical characteristic includes pH, dissolved oxygen (DO), salinity, BOD, heavy metals and biological characteristic includes counts of specific organisms and groups of organisms (Pooja Arora, 2017).

2.2.2.1 Biochemical Oxygen Demand (BOD)

The amount of dissolved oxygen needed by aerobic biological organisms to degrade the organic material contained in a water body at a given temperature over a given time period is known as biochemical oxygen requirement. It is commonly used to describe the emission load by indicating the organic content of water. It's usually measured in milligrams of oxygen absorbed per liter of sample over a 5-day incubation period at 20°C (BOD5). As organic matter decomposes, microorganisms (such as bacteria and fungi) prey on it, and the matter gradually becomes oxidized (Pooja Arora, 2017). The more the microorganisms perform, the more oxygen they use up, resulting in a high BOD level and less oxygen for all aquatic species. A sample with a 5-day BOD of 1 to 2 mg O/L suggests very clean water, 3.0 to 5.0 mg O/L indicates relatively clean water, and more 5 mg O/L indicates a contamination source nearby. BOD is a laboratory test that necessitates the use of an oxygen sensing meter, an incubator, nitrifying inhibitors, and a bacteria source (Brian Oram,2018).

2.2.2.2 Chemical Oxygen Demand (COD)

The quantity of oxygen needed to oxidize the organic matter contained in a water body under particular conditions of oxidizing agent, temperature, and time is determined by the COD. COD is a significant water quality metric because it provides an index for determining the impact of discharged wastewater on the environment. Higher COD levels indicate the inclusion of more oxidizable organic content in the solution, which, if degraded, can result in hypoxic conditions in the water body (Pooja Arora, 2017). The percentage of organic content in water that can be degraded by normal microorganisms in the environment is shown by the BOD to COD ratio. The COD of surface water for domestic uses normally ranges from 5 to 20 mg/L. COD is usually higher than BOD because chemical oxidation of organic compounds is more efficient than biological oxidation. This contains compounds that are harmful to biological life, which makes COD tests particularly useful for monitoring commercial sewage. ((Pooja Arora, 2017).

2.2.2.3 Ammoniacal Nitrogen

The amount of ammonia in landfill leachate and waste materials including water, liquid fertilizer, and other liquid agricultural waste products is measured in ammoniacal nitrogen (NH_3-N). It may also be used to assess the health of water in natural sources including rivers and streams, as well as in man-made reservoirs (Arya Rezagama et al., 2020). Ammonia can cause direct poisoning in humans and disrupt the balance of water supplies. While excessing production of nitrogen in the ecosystem will disrupt the normal nitrogen cycle between living organisms, soil, water, and the atmosphere. Contamination of a water source with nitrogen will result in significant issues such as loss of water quality, eutrophication of a dam, and a possible threat to animal and human health. The nitrogen compound is a nutrient that can induce algal bloom, lowering oxygen levels in the water. Organic nitrogen (40%) and ammonium nitrogen (60%) are the two forms of nitrogen contained in domestic wastewater (Muhammad Hibbaan et al., 2020).

2.2.2.4 Heavy Metal

Any metallic chemical substance with a comparatively high density that is toxic or poisonous at low concentrations is referred to as heavy metal. Mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), nickel (Ni), copper (Cu), cobalt (Co), lead (Pb) are some of the more common heavy metals (Pooja Arora, 2017). These are the geological environment's natural elements. To a limited degree, they reach the human body by food, drinking water, and air. As trace elements, certain heavy metals (e.g. copper, selenium, and zinc) are needed to keep the human body's metabolism running smoothly. However, at higher doses, they can be toxic, resulting in a variety of severe diseases. There have been several reports of heavy metals in drinking water. Surface water, groundwater, and desalinating seawater are the primary sources of drinking water, with desalination meeting a large portion of the demand in water-scarce areas (Kim et al., 2017). The origins of water, storage, finished water quality, length and materials of water distribution system and plumbing pipes may all play a role in heavy metal concentrations in drinking water.

2.2.2.5 pH

The pH in water indicates how acidic or basic (alkaline) it is It is defined as the negative log of the hydrogen ion concentration. The pH scale is logarithmic, ranging from 0 (extremely acidic) to 14 (very alkaline) (Pooja Arora, 2017). The hydrogen ion concentration reduces tenfold with each whole number rise (i.e. 1 to 2), and the water becomes less acidic. The pH of freshwaters varies widely, from about 4.5 in acidic, peaty upland waters to over 10.0 in waters with abundant photosynthetic production by algae. However, the 6.5-8.0 range is the most often observed. Changes in pH can cause other substances in water to revert to a more toxic state. Changes in pH value affect ammonia toxicity, chlorine disinfection quality, and metal solubility. The Environmental Protection Agency (EPA) warns that drinking water that is too acidic or alkaline may be toxic. To meet EPA requirements, drinking water must have a pH value of 6.5-8.5, and they also point out that even within the appropriate pH range, mildly high- or low-pH water can be unappealing for a variety of reasons (Pooja Arora, 2017).

2.3 Strategy for Water Management

2.3.1 Water Management andFunction

Two converging trends are driving water scarcity, the freshwater consumption and loss of available freshwater supplies. Water consumption has increased at more than double the rate of population growth over the last century, and an increasing number of regions, especially in arid regions, are ap59proaching the limitof how long water resources can be supplied sustainably. Water shortages would be compounded when quickly expanding metropolitan populations put a strain on nearby water supplies (Water Scarcity | Threats | WWF, 2021). Thirty-one nations are currently water-short, and by 2025, there will be 48 countries with severe water shortages. Water shortages are expected to concern 4 billion people by 2050, according to the United Nations. This would result in a slew of water-related tensions between nations. Around 20 of India's major cities are experiencing chronic or intermittent water shortages. The flows of 13 major rivers and lakes are shared by 100 nations. International agreements addressing the even allocation of water in those regions would be crucial to world peace. India and Bangladesh have also reached an understanding on the use of the Ganges' water (Constro Facilitator, 2020).

As a result, water conservation is a pressing necessity. It involves the long-term protection of water supplies for future generations. It involves the activity of maximizing the usage of water supplies by planning, growth, distribution, and management. Water management preservation can be accomplished using a variety of techniques (Water Conservation 2020). Water quality management priorities can differ depending on the environment and existing water conditions, regulation, and implementation. However, one of the most common Water Resources Management goals is to promote conditions that allow for environmentally friendly, commercially effective, and equitably distributed water supply use. They also involve increasing the advantages of current hydraulic facilities while lowering the risk. A common goal of these programs is to incorporate policy approaches into other sectoral policies in a broader region around the world. This often entails the development of social, scientific, and administrative resources for water resource management (Water Resource Management: our essential guide to water resource management objectives, policy & strategies, 2019).

Water management is the process of controlling and moving water supplies in order to reduce harm to people and property while maximizing their productive and profitable usage (Freedman, 2018). In this increasingly developing era, water management is important and needs to be done no matter where it is to ensure the adequacy of fresh water in this world. In addition, there are several reasons for the importance of water management. First and foremost is to stop pollution especially water pollution. Water pollution is characterized as the degradation of a stream, river, lake, ocean, or other body of water, resulting in a decrease in water quality and toxicity to both the environment and humans (Water Pollution: Everything You Need to Know, 2020). There are two forms of water contamination which is organic pollution caused by microorganisms in the water, such as bacteria and viruses, and inorganic pollution caused by excrement, animal and vegetable waste. Secondly, nitrates and phosphates from poisons, human and animal medicines, household goods, heavy metals, acids, and hydrocarbons often used in factories contribute to chemical waste (Solar Impulse, 2021). These noxious compounds not only poison marine life, they also contaminate drinking water supplies and pollute our atmosphere.

2.3.2 Water Conservation Strategy

Thus, using water more effectively is a necessary step in reducing negative impacts on freshwater and the aquatic ecosystem. Integrating water quality priorities into physical, social, and economic preparation is a central approach of sustainable water management. Agriculture policy, general land use planning, forest resource utilization, and coastal zone and aquatic habitat preservation from land-based operations are also included. It will help planners make more effective water usage decisions (Land-Use Planning - river, effects, important, system, source, effect, human, 2021).

2.3.2.1 Rainwater Harvesting

In arid and semi-arid regions, rainwater harvesting is characterized as a method of inducing, collecting, storing, and conserving local surface run-off for agriculture (Leal Filho & de Trincheria Gomez, 2018). Basically, vegetation control, surface treatment, and chemical disposal are all used in run-off inducement. In areas with an annual rainfall of more than 280 mm, vegetation management is more important. In addition, water scarcity is a problem in arid areas due to poor annual rainfall. If surface or ground water is available, the issue is always solved by introducing irrigation. Maintaining a favorable salt balance for crop growth necessitates a well-designed drainage system. The two most popular run-off collecting strategies are micro catchment water harvesting and run-off farming water harvesting. The aim of a micro catchment water harvesting strategy is to store enough runoff water during the rainy season to satisfy crop irrigation needs (Macro-Catchment Rainwater Harvesting - RUVIVAL Toolbox, 2017). Another choice is to store rainwater in small cisterns and recycle it. Appropriate water management techniques, such as terracing slopes to collect rainwater and various types of water storage, including underground storage, will vary depending on the region's characteristics and are especially important in arid regions.

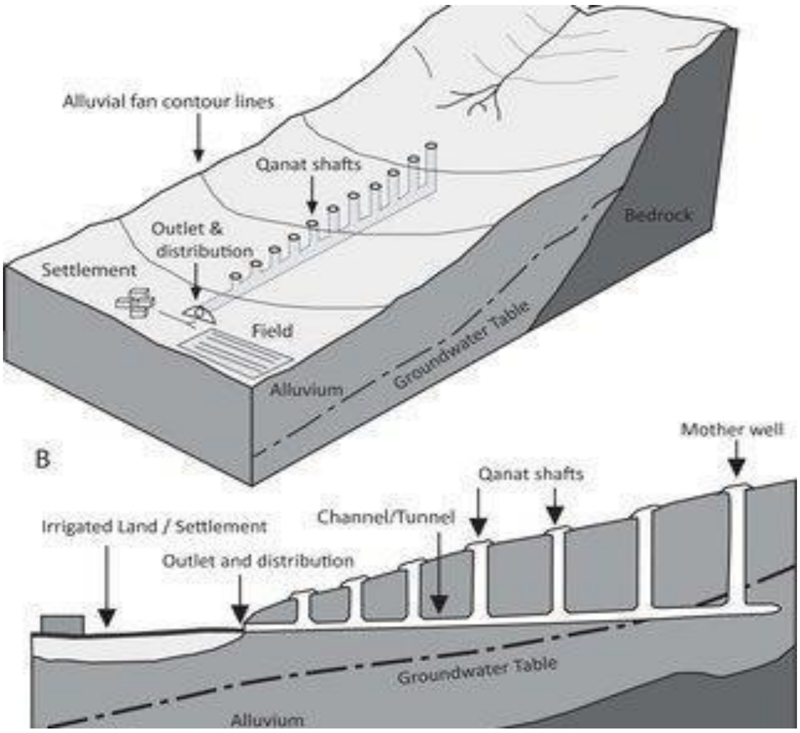


Figure 2.1: Micro and Macro Harvesting Techniques (Macro-Catchment Rainwater Harvesting - RUVIVAL Toolbox, 2017)

2.3.2.2 Vegetation

Other than that, the conservation of watersheds by the preservation of naturally vegetated buffer strips along streams, river banks, and around reservoirs is one of the simplest methods for improving both water resource management and water quality. The terms "watershed" and "river basin" are not interchangeable. According to one school of thinking, a watershed is the region that flows water into a river, and the divide is the line that separates neighboring watersheds. The catchment area or river basin is a term used by the other party to describe the area drained by a river. On the basis of size, Kenneth Brooks has distinguished himself. The watershed is the boundary between two regions.

The river basin is broader than a watershed, and it encompasses the whole region drained by the river and its tributaries. Watershed management must be seen as a collaborative mechanism that involves environmental, human, and other resources in the preparation, implementation, supervision, and evaluation of a course of action. Physical, socioeconomic, and institutional linkages between upstream and downstream of a river basin or watershed should be included in a systemic soil conservation and watershed management strategy (Kenneth Brooks).

Figure 2.2: Watershed Management Strategy (Kenneth Brooks).

2.3.2.3 Preventing Wastage of Water

Using water-saving strategies will help you conserve resources while still diverting fewer water from our rivers, bays, and estuaries, which is good for the climate. It will also save money on sewage and wastewater disposal as well as electricity needed to treat, filter, and heat water. Which reduces electricity consumption, which aids in the prevention of air emissions. Water efficiency isn't only a problem in the country's arid western regions. If our population grows, so does the need for scarce water supplies. There are several ways to make more usage of household water without cutting utilities. High-efficiency plumbing fixtures and equipment conserve about 30% of indoor water and consumption, resulting in significant water, sewer, and electricity bill reduction (Saving Water Helps Protect Our Nation’s Water Supplies, 2021).

First and foremost, check for leaks in your bathroom. Filled your toilet tank with a few drops of food coloring. If the coloring continues to show in the toilet after being flushed, you may have a leak that is losing more than 100 gallons of water every day (By Benjamin Franklin Plumbing, 2021). The second piece of advice is to refrain from using your bathroom as an ashtray or wastebasket. Any cigarette butt or tissue you flush away often flushes away five to seven gallons of water. And, in your toilet tank, place a plastic bottle. To weigh down a one-liter container, add an inch or two of sand or pebbles to the rim. Fill the container with water and position it securely away from the toilet's working system in your toilet tank. The bottle will save up to five gallons of water a day in a typical home without affecting the toilet's quality. If your tank is large enough, you could be able to fit two bottles in there. Aside from that, showers can be shorter. Five to ten gallons of water are used per minute in a typical shower. Showers can be limited to the period it takes to soap up, wipe off, and grow. There are numerous other ways to save water (By Benjamin Franklin Plumbing, 2021).

2.3.2.4 Reducing Irrigation Losses

One of the most important natural commodities on the planet is water. Water is needed for the survival of all life forms, whether human, animal, herb, or aquatic. There would be no life on the earth if there was no water. And though water covers about 71 % of the Earth's atmosphere, just around 2.5 % of it is fresh, with the remainder being salty. The majority of the world's freshwater is used for drinking and household purposes, as well as industry, trade, and agriculture. Water is important in every part of our lives, from drinking, bathing, and washing to industrial and agricultural operations. We have not used it with caution, despite its importance. The reckless and widespread usage of the valuable resource in recent decades has resulted in its rapid decline on our world (Water Use and the Environment).

Over the last few decades, rapid urbanization, increasing population, and a dramatic shift in habits have resulted in a significant rise in water use. As a consequence, groundwater is depleting quicker than it can be replenished. Agriculture is the largest producer of water, accounting for almost 70% of all freshwater supplies. Industrial consumption accounts for 20% of total usage, whereas domestic consumption accounts for 10%. According to current trends, feeding a world of 9 billion inhabitants by 2050 would necessitate a 50% rise in food productivity and a 15% increase in water use. Although many farmers around the world depend on groundwater and other pumped supplies to water their crops, the environmental consequences of water waste are a major cause of concern in the agricultural industry. Studies show that around 40 percent of the freshwater used for agriculture is lost either by evaporation, spills (overwatering), or deep infiltration (The Complexity and Urgency of Water: Time for the Accountancy Profession to Step Up, 2015).

The need of the hour is for farmers to recognize that making the best use of water will aid in the conservation of one of nature's most valuable resources. It would also aid in the production of healthy crops using fewer water – ‘More Crop Per Drop'. Water conservation and utilization are essential for long-term development. Agriculture is heavily reliant on the climate, and agriculture is reliant on us. This is particularly valid in an agrarian economy like India's, where agriculture employs more than half of the population. As a result, environmental protection is crucial.

Firstly, utilizing an effective irrigation scheme. For example, making the best use of natural resources by switching to new and reliable irrigation methods such as "Drip and Sprinkle irrigation" would dramatically reduce water consumption. Unlike the conventional overhead spray system, the drip irrigation method delivers water directly to the plant's roots. Drip irrigation saves up to 80% more water than traditional irrigation by lowering the percentage of evaporation. It also increases the yield by about 20%.

Second, create an irrigation plan. Water conservation is critical for maintaining long-term sustainability and the preservation of natural resources. Watering the plants in the right moment, in the right location, with the right quantity, and in the right way is crucial to maximizing the natural resource's potential. It boosts productivity while conserving water and lowering irrigation energy costs. Water loss may be further reduced by using timers to schedule watering for cooler times of the day. Farmers use robotics to simplify the irrigation schedule. Considering the atmosphere, plant and soil moisture levels, humidity, temperature, and other factors (How Does Water Conservation in Agriculture Help in Environmental Conservation, 2019).

2.3.3 Water Reuse Strategies

The results of this study are based on knowledge distributed by the government and the interaction between the public, municipalities, and water utilities. A concise summary of hypotheses is also included. The cognitive and contextual factors that influence public approval of and resistance to water reuse have been extensively researched in the literature and are outside the reach of this study. Fielding et al. (2018) summarize the current state of the literature in a study that considers, among other aspects, a strong positive association between knowledge acceptance and distribution such as about recycling processes, safety, and benefits. This trend is used through a variety of testing methodologies, including case studies and trials, according to the authors. Sustainable Energy Management (SEM) has also been used to investigate certain relationships, yielding results that are relevant to the methodology and research presented in this paper. Besides, some researchers find that water utility coordination and public confidence are important determinants of customer satisfaction with water reuse systems, and that a community's mutual identification with water utilities over recycled water schemes is reliant on consultative exchange and information-sharing, thereby strengthening trust in a way that lowers risk perceptions and raises adoption levels. In a SEM-based analysis of water reuse in Australia, trust in government was found to have an effect on perceptions and, as a result, expected consumption behavior. In an Australian study, confidence research and government were found to be a determinant of public approval of multiple water supplies, including reuse, stormwater, and desalination (Tortajada & Nambiar, 2019).

The importance of knowledge as a determinant of water reuse acceptance is less clear. External data, on the other hand, is a poor indicator of public acceptance. However, a South African study found that respondents' intention to consider water reuse for both domestic and non-domestic purposes was predicted by their knowledge of the benefits of water reuse and their confidence in suppliers for utilities purposes, with knowledge having the highest route coefficient of all determinants among domestic-use respondents (Hartley et al., 2019). Studies like the ones described above have been able to classify the types of latent variables that are difficult to quantify in socio-political contexts using SEM. Their results are broadly consistent with those of qualitative and non-SEM research (Hartley et al., 2019).

2.3.3.1 Irrigation

Water withdrawal, especially for irrigation, has resulted in overexploitation of rivers, streams, and aquifers, and therefore human influence on water sources has become significant. Agriculture is by far the most water-intensive industry in most nations, accounting for about 70% of overall withdrawals and 90% of water use worldwide (Navarro et al., 2015). To resolve this problem, wastewater reuse has been shown to be a viable option for reducing anthropogenic impacts. Furthermore, raw wastewater reuse in agriculture is an important method for developed countries to reduce emissions and meet the challenge of rising food output in water-scarce regions. The advantages of reusing water in agriculture are numerous and undeniable. Firstly, it saves a significant amount of first-use water that can be allocated to critical uses, provides nutrients that can replace chemical fertilizers and increasing soil fertility and crop yield thus lowering production costs. Then, it allows agricultural land to be expanded in arid areas and it is a relatively inexpensive disposal method. Furthermore, reusing water in agriculture has been seen to pose marginal health threats as long as the biological content follows defined standards.

However, toxic effects such as soil salinization and metal and organic compound contamination of soil and groundwater should be noted. Furthermore, the use of raw wastewater for crop production presents health risks due to its microbial material, especially bacteria, viruses, and parasites, which can cause a broad range of diseases due to their ability to persist for long periods of time in the atmosphere (Health risks associated with wastewater use, 2021).

The biggest concern with wastewater reuse is environmental health and infection threats, which may be actual causing disease or possibly causing disease and transmits the infection but the disease does not develop. Depending on the pathogen, the infective dosage, and the infected person's tolerance, infection rates can be elevated, marginal, or negligible. According to epidemiological studies conducted over the last 20 years, pathogens may pose real infection threats when untreated wastewater is applied to land for crop development. Control measures must be adopted to minimize certain threats, such as treating wastewater to meet regulatory limits, developing fast, inexpensive, easy, and reliable identification strategies, breaking the disease-infection chain through medical care, and developing population-wide communication programs (Navarro et al., 2015).

2.3.3.2 Residential Uses

Domestic water use provides for 8% of global water use (UNWATER 2012). Domestic water usage is frequently several times greater than the WHO minimum per capita intake recommendation, especially in developing countries. As a result, there is a lot of room to cut down on household water use. Lower water costs or fewer time expended harvesting water, decreased demand on local water supplies, and improved supply of potable water for suitable uses such as drinking, heating, and grooming are all advantages of reducing domestic wateruse.

Reusing wastewater produced at the household level is one efficient way of reducing water use. Through minimizing water use, wastewater reuse provides an ability to not only conserve water and money, but also to improve food production and build jobs. Optimizing wastewater reuse in developed countries will therefore be a major growth opportunity.

The consistency of the wastewater must be suitable for reuse, which is a crucial feature of wastewater reuse. Rainwater, greywater (all household wastewater excludingtoilet flushing water), vomit, blackwater, and faeces are several of the various forms of wastewater collected at the household level, all of which have varying amounts of pollutants such as nutrients, pathogens and reuse capacity. Separating both sources of drainage decreases the volume of pathogen-contaminated wastewater (i.e. blackwater, faeces, urine) by stopping it from mixing with less contaminated water (i.e. greywater, rainwater), enabling greywater and rainwater to be utilized for moreuses.

It is possible to store large quantities of comparatively clean water (i.e. greywater, rainwater) that can be directly reused thus reducing the amount of pollution (i.e. blackwater) that must be handled before reuse by separating certain waste streams at the source. Implementing source separation is critical in creating sustainable systems that will support users in the long run, particularly in developing countries where water and sanitation systems are non-existent or incomplete. Wastewater may either be reused directly or processed and reused, depending on the pollutants present and its intended application (recycled). Similarly, food waste (such as cooking waste or bathroom waste) may be reused at the household level to minimize waste production and reap nutritional or energy benefits.

2.3.3.3 Urban and Recreational Uses

Non-potable reuse has been used in communities for decades, mostly for landscape irrigation. The fact that demand for non-potable reuse is seasonal, with higher demand during the warmer, dry summer months, is one drawback. While this seasonally-dependent demand trend offsets potable water consumption throughout the summer, it does not increase the amount of water that may be utilized for other uses during the year. A separate purple pipe delivery system is often needed for most non- potable water systems. Purple piping is used to transport filtered water that has been processed to a condition appropriate for irrigation and industrial usage but not for human use. As a consequence, a binary pipe network is developed, with high capital costs and different operations and maintenance needs from the potable water grid. Long pipes are costly, and cross-connection avoidance standards make non-potable reuse schemes more complicated. Due to these constraints and problems, emerging trends and advances in water reuse in urban areas have emerged (Harris, 2018).

2.3.3.4 Aquaculture

Natural fisheries overfishing is a worldwide problem that is becoming increasingly serious as the world's population grows rapidly. About 70% of the world's fish species have been entirely consumed or eliminated, according to the Food and Agriculture Organization of the United Nations. This strong demand for seafood protein is not going away; in practice, one out of every five people on the planet relies on it. Traditional aquaculture methods depend on pond and flow-through processes, which are often blamed for polluting the ecosystem (Kuhn, 2008). Furthermore, aqua cultural feeds also produce large amounts of fish protein, implying that the demand on wild fisheries is not entirely alleviated. About the pitfalls of conventional aquaculture, there is a major trend for more productive activities. Implementing recirculating aquaculture systems (RAS), for example, maximizes the reuse of culture water, lowering water demand and lowering the amounts of contaminants released into the setting. Alternative proteins such as soy bean are increasingly being used in aquaculture diets to replace fish and seafood proteins.

As a result, the emphasis of the research discussed in this dissertation was on optimizing the reuse of freshwater fish effluent in marine shrimp culture. More directly, by treating a tilapia effluent waste stream with suspended-growth biological reactors and generating microbial flocs that could be used to help shrimp culture. By - the volume of recycled water, this RAS technology can reduce water use while also improving the efficiency of effluent water (Grabicová et al., 2020). The biomass produced in the bioreactors could be used to provide an alternate protein source for shrimp. Treatment of fish effluent for reuse in shrimp culture when processing this alternate feed will substantially reduce operating costs and increase the sustainability of these operations.

It's crucial to figure out which ions are essential for marine shrimp survival and natural growth in freshwater effluents. Understanding how to turn the organic matter in an effluent into shrimp food is also important. The marine shrimp *Litopenaeus vannamei* may be raised in freshwater effluent when supplied with special ions, and wet microbial flocs fed directly to shrimp can stimulate growth in shrimp fed a limited ration of commercial feed, according to research findings. The tilapia effluent's treatability with suspended-growth, biological reactors, and nutritional analysis of the produced biomass were also recorded. Carbon supplementation improved reactor efficiency as well as the production of microbial flocs. When dried and mixed into a pellet feed, these microbial flocs have proved to be a superior feed ingredient (Grabicová et al., 2020).

2.4 Separation Process and Conventional Methods for Water Treatment

2.4.1 Water Treatment

Water treatment is done to increase the consistency of the water. The water management systems used are determined by the consistency of the water supply. In both cases, water must be disinfected in order to kill any microorganisms that may be present (Karapanagioti, 2016). So far, this strategy has been shown to be the most effective for human life security. Chlorine or chlorine dioxide are widely used, although some methods such as ozonation and ultraviolet irradiation are still used in many instances. If the water comes from a surface water source like a canal, lake, or dam, suspended particles are the most serious issue. The use of membranes and the addition of coagulants are two methods for removing suspended particles. The water quality is normally good if it comes from groundwater from mountain springs, and disinfection is usually all that is needed ("Water supply system - Surface water and groundwater | Britannica," 2021). If the water comes from a groundwater well, though, it may be high in metals and require chemical precipitation to extract. Other than that, softening is another method for removing hardness from hard water, which involves adding lime and allowing calcium and magnesium to precipitate as calcium carbonate and magnesium hydroxide, respectively.

Many procedures are involved in a typical water treatment plant. To begin, pre-treatment is needed to extract large artefacts from the pipes that deliver water from the source to the treatment plant. The hardness and/or suspended particles are then removed by softening or coagulation. After that, any small particles that remain in the water stream are filtered into sand beds. In addition, an activated carbon filter or an air or water jet may be used to sorb or oxidize any liquid organic matter, followed by disinfection to remove any bacteria that remain. Finally, disinfected water must be stored before being distributed to customers.

2.4.2 Community Water Treatment

Drinking water supplies may be contaminated, and disease-causing agents must be removed with proper care. To provide clean drinking water to their residents, public drinking water systems employ a variety of water treatment methods.

2.4.2.1 Coagulation and Flocculation

The first phases of water treatment are mostly coagulation and flocculation. Positively charged chemicals are applied to the water. The negative charge of soil and other dispersed particles in the water is neutralized by the positive charge of these compounds. As this happens, the particles combine with the chemicals to create floc, which are bigger particles (Flocculants and Coagulants | ChemTreat, Inc., 2020).

2.4.2.2 Sedimentation

During sedimentation, floc sinks to the bottom of the water supply, due to its weight. Sedimentation is the term for this settling method (Sedimentation Processes | IWA Publishing, 2016).

2.4.2.3 Filtration

The clear water on top will travel through filters with different compositions (sand, dirt, and charcoal) and pore sizes to eliminate dissolved contaminants such as pollen, parasites, microbes, viruses, and chemicals until the floc has cooled to the bottom of the water source (Jacobsen, 2021).

2.4.2.4 Disinfection

Once the water has been purified, a disinfectant (such as chlorine or chloramine) can be used to remove any lingering pathogens, microbes, or viruses, as well as to shield the water from germs when piped to homes and companies (National Research Council (US) Safe Drinking Water Committee, 2019).

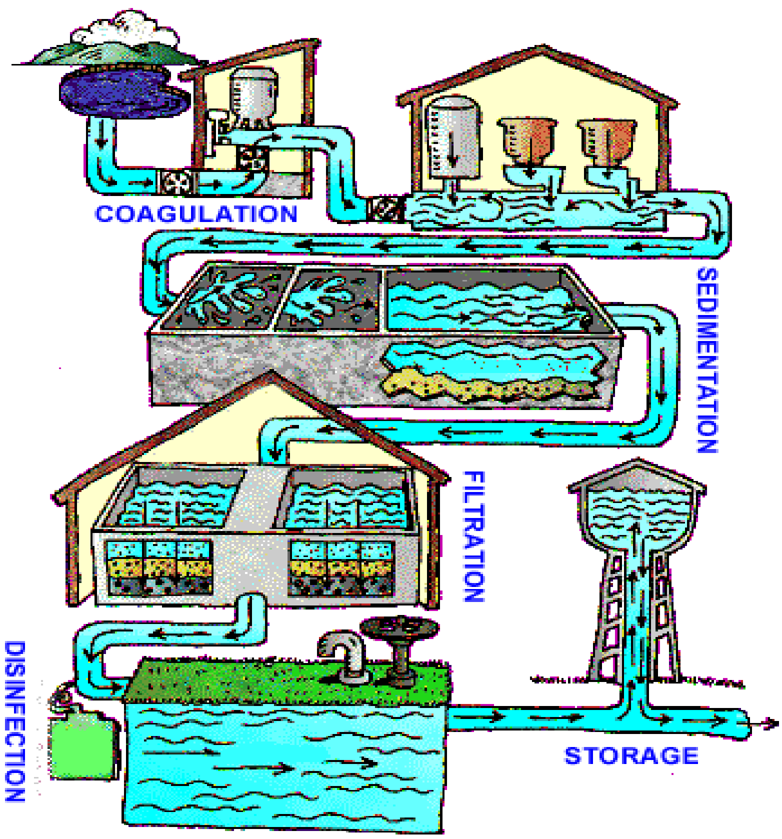


Figure 2.3: Water Treatment used by Community Water System (Water Treatment, 2021)

2.4.3 Household Water Treatment

Nearly two billion people use either unimproved or faecal polluted drinking water supplies around the world. Inadequate drinking water is responsible for over half a million diarrheal deaths in low- and middle-income nations, with the overwhelming majority of these deaths occurring in children under the age of five.

Household water treatment and safe storage (HWTS) is an effective public health initiative for improving the quality of drinking water and reducing diarrheal disease, particularly for those who depend on unimproved sources of water and, in certain instances, contaminated or inadequate piped water supplies. Furthermore, in most crises, clean drinking water is a top concern, and HWTS may be an important emergency management intervention ("Household water treatment and safe storage," 2020).

2.4.3.1 Filtration Systems

A constant supply of portable drinking or process water is needed by many industries. Process water is used in activities like food processing and car production, whereas wastewater treatment plants need efficient wastewater filtration. Strong contaminants are fully separated from the water through filtration in water treatment. This can come from groundwater, sea water, or even wastewater that has been pre- treated. This water management processes have a clear goal: to have the right water content for the relevant industrial use (Cosgrove & Loucks, 2015).

When it comes to water treatment, filtration is crucial. To begin with, there are a variety of pre-treatment options available. Flocculation, coagulation, and sedimentation are examples of this. Various types of water filtration may be used during pre-treatment. Drum filters and disc filters are commonly used for fine scanning. They polish wastewater treatment system effluent to strip dissolved solids from the stream. Pressure gravitational filters may be used if media filtration is desired. This act by creating a barrier to the flow of suspended solids and removing some of the liquids' compounds. Membrane systems may also be utilized. Ultrafiltration, microfiltration, nanofiltration, and reverse osmosis are examples. Although enabling clear water to pass in, they can maintain varying sizes of particles and ions. Water filter cartridges are indeed a good idea. Upstream, they function as safety walls, retaining solids and ions.

The amount of materials that can be separated through filtration is determined by the filter's pores. The map below outlines the different separation processes in terms of the typical materials that will be separated out of each one. The term "particle filtration" applies to traditional media filtration, while "membrane filtration" refers to membrane filtration (Hancock, 2016).

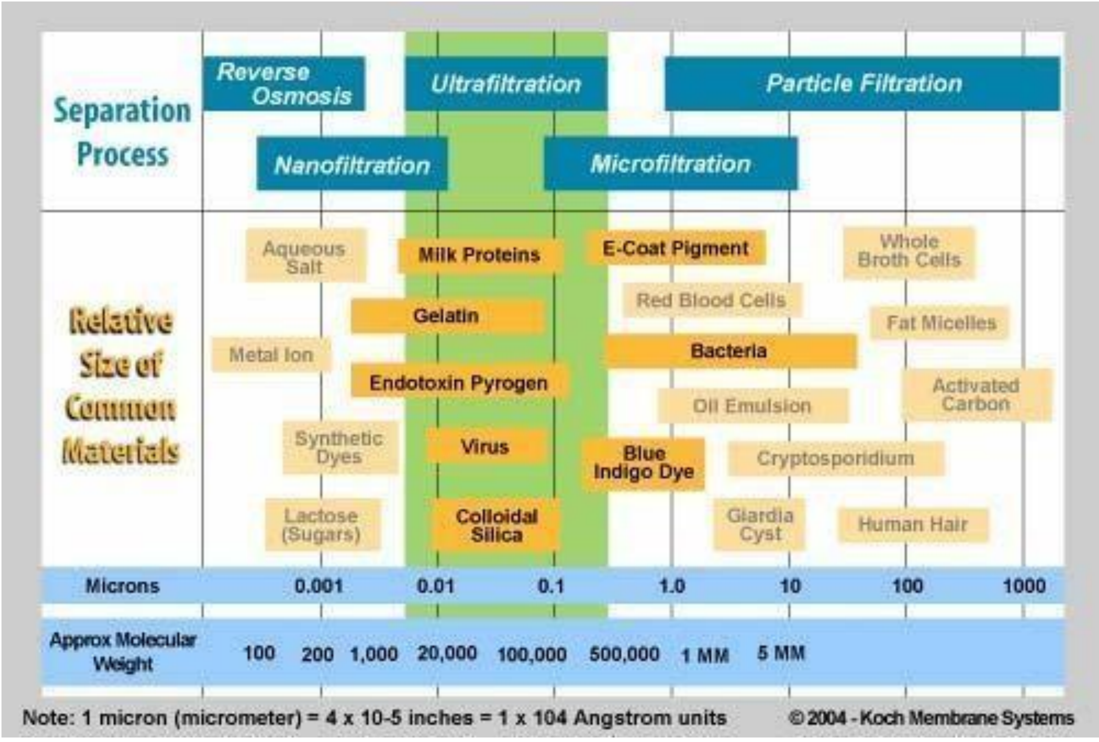


Figure 2.4: Size of Materials That Are Removed by Various Separation Processes (Hancock, 2016)

Figure 2.5 below shows the different kinds of particles that each form of membrane filter removes from the water. The green arrow means that the particle is tiny enough to move through the filter, while the deflected orange arrow indicates that the particle is too large for the filter to pass through.

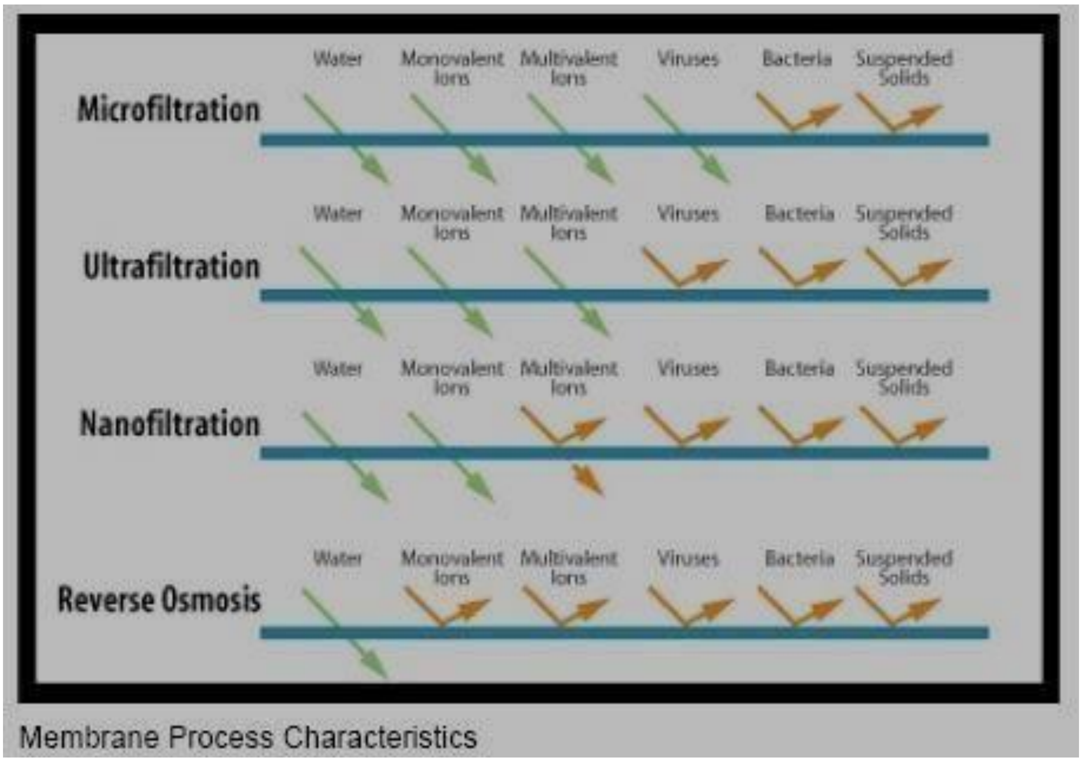


Figure 2.5: Substances Removed from Water by Membrane Filtration Processes (Hancock, 2016)

A pore size of 0.01 µ is typical for an ultrafiltration filter. Since a microfiltration filter's pore size is about 0.1 µ, several microorganisms are killed through microfiltration, but viruses stay in the water. These bigger objects, as well as certain viruses, will be removed by ultrafiltration. Unless the dissolved compounds are first adsorbed (with activated carbon) or coagulated, neither microfiltration nor ultrafiltration will separate them (with alum or iron salts) (Hancock,2016).

Next, the pore size of a nanofiltration filter is about 0.001µ. Most organic compounds, almost all bacteria, the majority of natural organic matter, and a variety of salts are removed by nanofiltration. Since nanofiltration extracts the divalent ions that render water stiff, it is often used to soften rough water (Hancock, 2016). The pore size of reverse osmosis filters is about 0.0001 µ. Water that has been through a reverse osmosis filter is almost completely pure. Reverse osmosis not only destroys both biological compounds and bacteria, but it also removes the majority of contaminants in the water. Reverse osmosis separates monovalent ions from water, effectively desalinating it. It helps to provide a basic understanding of osmosis before learning of reverse osmosis (Hancock, 2016).

When two salt solutions with varying amounts are separated by a semi- permeable membrane, osmosis happens. Since the semi-permeable membrane requires water to move through but not salt, water can transfer from the weaker solution to the stronger solution before the two solutions have the same concentration. The osmosis mechanism is depicted in the following diagram by (A) and (B).

The two solutions are always isolated by a semi-permeable membrane in reverse osmosis, but energy is used to reverse the normal movement of the material. Which causes the water to shift from the stronger to the weaker solution. As a result, toxins are trapped on one side of the semi-permeable membrane while pure water is trapped on the other. The reverse osmosis process is shown in the illustrationbelow (C).

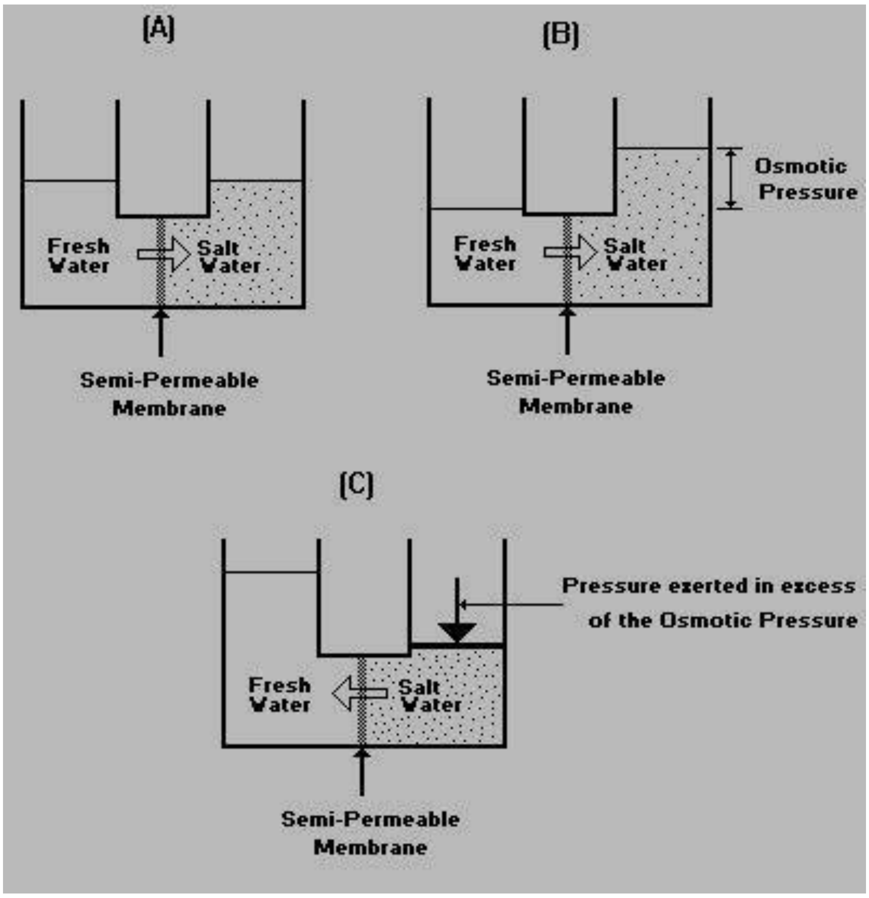


Figure 2.6: Osmosis and Reverse Osmosis (Hancock,2016)

2.4.3.2 Water Softeners

A water softener is a whole-house filtration device that uses a mechanism called ion exchange to strip hardness-causing calcium and magnesium minerals from the water. Hard water is one of the most common and dangerous water issues, and a water oftener can help. The new home is wreaking havoc with hard water. Scale builds up in your drains, causing them to clog and lowering your water pressure. Dishwashers, coffee makers, and ice machines all suffer from scale, which drastically reduces their lifetime. Hot water appliances are destroyed by hard water. Calcium and magnesium can solidify and harden into crystal deposits within your hot water heater as the temperature of the water rises. It could sound like your water heater is popping popcorn if you live in a hard water region. This is due to the fact that scale has built up on the heating unit. The calcified rock layers crusted on the heating components start cracking and stretching as the temperature of the furnace increases and the tank extends. The sound of popcorn popping is caused by hard water-induced size (What Is a Water Softener and How Does It Work, 2019).

If you don't have a water softener, you'll need to use more detergent to save your clothes from being dingy. Your dishes would be streaked and stained as they come out of the dishwasher. Your shower walls are covered with a filmy scum, and your soap and shampoo are unable to lather. Bathing in hard water causes your skin to become itchy and brittle, as well as your hair to become dead and oily. It's mind-boggling how much time, resources, and money it takes to clear up the negative consequences of hard water. The alternative to the problem of water hardness is a whole-house water softener (https://www.facebook.com/thespruceofficial, 2021).

Ion exchange is the mechanism by which water softeners remove calcium and magnesium from the water. The hard water runs into a bed of spherical resin beads as it reaches the mineral tank. The sodium ion is charged in these acrylic beads, which are usually constructed of polystyrene. The resin beads have a negative charge, which means they are anions. Calcium and magnesium are also cations, which means they have a positive charge. The negative charge of the minerals is drawn to the positive charge of the resin beads so opposite charges draw. The beads take hold of the mineral ions to extract them from the water while the hard water flows through the resin. The sodium ion is emitted as the bead captures the mineral ion. If the water goes into the mineral tank, the resin column extracts much of the stiffness, resulting in softened water that runs through your house (What Is a Water Softener and How Does It Work, 2019).

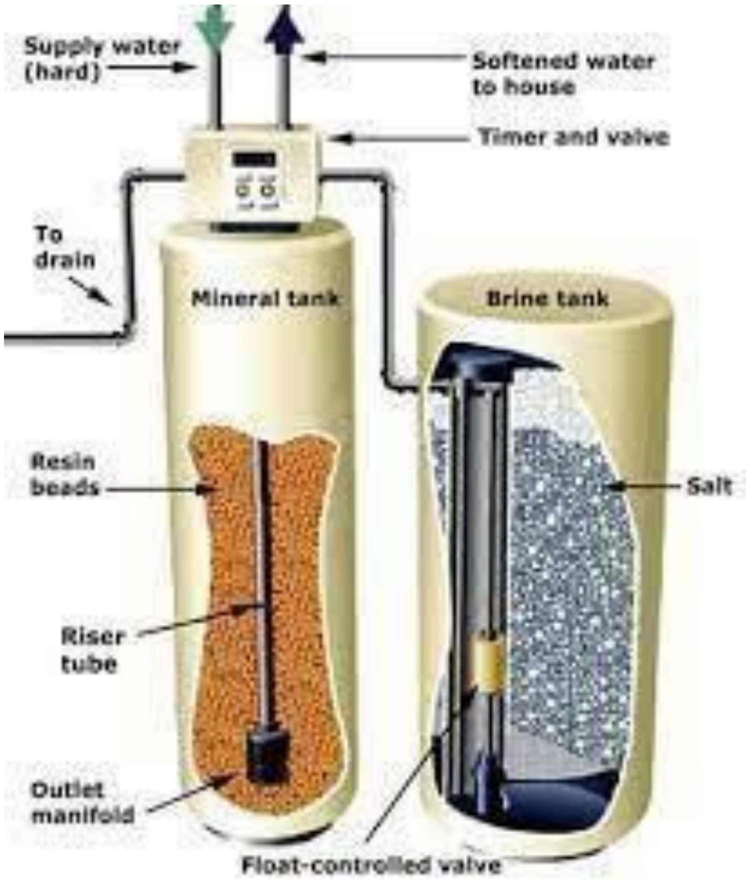


Figure 2.7: Water Softener System (What Is a Water Softener and How Does It Work, 2019).

2.4.3.3 Distillation Systems

Water distillation is a water purification method that involves vaporizing water and separating it from the pollutants it contains using a heat source. The unfavorable elements are often found naturally in land or surface water.

Untreated water is heated until it approaches its very low boiling point and starts to vaporize throughout the distillation process. The temperature of the water is then maintained at this level to keep the water vaporizing while preventing other components from vaporizing as well. This procedure also aids in the separation of water molecules from disease-causing species on a microscopic level. The smoke is then funneled into a condenser until the water has vaporized. When the water is removed from the heat source, it cools and returns to a liquid state, where it then flows into a receiving tub. People have also played with utilizing solar power for the water distillate ion method throughout history. The high cost of heating sources to begin the method is the reason for this. Solar energy is used in this version, and is more environmentally sustainable than any other electricity sources (Advanced Water Solutions, 2017).

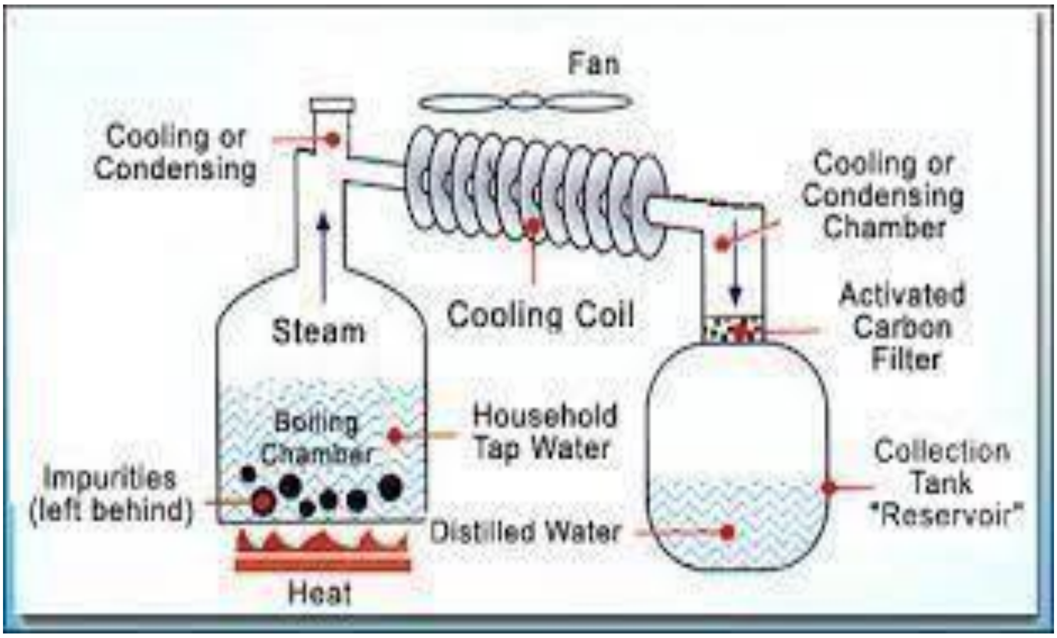


Figure 2.8: Distillation Water Processes (Advanced Water Solutions, 2017).

2.5 Water Treatment Process Engineering

Water sustainability science is experiencing a paradigm change to highlight the increasingly intertwined and interdependent existence of Earth–water–human environments, as a result of factors such as economic and demographic development, ageing infrastructure, and increased worries about pollution (Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review, 2019). Furthermore, heightened knowledge of the gaps in emerging water storage and management infrastructure has sparked interest in using non-traditional water resources such as seawater desalination, waste-water reuse to satisfy rising demand. As a result, many improvements and solutions to integrated water treatment facilities that deliver a single, potable level of water have been suggested. Distributed applications, for example, may be integrated into broader networks as part of regenerative care approaches tailored to deliver fit-for-purpose water closer to its point of use. Sustainable engineering is described by Mihelcic et al as "the design of human and industrial processes to ensure that humankind's use of natural resources and cycles does not result in reduced quality of life due to either reductions in potential economic opportunities or adverse effects on social circumstances, human health, and the climate." Sustainable water systems, in this sense, optimize reuse while minimizing environmental effect by using a sequence of treatment processes and recycling loops to deliver water at the purity quality required by its consumers. Furthermore, dissolved solutes in waste waters for example, nutrients and metal ions may be considered natural resources that can be retrieved. Finally, the effective construction of these systems would necessitate answering fundamental questions ranging from the molecular to the systems scales about the creation, adoption, and incorporation of treatment technologies into reliable networks that ensure a stable and durable infrastructure that can easily recover from harm or disturbance caused by natural disasters and equipment failures.

Advances in chemistry, materials science, and molecular engineering are creating remarkable abilities to develop, classify, and modify materials at the molecular to nanoscales, which is occurring in tandem with attempts to re-envision the design of water quality and management infrastructure (Darling & Yang, 2020). As a result, through combining this regulation with the robust design of treatment networks through the establishment of comprehensive structure–property relationships, substantial opportunities to enable the rational design of materials to positively impact water quality occur. For example, zirconium metal organic frameworks (MOFs) are excellent candidates for designing selective sorbents that target the removal of hazardous organic pollutants from water that has been prepared for direct potable reuse. Furthermore, thermo sensitive solvents allow for the extraction of water from high-salinity brines utilizing low- cost waste heat as the primary energy source. Membrane-based systems are promising opportunities for clean water technology because of their simplicity of use, compact construction, and low energy requirements. Membranes with pore wall chemistries that can be easily tailored to allow solute-specific separations and detection can be made using self-assembled block polymer materials. Membranes with pore walls optimized to trap and absorb metal ions, for example, could be used for resource recovery or remediation operations if they were properly designed. Nano composite membranes, which are made by inserting nanomaterials into the matrix of traditional membrane structures, may be engineered to facilitate the inactivation of pathogenic microorganisms and biofouling. Nano composite membranes, on the other hand, may be engineered to allow for localized solar- thermal heating, which improves membrane distillation processes (Darling & Yang, 2020). Although the potential of these materials is promising, significant advancements in clean water have been sluggish to materialize in reality. The empirically-driven, heuristic methods that direct most efforts to improve material properties and system efficiency are one impediment to realizing this ability because of their time- and resource-intensive existence. Furthermore, traditional workflows are often tightly based on a single, defined system architecture and do not take into account input from comprehensive processes analyses and method synthesis optimization.

To address the gaps in expertise that prevent the translation of new materials and devices from the laboratory scale to sustainable water treatment technology, a shift away from traditional Edisonian approaches and toward principled and data-driven structures that can direct material design and process synthesis is needed. While it is widely agreed that materials-enabled solutions can play an importantrole, achieving the aim of improving clean water technology and resilient water resources infrastructure will necessitate contributions from a variety of fields (Darling & Yang, 2020**)**

2.5.1 Inverse Design

We anticipate that the integration of materials informatics, Bayesian optimization, and inverse architecture can speed up the discovery of promising materials for sustainable water technologies by two to three orders of magnitude. Inverse architecture aims to predict (macro) molecular and/or self-assembled structures that attain desired material properties using computer simulations. While certain polymer structures have analytical structure–property relationships, the fundamental understanding of molecular interactions and transport mechanisms that control solute - specific separations is still lacking (Reducing Time to Discovery: Materials and Molecular Modelling, Imaging, Informatics, and Integration, 2021). Materials informatics makes use of large online databases to learn structure–property relationships, which are critical for solving the inverse problem of materials discovery. We believe that the coming convergence of materials informatics, physical chemistry, and synthetic chemistry will contribute to new discoveries and more precise structure property relationships, allowing automated structures that will speed up the molecular engineering of nanostructured polymers. Figure
2.9 depicts the traditional materials exploration workflow's sequential and heuristic nature and contrasts it with the streamlined existence of data-science tools, demonstrating the advantages that each model may reap from the other.

With traditional high throughput numerical screening approaches, the almost infinite design space of applicant materials cannot be enumerated. Instead, a proxy or machine learning model is built in materials informatics to simulate material properties such as solubility from input design variables such as molecular structure. Adaptive modelling methods evolve the surrogate model over time by continuous (re)learning and propose new materials to synthesize or simulate using the surrogate model. The use of Bayesian optimization approaches, in which domain specific information, such as actual but incomplete structure property relationships and observed results, is integrated into the surrogate model's prior distribution, is a common technique. When it comes to choosing potential studies, the computationally cheap surrogate model allows for the optimization of experimental conditions that balance discovery (sampling regions with high uncertainty) and exploitation (sampling regions with best expected material performance). The technique becomes flexible as new observations are used to refine the surrogate model using the Bayes law (self-learning). In many trials, adaptive architectures have been shown to outperform pure exploitation methods in a variety of applications, including the analysis of self-assembled nanoparticles, medicinal medications, and high strength alloys (Machine Learning Force Fields, 2021).

Data-driven inverse design strategies, including their ability to speed technological growth, present a number of obstacles and opportunities. Many effective adaptive design implementations so far have used either narrow design spaces such as ternary alloys or crystalline materials with well-defined, equilibrium structures. Structure–property relationships for amorphous soft materials including polymeric and nanocomposite membranes, on the other hand, are less readily accessible and difficult to describe. Since they are processed far from equilibrium and therefore have non- equilibrium configurations, polymer membranes in particular have exceptionally broad design spaces. To encrypt all of the design choices for soft, polymeric materials, new mathematical descriptions rooted in physical and chemical understanding are needed. In certain instances, comprehensive molecular simulation is needed to understand the self-assembly mechanism and, as a result, predict the structure and properties of soft materials. This trade-off between computational cost and molecular-scale precision encourages the development of new multi-fidelity adaptive modelling approaches to aid in inverse materials design. Finally, the water treatment systems that these products are used in are often multifaceted and use a variety of phenomena to accomplish their objectives. To traverse conflicting design objectives which are material targets and assimilate heterogeneous data from multiple sources in this large design area, advancements in multi objective optimization are needed.

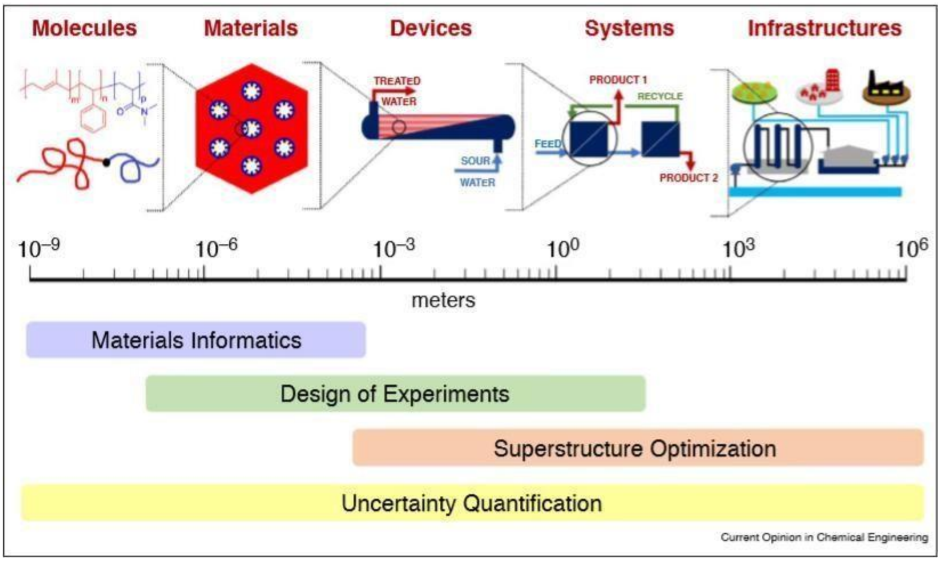


Figure 2.9: Inverse Design (Machine Learning Force Fields, 2021).

2.5.2 Model-Based Design of Experiments (MBDOE)

Designing experimental campaigns that optimize valuable knowledge gathered to examine ruling theories is a profound obstacle of scientific exploration. By using MBDOE can help gain a better understanding of the thermodynamic and transport dynamics that control water treatment processes. MBDOE is a mathematical methodology that uses the smallest number of experiments to accomplish a user- defined objective, such as distinguishing between rival models or optimizing predicted parameter precision. Traditional design of experiments strategies (for example, multi- level factorial and partial factorial designs) aid in the development of analytical models such as polynomial response surfaces, which, while predictive, seldom provide insight into fundamental scientific phenomena. MBDOE frameworks, on the other hand, explicitly consider differential and/or algebraic equations based on mathematical and technical fundamentals such as conservation laws and thermodynamics when formulating them. Since these experiments are often time and resource consuming, MBDOE techniques are common in biology, pharmacology, and reaction engineering. Lanez-Aguirre et al., for example, use a completely Bayesian MBDOE method to approximate nonlinear differential algebraic pharma co-kinetics models, allowing dosing regimens to be tailored to particular patients. Han et al. use MBDOE to differentiate between competing kinetics models for chemical-looping combustion in another recent illustration. Despite the fact that there are comparable problems in sustainable water management, such as determining fouling processes and recognizing pollutants' degradation pathways, MBDOE techniques have seldom been used in this sector (Lanez-Aguirre et al).

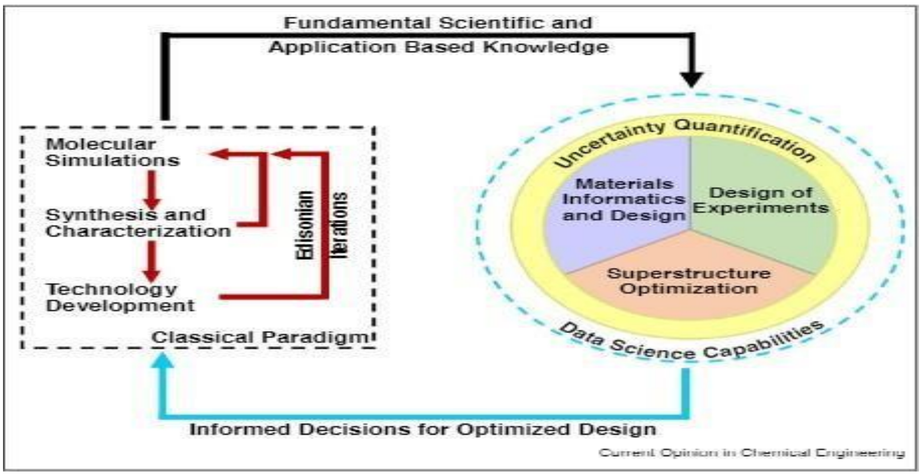


Figure 2.10: Model Based Design of Experiment (MBDOE) (Lanez-Aguirre et al)

` The transport, thermodynamics, and reaction mechanisms that allow water treatment technologies are frequently not properly understood, as illustrated in inverse architecture. We assume that model sets should be proposed, with each model corresponding to basic empirical theories regarding the prevailing physical and chemical phenomena. MBDOE then aids in the development of multifaceted experimental campaigns in order to identify the most likely subset of models. This suggested paradigm is particularly useful for identifying environments under which a single mechanism dominates and situations under which transformations between mechanisms occur. It may be used, for example, to figure out when membrane transport switches from a solution-diffusion to a pore flow-dominated regime. Furthermore, MBDOE can be used to plan and analyze high-throughput transient tests, reducing the amount of time it takes for a test device to achieve equilibrium. This capability could come in handy when putting emerging technology to the test against real-world feed solutions. Materials characterization is often carried out with idealized solutions containing only a single dissolved part. Water management systems, on the other hand, are complicated in reality by dynamic, multi- component methods whose structure changes with time. As a result, there is a pressing need to evaluate material and system efficiency through a wider range of feed solution environments. In this respect, the MBDOE's proposed capabilities will hasten the advancement of long-term water technologies that can withstand a broad variety of environmental conditions (Han et al).

2.5.3 Superstructure Optimization

Water transport networks, water supply chains, and sensor positioning are all examples of superstructure optimization, which is a classic paradigm of process systems engineering. To begin, the modeler creates a superstructure at the required length scale that contains all possible device configurations. The superstructure is then used to formulate an optimization problem. Minimize water processing costs, for example, by examining all possible variations of design options, such as device selection and scale, and flow speeds. Finally, the optimization problem is numerically solved, culminating in the identification of one or more prototypes of ideal topology (discrete decisions) and functional conditions (continuous decisions). Superstructure optimization is often used to reveal new machine topologies. For example, utilizing superstructure optimization, Du et al. discovered permeate split designs for a single - feed, multi-product seawater reverse osmosis desalination network, showing how commercially accessible products, when optimally designed into devices and systems, can solve operational difficulties including boron removal. Yenkie et al., for example, use superstructure optimization to determine quantitative output levels that specify when different separation pathways reduce production costs (Yenkie et al).

Extending developed top-down superstructure optimization approaches to include evolving fit-for-purpose paradigms and the additional constraints required to solve resource recovery and water reuse will help to concentrate research attention on the most impactful aspects of these highly-integrated, dynamic systems. In this domain, there is a pressing need to comprehend the fundamental cost and efficiency factors for emerging sustainable water technologies in the light of current or potential infrastructure, legislation, and public sentiment across a diverse set of stakeholders. During the construction of new materials, superstructure optimization is often ignored. However, as seen in Figure (a), new initiatives in this area are concentrating on developing top-down guidelines at the system level by defining material property goals that are needed to allow novel process configurations. Furthermore, through embedding analytical associations that direct materials selection within the optimization process, top-down methods are starting to bridge the divide between the materials and systems scales. When refining the nature of binary gas separation systems, for example, the Robeson map, which quantifies the trade-off between permeability and selectivity for membranes, was taken into account. As seen in Figure (b), incorporating these structure–property relationships into the optimization process will both measure the relative value of competing material properties and elucidate the potential for performance improvements at the systems level from technical breakthroughs, i.e. shifting the Robeson map. As a result, potential superstructure optimized ion frameworks can provide guidance on both how to build nanostructured materials and how to incorporate them into resilient infrastructures with multiple conflicting goals (Yenkie et al).

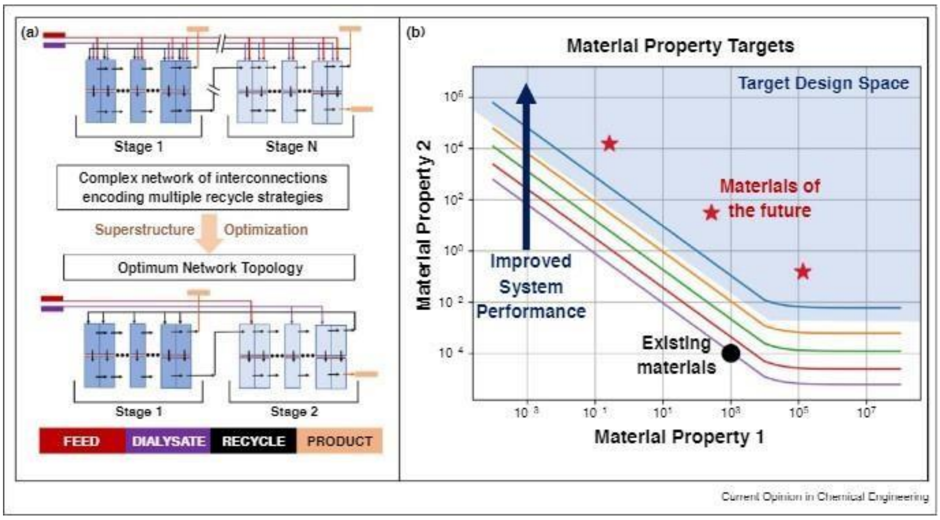


Figure 2.11: Superstructure Optimization (Yenkie et al)

Via bottom-up study or inverse architecture, superstructure optimization is also well-positioned to lead molecular engineering. For materials that have already been characterized, robust superstructure optimization allows for quick comparisons to rival technology in the sense of completely optimized structures, as well as the identification of new uses for materials. Recent research suggests superstructure optimized ion formulations for designing crystalline material architectures, such as MOFs, based on process separation constraints. Since the mechanisms regulating solute-specific separations are not well known, extending this bottom-up research to soft materials, such as polymeric membranes, remains a task. Nonetheless, we expect that materials informatics and MBDOE can have fresh perspectives and more precise structure–property relationships, which will be critical for direct molecules–infrastructure optimization. We also see possibilities for combining molecular simulations and superstructure optimization to allow high-throughput screening of new materials utilizing systems-scale metrics. For example, performance benchmarks may include separation selectivity, energy use, and product expense (Yenkie et al).

2.6 Water Recycling and Sustainability

Water access is essential for a long-term future, and climate change is projected to escalate water shortage issues in many European regions. Water recycling is seen as an adaptation strategy for conserving energy by repurposing water for non-drinking purposes. Grey water collected from pools, toilets, and drains may be reused for toilet flushing, washing, and garden drainage, among other things. Irrigation of waste water is also possible in agriculture. Water may be used in closed circuits to regulate the temperature in greenhouses and manufacturing processes.

In places where water is scarce, wastewater reuse can therefore be a viable choice for water supply. There are two forms of reuse: direct and indirect. Modified wastewater that is piped directly through a water delivery system without first being dissolved in a natural stream, lake, or groundwater is referred to as direct reuse. Indirect reuse entails combining reclaimed wastewater with another source of water before reusing it. As a grey climate change adaptation alternative, both forms are interesting. The amount of water that could be reused is projected to be of the range of 3000 million cubic meters each year. Spain alone consumes 1200 million cubic meters of water each year (Report on good practice measures for climate change adaptation in river basin management plans). The AQUAREC project has documented more than 200 water reuse initiatives around Europe (Helmer et al). Treated wastewater may be used as a more dependable supply of water, resulting in more efficient resource use and demand control. Overall water usage and treatment requirements may be reduced, resulting in cost reductions. Furthermore, the usage of nutrient-rich treated waste water for cultivation will reduce or eliminate fertilizer use while still increasing efficiency, contributing to food protection (Wastewater Treatment Water Use, 2018). When it comes to the ecosystem, reusing reclaimed water provides for the regeneration and allocation of groundwater, as well as the enhancement of creek, wetlands, and pond preservation.

Water is essential for socioeconomic growth, stable environments, and human life itself, and it is at the heart of sustainable development. It is critical for lowering the global burden of illness and improving population wellbeing, welfare, and efficiency. It plays a crucial role in the development and preservation of a wide range of human benefits and services. Water is therefore essential to climate change adaptation because it serves as a vital connection between the climate system, human culture, and the atmosphere.

Water is a limited and irreplaceable resource that is essential for human survival. It can only be regenerated if it is properly handled. More than 1.7 billion people reside in river basins where human erosion exceeds natural replenishment, a development that would see two-thirds of the world's citizens residing in water-stressed countries by 2025. Water may be a significant barrier to sustainable growth, yet when handled effectively and equitably, it can help to improve the stability of social, economic, and environmental processes in the face of rapid and unexpected change (Camara et al., 2019).

2.6.1 Sustainable Water

The desire to satisfy current water demands without jeopardizing future generations' ability to do so is what sustainable water management entails. Sustainable water management necessitates a multidisciplinary and comprehensive approach that takes into account technological, financial, economic, landscape aesthetic, societal, and cultural concerns. On a global scale, having clean water means providing every citizen on the globe with affordable access to the minimum 20 to 50 liters of regular water available for survival. This comes after the United Nations General Assembly declared "the right to healthy and clean drinking water and sanitation as a fundamental right that is essential for the complete enjoyment of life and all human rights." (United Nations General Assembly)

Water preservation also entails the conservation of water supplies in a comprehensive and effective manner. Multiple pressures on water supplies already exist, necessitating the need for long-term, coordinated, and comprehensive water management. "A renewable water cycle through which we are able to fulfil our requirements for water and sewerage facilities while allowing potential generations to meet their own needs," according to the UK regulator Ofwat (UK regulator Ofwat).

According to the Environmental Protection Agency (EPA) in the United States, this may include proactive preparation for water and wastewater facilities to handle operations and maintenance while still ensuring the sustainability of the populations they represent. The following are some of the advantages of including resilience during infrastructure preparation, according to the Agency:

- Setting priorities and choosing initiatives in an open and participatory mechanism with the group to maximize natural, fiscal, and social benefits.

- Achieving continuity through a variety of options that address utility as well as neighborhood priorities
- Increasing the utility's long-term technological, economical, and managerial capabilities.

Water services, on the whole, have a long-term planning period as well as long-term service operations and repair obligations. Investment choices' risks and future gains are realized over a lengthy period of time. As a result, the EPA's Sustainability Policy encourages drinking water and wastewater programs to conduct "robust and systematic" preparation to ensure that water infrastructure projects are cost-effective throughout their lifetimes, resource-efficient, and aligned with other related community priorities (Hansen, 2018). Water sustainability levels may often vary depending on the utility. Any utilities and municipalities have begun to include environmental aspects in their development procedures, but they are searching for opportunities to strengthen and refine their initiatives. Others may choose to concentrate on how those aspects will aid in meeting current regulatory or utility criteria in a cost-effective manner (Environmental Protection Agency).

2.6.2 Recycling Water

Water reuse (also known as water recovery or water reclamation) is the method of reclaiming water from a range of outlets, treating it, and reusing it for beneficial purposes such as cultivation and irrigation, potable water supplies, groundwater replenishment, manufacturing processes, and environmental conservation. Water reuse may be used to improve water quality, sustainability, and stability by providing alternatives to conventional water sources.

There are two types of water reuse: scheduled and unplanned. Unintentional water reuse occurs where a supply of water contains a significant amount of already utilised water. As cities derive their water sources from rivers such as the Colorado River and the Mississippi River, which collect treated wastewater discharges from communities upstream, this is an illustration of unplanned water reuse.

Water systems that are constructed with the intention of beneficially reusing a renewable water source are referred to as planned water reuse. Frequently, municipalities will aim to maximize their total water usage by reusing water within the city to the greatest degree practicable before reintroducing it to the setting. Agricultural and landscape drainage, commercial process water, potable water sources, and groundwater resource protection are all examples of expected reuse (US EPA,OW, 2019).

Municipal drainage, industrial process and cooling water, stormwater, agricultural runoff and return flows, and produced water from natural resource mining operations are all possible sources of water for future reuse. These water bodies have been sufficiently treated to follow "fit-for-purpose requirements" for a specific next application. "Fit-for-purpose standards" refer to the treatment criteria for bringing water from a given source to the required level for public health, environmental safety, or specific consumer requirements. Reclaimed water for field irrigation, for example, will need to be of adequate consistency to avoid harming plants and soils, maintaining food protection, and safeguarding farm workers' health. Water may need further care in applications where there is a higher risk of human exposure. There are several uses of recycled water listed below (Uses of Recycled Water | Cucamonga Valley Water District - Official Website, 2018).

- Agri-irrigation is a term used to describe the process of wateringcrops
- Irrigation for parkland, rights-of-way, and golf courses
- Power source from the city
- Power plants, refineries, mines, and factories all useprocesswater.
- Toilet flushing is an example of an indooruse.
- Roads, building sites, and other heavily trafficked places needdust management or surface cleaning.
- Such building methods, includingconcretemixing
- Providing water to freshwater and marine aquifers and artificial reservoirs
- Restoration of the environment

2.7 Impact of Water Treatment, Recycling andReuse

Water reuse is gaining traction around the world as a safe substitute source of water for uses that do not demand high-quality water, freeing up scarce potable water supplies and reducing effluent discharges into receiving waters. The aim of water conservation and reuse is to reduce the burden on water environments while fulfilling significant and long-term water requirements (Han Jiangb et al., 2019). Water treatment systems, project economics, and environmental assessments are also in need of improvement. However, focused effort will reverse the deterioration of the water ecosystem while addressing water supply requirements in a sustainable manner. The recycling process increases overall water quality in the ecosystem while also reducing the pressure on clean freshwater supplies. Most of the water demands can be met with recycled water if it is properly maintained to ensure water quality suitable for use. Agriculture, landscape, public parks, and golf course drainage are also examples of non-portable (not for drinking) uses for recycled water. Conventional wastewater treatment plants (WWTPs) disinfect wastewater and reduce water leakage, but they often pollute the environment and require energy/material supply, resulting in emissions. However, resource regeneration (e.g., water reuse) and energy conservation (e.g., anaerobic digestion) help us to mitigate the negative environmental effects of wastewater treatment (Xiaodi Hao et al., 2019).

2.7.1 Household/ Residential

Greywater and blackwater are the two forms of wastewater generated at home. Greywater is wastewater from plumbing fixtures other than toilets, such as sinks, basins, and taps. Blackwater is water that has been mixed with waste from the toilet. Because of the potential for contamination by pathogens and grease, water from kitchens and dishwashers should be excluded from greywater and considered as blackwater (Ali hadi Ghawi, 2018). Each type of wastewater requires different treatment and can be used in a variety of ways. With the proper measures, such as using minimal to no sodium and phosphorus products and applying the water below the soil, greywater is suitable for garden watering. Greywater that has been properly handled will also be reused indoors for toilet flushing and laundry washing, all of which require a lot of water. For the blackwater, before reused, it must be treated with biological or chemical agents and disinfected. Treated and disinfected blackwater can only be used outside for single-family homes, and then only for subsurface drainage.

2.7.2 Drinking Water

Treated wastewater is often discharged into rivers and wetlands, which are often used as reservoirs of drinking water. Because of the increased need for water, treating drainage flows and restoring them to their original sources has become a valuable and readily accessible source of raw water (Charles P. Gerba, 2017). Many industrialized countries have high treatment and recycle rates, unless they are extended to useful reuse. As a result, reclaimed water makes up a significant part of many rivers base supply. Recycled water is used by various sanitation districts to recharge a potable groundwater source through surface spreading basins. Prior to discharging into the groundwater source, the recycled water is disinfected and then upgraded with extra filtration. Treated water is pumped under pressure into a heavily used potable aquifer in some regions. The time it takes for water to be drawn for supply varies according to location. This mechanism eventually avoids salt water penetration in specific locations. Other reclamation plants discharge their treated water into drinking water tanks, where it sits for a period of time before being released (Charles P. Gerba, 2017). Water safety challenges, such as toxins and organics/inorganics, are the same with every potable water supply project when recycling or reusing water. Since the recycled water is made up of wastewater, filtering technologies must handle elevated levels of microbiological and chemical pollution in order to guarantee clean drinking water while also addressing environmental issues.

2.7.3 Agriculture / Irrigation

Due to treated wastewater percolating into aquifers, which provides additional or natural treatment, crop yields have risen in areas where rainfall is limited and/or soils are weak. This approach also improves groundwater recharge, the formation of fresh aquifers, and the flow of local streams. The agriculture industry may use reclaimed water for nearly anything depending on the degree of treatment, but it is most often used for pasture, field or fodder irrigation, and shed or stockyard wash down. Recycled water is rich in nutrients, eliminating the need for fertilizer. Using recycled water, or non-traditional water sources in agriculture has many benefits such as water recycling has the potential to be less costly in the long time (Manuela Helmecke et al., 2020). When groundwater becomes scarcer, the costs and resources used to pump it rise, as the pumps need more energy to operate. Water recycling will help you save money in the long run. The two elements of water and energy are inextricably related. Water is used to generate electricity, and collecting, cleaning, and distributing water requires energy. Furthermore, diverse end users necessitate varying degrees of water quality. It saves resources to reuse water and treat it for its intended use (Christoph Schulte et al., 2020)

2.7.4 Industrial Area

For power plant cooling and boiler feed water, recycled water is used. To supply filtered water for power station turbines, microfiltration and reverse osmosis treatment are used to obtain potable water grade, which is then further treated to de-mineralize. For cooling water and quenching blast furnace or coke oven slag, steelworks use reclaimed water. For their processes, high-tech/semiconductor companies use filtered high-purity water. Water storage, reuse, and recycling will significantly boost the advantages derived from small freshwater resources. When downstream river levels are changed due to reduced water demands, the water balance in a river basin change. Water management and productivity in rural and urban environments, along with reclaimed water flows, result in lower discharge pollutants and freshwater extraction, resulting in better downstream water quality (J. Anderson, 2018)

2.8 Summary of Literature Review

Water is one of the most important elements on the planet. Water is needed for the survival of all plants and animals. There would be no life on Earth if there was no water. In the Literature Review, all the main issues are highlighted which is water usage for household. The issues related with water demand management, water end use behaviors and water consumption in Malaysia is studies to understand the water consumed for household. Humans use water in a number of ways, including food preparation, personal hygiene, irrigation, and a variety of other industrial and domestic uses, including the use of electricity. Physical, chemical, and biological characteristics are the three general categories in which water can be categorized. BOD, COD, Ammoniacal Nitrogen, Heavy metal and pH are common elements that have been found in water. The amount of the element in the water must not exceed the standards set by World Health Organization (WHO) in order to provide a clean water supply.

Involves the activity of maximizing the usage of water supplies by planning, growth, distribution, and management is one of the long-term protections of water supplies for future generations. Encourage the use of water in an environmentally sustainable, economically viable, and equitably distributed water supply use also the strategy of saving water. Water conservation strategy is a necessary step in reducing negative impacts on freshwater and the aquatic ecosystem. Rainwater harvesting and vegetated buffer strips is simplest method for improving water resources management and quality. Water-saving techniques will help save energy by diverting less water from our rivers, bays, and estuaries, which is beneficial for the environment. Agriculture is the largest producer of water, accounting for almost 70% of all freshwater supplies. Thus, the strategies on how to reduce the irrigation loses is described. Water reuse strategies included irrigation, residential uses, urban and recreational uses and aquaculture is highlighted in order to give a better understanding of how to reuse water for a sustainable environment.

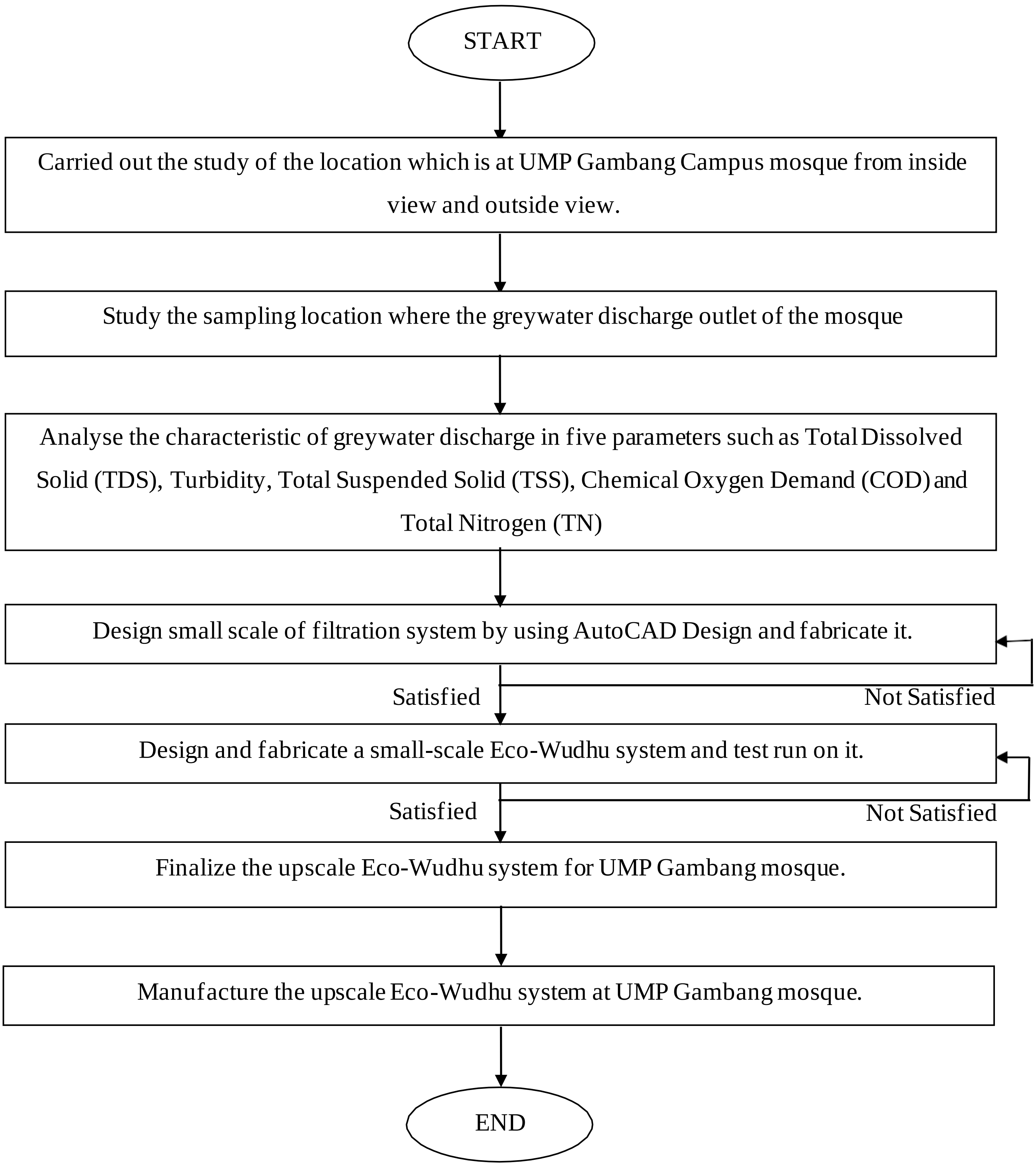
The aim of water treatment is to improve the quality of the water. The quality of the water source determines the water treatment mechanisms used. In both scenarios, disinfecting the water is needed to destroy any microorganisms that may be present. For the community water treatment, there are some method for treatment such as coagulation and flocculation, sedimentation, filtration, disinfection is used to treat water to provide clean drinking water to the residents. Household water treatment use filtration system, water softeners and distillation system are an effective public health initiative for improving the quality of water. Water treatment process engineering use Inverse Design which is aims to predict (macro) molecular and/or self-assembled structures that attain desired material properties using computer simulations while Model-Based Design of Experiments (MBDOE) uses the smallest number of experiments to accomplish a user-defined objective, such as distinguishing between rival models or optimizing predicted parameter precision and Superstructure Optimization is used to formulate an optimization problem.

Water recycling is seen as an energy saving adaptation technique that involves repurposing water for non-drinking purposes. Sustainable water management necessitates a multidisciplinary and comprehensive approach that takes into account technological, financial, economic, landscape aesthetic, societal, and cultural concerns. Lastly, the impact of water treatment, recycling and reuse is analyzed based on the irrigation, drinking water and industrial that can give a lot of benefits to all living things as well.

CHAPTER 3

METHODOLOGY

3.1 Flowchart of Eco-Wudhu System



3.2 Materials and Costing

No	Descriptions	Quantity	Total Price (RM)
1.	Clean River Sand	5 kg	13.00
2.	Gravel Stones	2 kg	12.00
3.	Column Filtration	1	20.00
4.	Arduino Controlled Water Pump	1	11.80
5.	Water Tank (20 x 20 x 20)	3	90.00
6.	Pipes and Fittings	2m	40.00
		Total	186.8

Remarks: This project under of consultant Dr. Azrina with UMP Holdings Sdn. Bhd.

Table 3.1: List of materials of Eco- Wudhu

3.3 Study Location

The research was carried out at the UMP Gambang mosque, which is situated in the heart of Kolej Kediaman 1 (KK1) and the UMP Gambang campus's nursery plant. At any one moment, it can hold at least 3000 people. There are two ablution areas within the mosque, one for men and one for girls. For male Muslims, there is an extra ablution space outside the mosque. The ablution water is drained via covered pipe drains, while stormwater is collected in open drains surrounding the mosque. The mosque, on the other hand, does not have its own water meter to track how much water is consumed each month of the year. According to Pusat Islam & Pembangunan Insan Universiti Malaysia Pahang (PIMPIN), the projected average daily total number of individuals praying (excluding Friday) is about 900. Although water is not expensive in Malaysia, it would be beneficial to the environment and resource conservation if spent ablution water were recovered and repurposed for different authorized activities on campus.

Figure 3.3 (a) Outside View of UMP Gambang Mosque

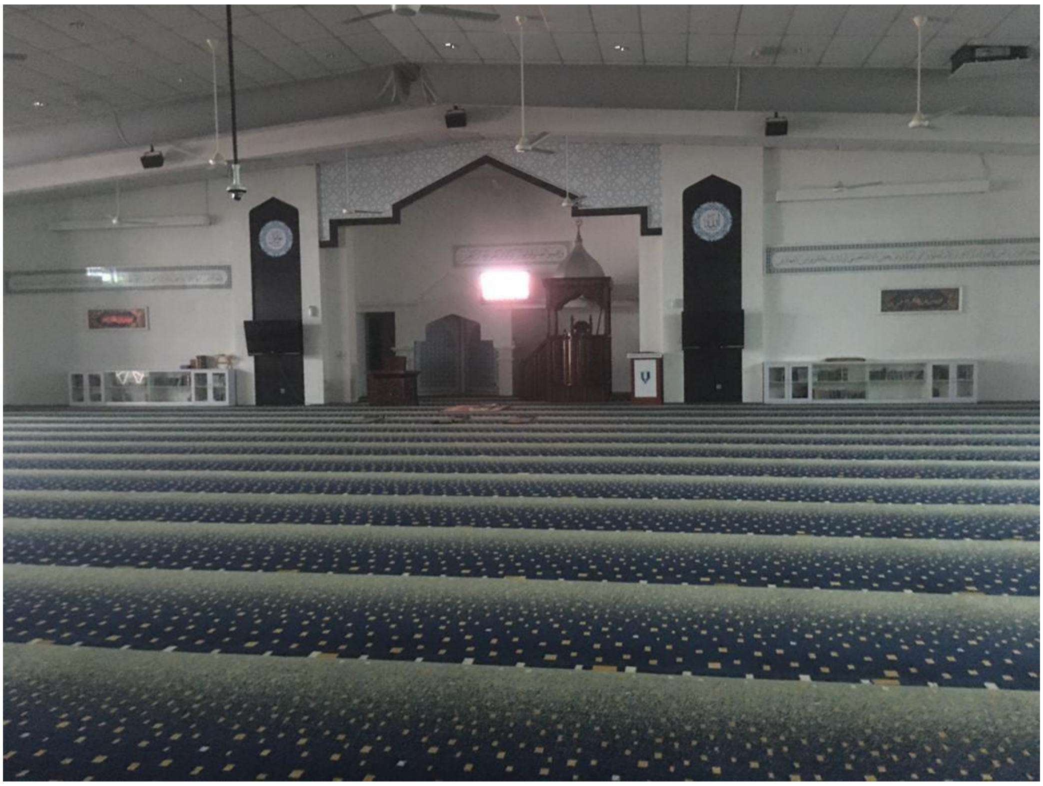


Figure 3.3 (b) Inside View of UMP Gambang Mosque

3.4 Sampling Location

To determine the amount of water used and the quality of the water released to the drains, samples of used ablution water were taken from three major sites of the UMP Gambang mosque. The used water from these locations is dumped via the outlet in figure 3.4 (c). Ablution water samples were collected and examined for two months, five samples from each site. Total Dissolved Solid (TDS), Turbidity, Total Suspended Solid (TSS), Chemical Oxygen Demand (COD), and Total Nitrogen (TN) were all measured. The quality of the utilized ablution water was determined using Standard Methods before and after treatment with a sand filter.

Figure 3.4(a): Indoor Ablution Area of UMP Gambang Mosque

Figure 3.4(b): Outdoor Ablution Area of UMP Gambang Mosque

Figure 3.4(c): Discharge Outlet of UMP Gambang Mosque

3.5 Design Small Scale Filtration System

Used ablution water should be processed using sand filters to provide acceptable quality recycle water, with effective sizes ranging from 0.3 to 1.0 mm and uniformity coefficients between 0.3 and 1.0. The range should be between 1.3 and 1.7. As such, clean river sand was tested in a lab-scale filter for its filtration performance. The sand was sieved to determine its effective size [ES] and uniformity coefficient [UC]. The conventional filtration process is probably the most important single unit operation of all water treatment processes. It is an operation process to separate suspended matter from water by flowing it through porous filter medium or media. The filter media may be sand, anthracite coal, diatomaceous earth, garnet or finely woven fabric. A lab-scale sand filtration system was fabricated and tested to clean the used ablution water. The section of the gravity sand filter is shown in Figure 3.5, where the major information is given. Size of the sand filter was determined based on the allowable overflow rate, which was 39.1 m/d. This value falls within the range of slow sand filter (2.9 to 7.6 m3/d) and rapid sand filter (120 to 235 m3/d). However, it was discovered that the sand filter, which was designed to purify wasted ablution water with the goal of using it for plant irrigation could also be utilised as a slow sand filter, reducing the frequency of maintenance.

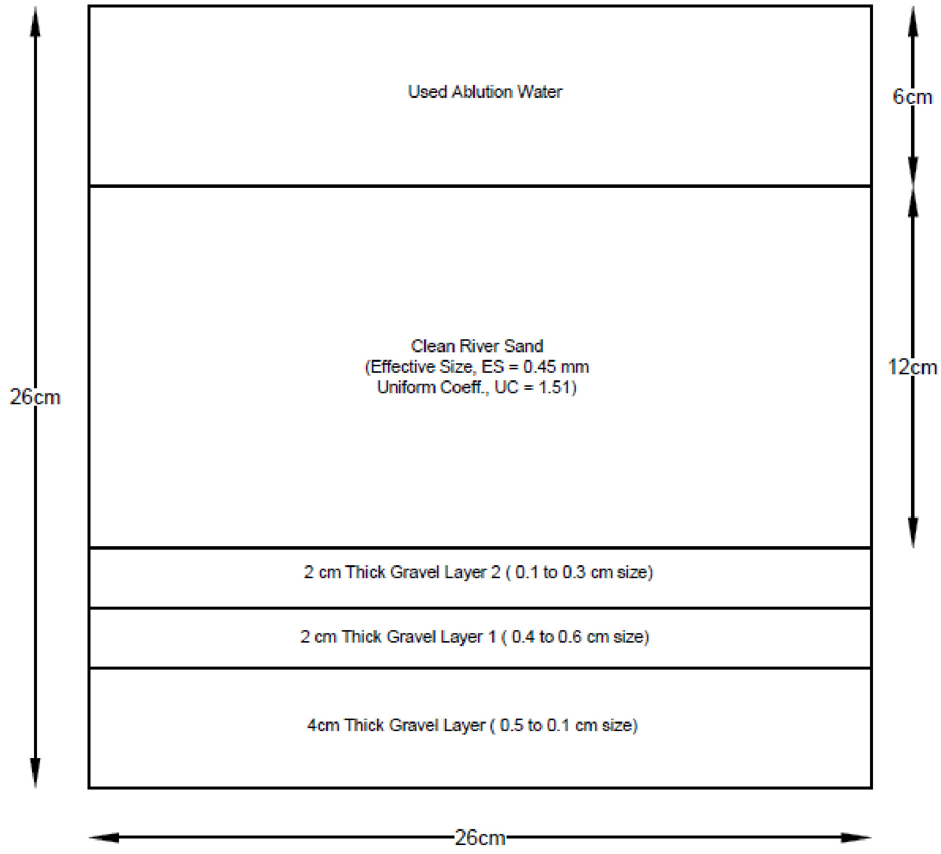


Figure 3.5: Design of Sand Filtration

3.6 Design Eco-Wudhu System

Closed loop flow method was chosen for the circulation of water in the Eco-Wudhu, using main water ablution as its main water source. Since a closed loop flow does not allow any discharge of water along the flow system, therefore it is easier to monitor the water level in the main ablution tank after a period of time. This closed loop system has the advantage of minimizing water wastage via greywater discharge, and prevent contamination from external sources. In the second design stage, a small scale model was built to gather sufficient information prior to Eco- Wudhu construction. Its major components consist of water tanks, water filter and Arduino- controlled water pump.

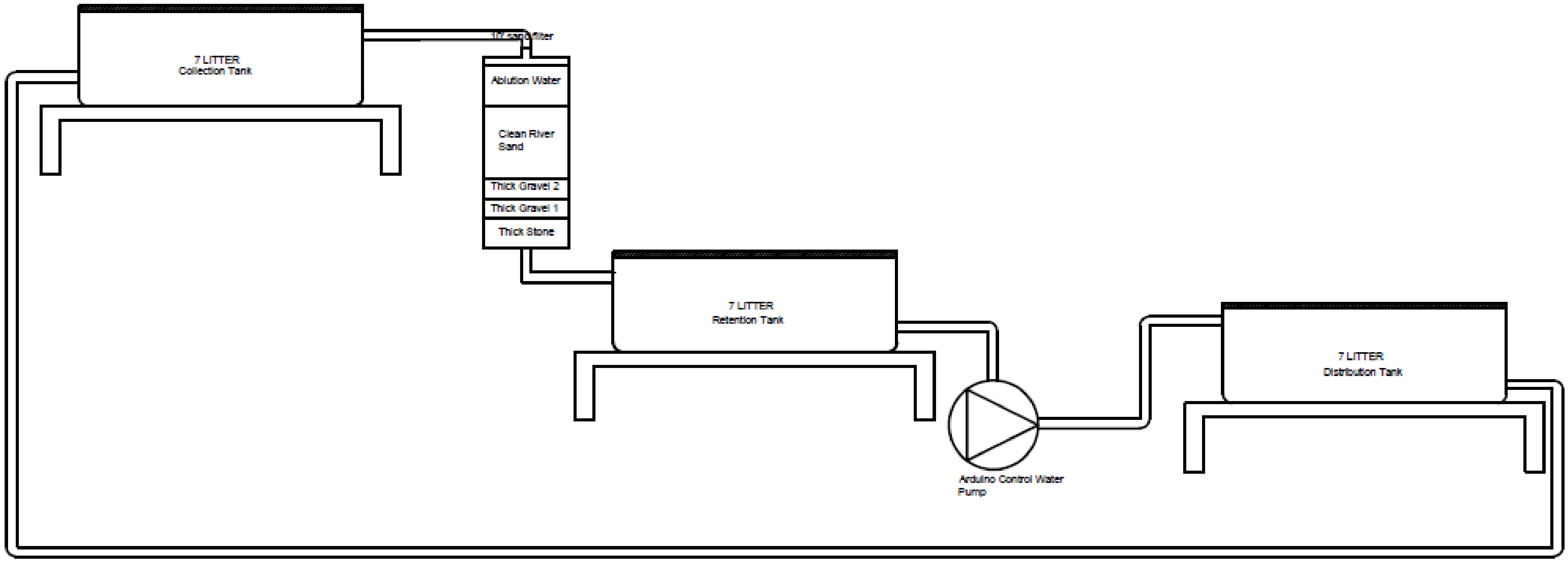


Figure 3.6: Design of Eco-Wudhu System

CHAPTER 4

RESULT AND ANALYSIS

4.1 Wastewater Characteristic

The UMP Mosque's daily water consumption owing to ablution is around 7 L/Cap.day. As a result, monthly water use would be between 650 and 750 m^3. Although the cost or savings of 750 m^3/month due to recycling is not particularly great in terms of monetary value, in terms of natural resource and energy conservation, recycling and reuse of ablution water would be a recommended option if the quality of the spent water is not too polluted.

The quality of the ablution water was assessed using a few key parameters (Table 4.1). The mean values of the parameters were found to be lower than the Malaysian Ministry of Health (MOH) drinking water quality standard. However, this does not necessarily imply that the ablution water used is acceptable for drinking. Because other important characteristics, such as E. coli, were not assessed in the research.

Table 4.1: Water Quality Data of Ablution Water

	Before Filtration			After Filtration			MOH Standard
	Sample A	Sample B	Sample C	Sample A	Sample B	Sample C	
Turbidity, NTU	**15.3**	**2.79**	**1.99**	**8.61**	**2.52**	**1.34**	**<5.00**
Chemical Oxygen Demand (COD), mg/L	**45**	**33**	**26**	**20**	**24**	**12**	**N.A**
Total Suspended Solid (TSS), mg	**21**	**21**	**12**	**15**	**13**	**7**	**15-30**
Total Dissolved Solid (TDS), mg	**125**	**109**	**45**	**96**	**46**	**22**	**<1000**
pH	**7.43**	**7.82**	**7.57**	**6.81**	**6.97**	**7.22**	**6.5-9.0**

Across all samples provided, the sample at location A showed the highest values for all parameters before the filtration process was performed. this is because, the ablution water channeled at location A has been mixed with nonportable application in the toilet of the UMP mosque. The reason why 3 water sample locations were taken is that we want all the ablution water from the mosque to be fully tested and fully treated. The location of sample C is the least parameter reading after the test in the laboratory even though the location in C is close to the main ablution water source in the UMP Mosque. This is because the number of visitors to the mosque has decreased when the water sample is taken, and the usual activities done in the mosque such as '*iftar*' cannot be implemented because of Covid 19. Usually, the water sample at location C is highly contaminated with oil contamination due to cooking activities in UMP mosque kitchen.

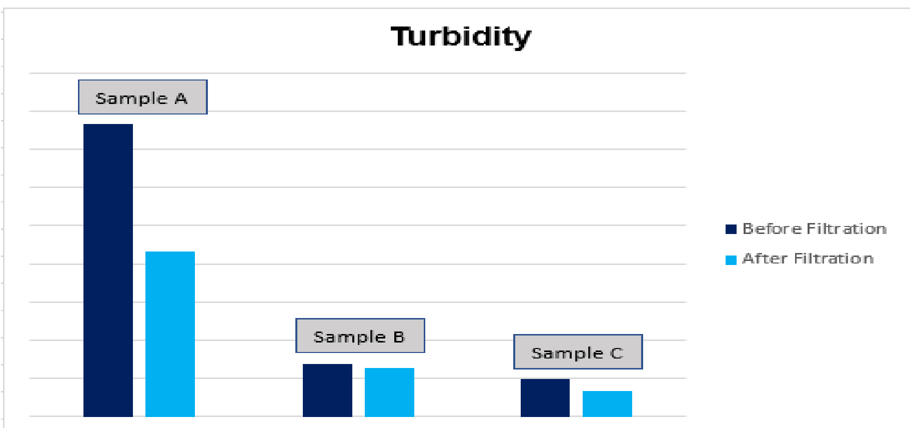


Figure 4.1: Turbidity graph before and after filtration

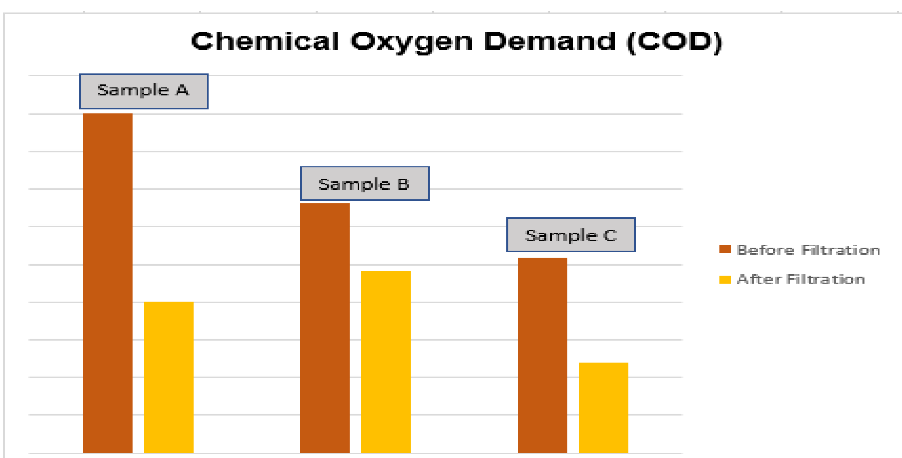


Figure 4.2: Chemical oxygen demand (COD) graph before and after filtration

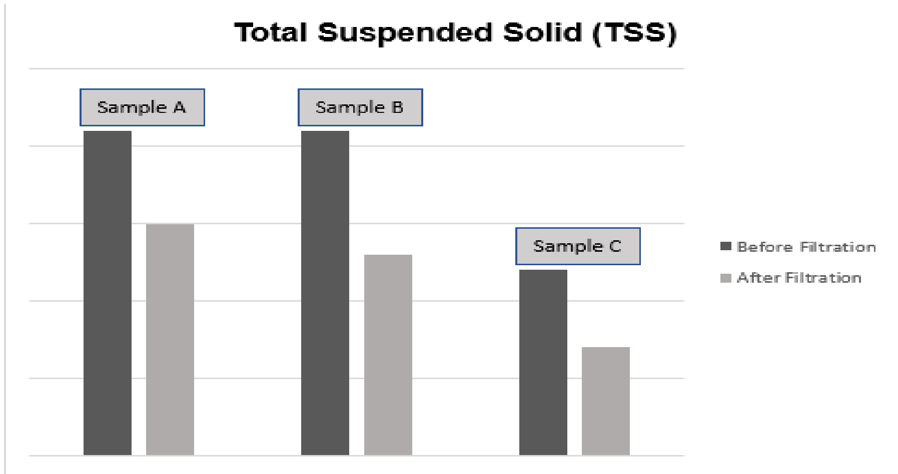


Figure 4.3: Total suspended solid (TSS) graph before and after filtration

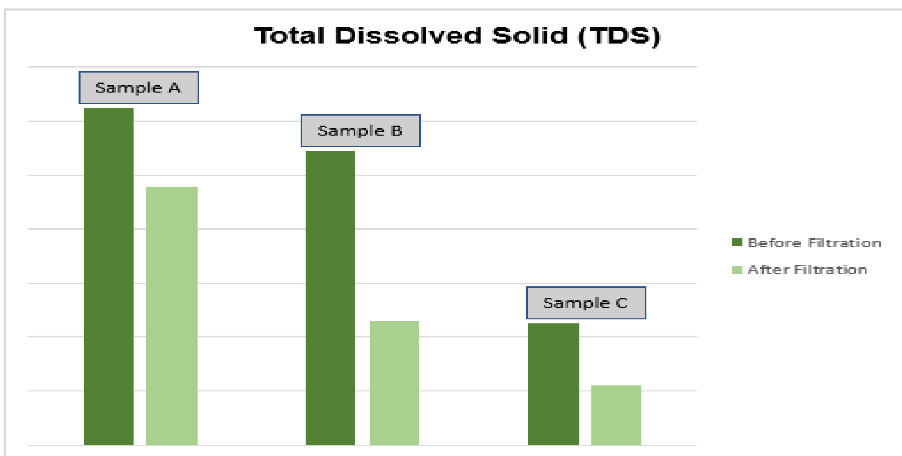


Figure 4.4: Total dissolved solid (TDS) graph before and after filtration

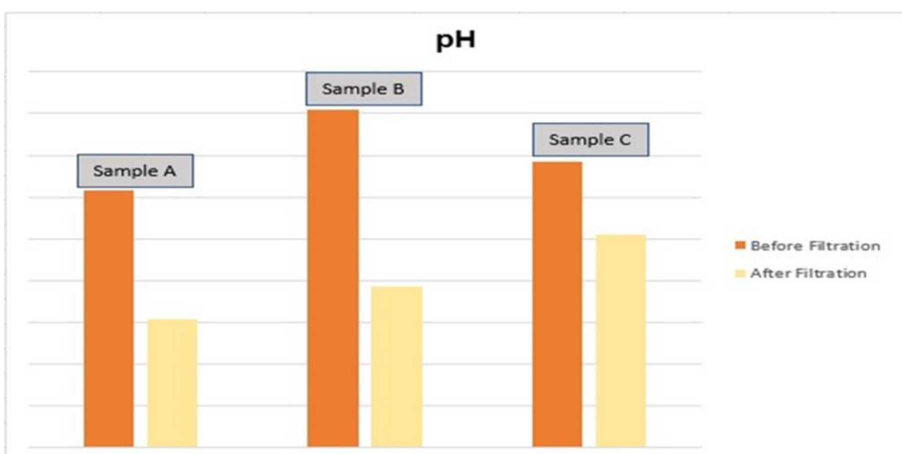


Figure 4.5: pH graph before and after filtration

Based on the data analysis above, all parameters showed a decrease in reading after filtration. Ablution water taken from UMP Mosque has an average pH of 7.61. Average pH value for the treated ablution water was 7.00, which was the exact value to neutral pH. This result proved the effectiveness of the filtration agent used. A pH requirement outlined by Minister of Health (MOH) Standard is between pH 6.50 to 9.00. Turbidity, chemical oxygen demand, total suspended solids and total dissolved solid for the treated water show insignificant reduction in values.

4.2 Sand Filtration

Although the data showed that the quality of chosen chemical and physical parameters is adequate for non-potable uses, aesthetic pollutants [such as turbidity and solids] can spike at any time. As a result, to provide acceptable quality recycled water, used ablution water should be processed using sand filters using sand media with effective sizes ranging from 0.3 to 1.0 mm and uniformity coefficients of 1.3 to 1.7. As a result, the filtering performance of clean river sand was examined in a lab-scale filter. As shown in Figure 4.6 , the sand was sieved to assess its effective size [ES] and uniformity coefficient [UC], and was found to be appropriate for gravity sand filtration.

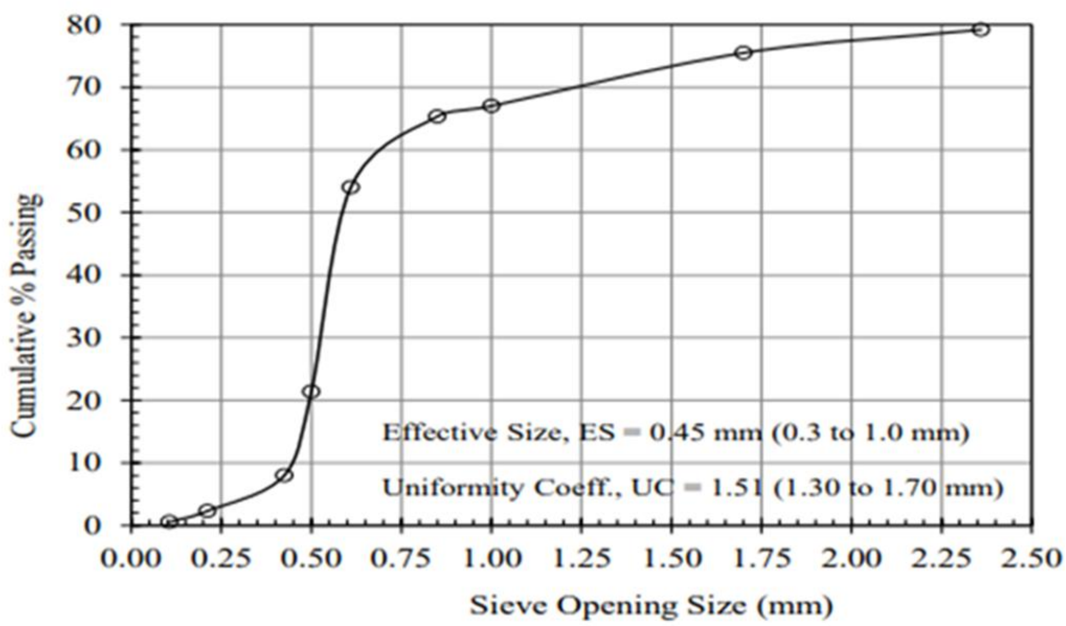


Figure 4.6: Characteristics of the Sand Filter Media used for the Lab-scale Filter

The conventional filtration process is probably the most important single unit operation of all water treatment processes. It is an operation process to separate suspended matter from water by flowing it through porous filter medium or media. The filter media may be sand, anthracite coal, diatomaceous earth, garnet or finely woven fabric. In this project, we only use clean river sand, gravel, and thick stone as sand filter media. This is because it is easy to find and its effectiveness is also up to more than 90% based on the results obtained from laboratory tests. This shows that the media used can filter fine particles well despite the low material cost.

A lab-scale sand filtration system was fabricated and tested to clean the used ablution water. The section of the slow sand filter is shown in Figure 4.6, where the major information is given. Size of the sand filter was determined based on the allowable overflow rate, which was 39.1 m^3/d (1.629 m^3/h). This value falls within the range of slow sand filter (2.9 to 7.6 m^3/d) and rapid sand filter (120 to 235 m^3/d). However, it was realized that the sand filter, to clean the used ablution water with a target to use for landscaping, can be operated as a slow sand filter to minimize its maintenance frequency. For this sand filter, its filtration rate was 52. 21 $m^3/m^2/h$. It's concluded that it is low rate and has very good filtration but requires a very large surface area.

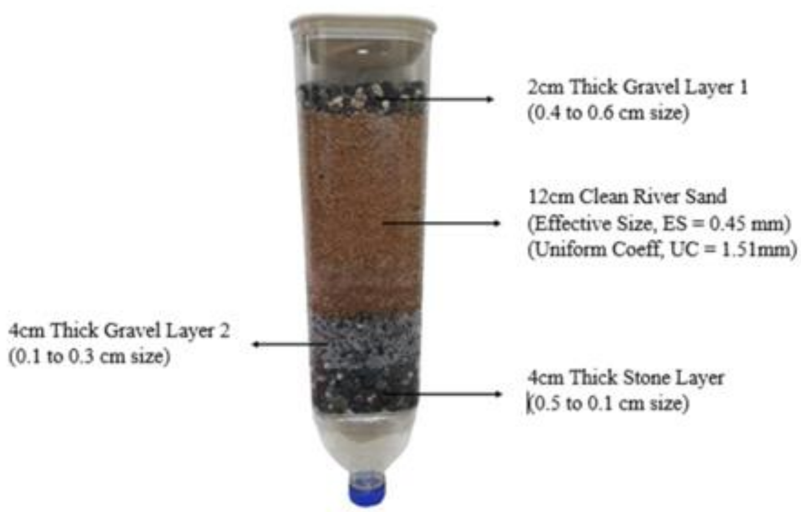


Figure 4.7: Fabricated Lab-scale Sand Filter

A well-designed and properly maintained slow sand filter (SSF) effectively removes turbidity and pathogenic organisms through various biological, physical and chemical processes in a single treatment step. Slow sand filtration systems are characterised by a high reliability and rather low lifecycle costs. Moreover, neither construction nor operation and maintenance require more than basic skills. Hence, slow sand filtration is a promising filtration method for small to medium-sized, rural communities with a fairly good quality of the initial surface water source. As stated by the WHO, slow sand filtration provides a simple but highly effective and considerably cheap tool that can contribute to a sustainable water management system.

4.3 Eco Wudhu System

The Closed loop flow method was chosen for the circulation of water in the Eco Wudhu, using the main ablution tank as its main water source. Since a closed loop flow does not allow any discharge of water along with the flow system, therefore it is easier to monitor the water level in the main ablution tank after a period of time. This closed loop system has the advantage of minimizing water wastage via greywater discharge and prevent contamination from external sources.

In the second design stage, a small scale model was built to gather sufficient information prior to Eco Wudhu construction. Its major components consist of water tanks, water filters, and Arduino-controlled water pumps. Gravel, thick stone, clean river sand, and slow sand filter were used as the filtration agent as shown in Figure 4.8. Field tests were conducted in the university’s mosque to identify any technical problems.

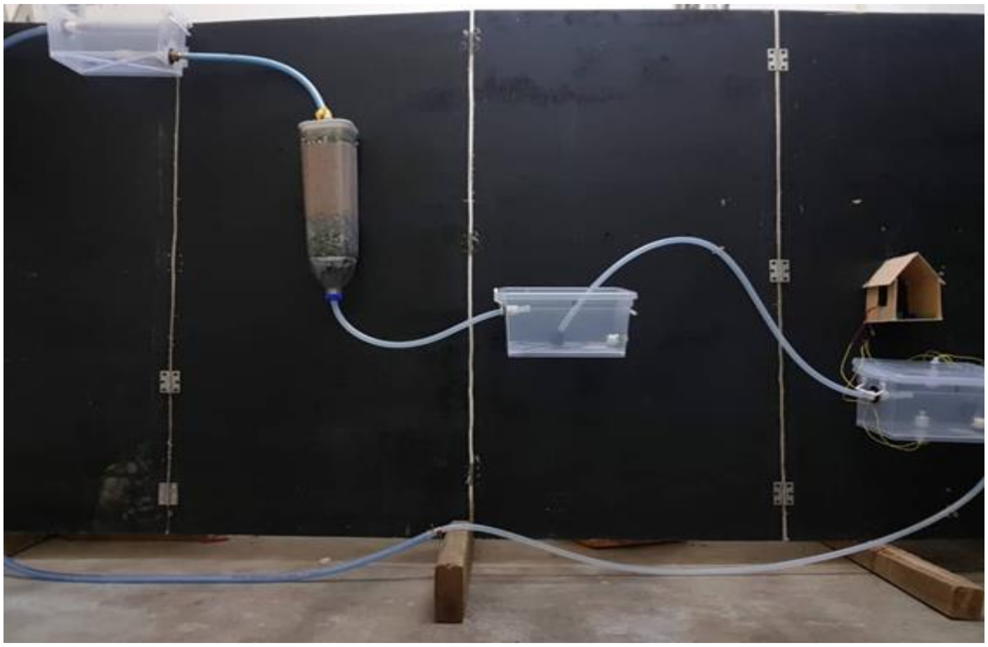


Figure 4.8: A small scale model of Eco Wudhu system

The close-loop flow is widely used in manufacturing industry. In a real case, there is a make-up control valve that senses pressure in the closed loop system. When pressure drops, it automatically adds water. Any increase of make-up water will be an indication that there is a leak or loss in the system. The closed loop flow started with the water was collected in the collection tank and then the water will flow into the sand filter as a physical treatment to remove other coarse particles and insects before channel it to retention tank. The use of this tank is to give support to water supply if the water at the distribution tank is drop. In this part we also use Arduino control water pump to make sure that the water at distribution tank is always enough to supply clean water. As the water in the distribution tank reaches a certain level, it will trigger the water pump where water is pumped directly into a retention tank. The treated water is now ready to be used for irrigation. No technical abnormalities were found during the test run of the small scale model apart fro minor hose leakages. This issue was quickly resolved using stronger silicon glue. Now we see how it works.

CHAPTER 5

CONCLUSION

In conclusion, this study revealed that the concentration of COD, TSS, TDS, turbidity and TN in the used ablution water was quite low for all location of water samples, accept slightly high Turbidity of 15.3 NTU with respect to the Malaysian of Health (MOH) Standard. Therefore, the ablution water discharged from UMP Mosque could be recycled in order to conserve water resources. The water used for ablution is recommended to be filtered by sand filter and recycled for irrigation purpose. A lab-scale sand filtration system was designed, fabricated and tested to clean the used ablution water. Size of the sand filter was determined based on the allowable overflow rate, which was 39.1 m/d and filtration rate was 52. 21 $m^3/m^2/h$. It's concluded that it is low rate and has very good filtration. Eco wudhu reveals how far technical design may progress when combined with a thorough understanding of Islamic beliefs and teachings. Because it was built based on the geographical design of ablution spaces in Malaysia, this system has numerous advantages. It's small and simple to adapt into a mosque or musolla's existing ablution water tank. Despite the fact that this study was based on data acquired from a small scale model, the results can be extrapolated to a full-scale recycling system (Eco Wudhu). In conclusion, greywater recycling can be considered one of the forerunners in the use of sustainable ablution equipment, demonstrating the adaptability of Islamic teachings.

RECOMMENDATIONS

The Eco-Wudhu system is one of the suggested ways for recycling the water ablution used by Muslims when performing their wudu'. As a result, this small-scale Eco-Wudhu system can be upgraded and put in any mosque in Malaysia. This system is well suited for installation not just in mosques, but also in any residence with a designated prayer area. Furthermore, good material selection is an important component of the design, such as a suitable filter that is less expensive, tanks, and pipe systems that can increase and satisfy the needs that this system is well-known to build. Furthermore, the installation of this system does not cost any additional money. It is because the filter utilised in this project is a sand filter, which is less expensive than other filters and also provides more effectiveness for the same price. Last but not least, greywater can be collected as a source of Eco-Wudhu for non-potable uses from rainwater collection. It has been established that this system should be put at any mosque and is also applicable to any living houses in order to recycle water.

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