De La Salle Santiago Zobel School

Senior High School

STEM Academic Strand

Waterlily: Its Effect on the pH Level, Absorbance, and Transmittance of Greywater and Tap Water

Submitted to:

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In partial fulfillment of the requirements of

Research 3: Scientific Research

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January 2018

ABSTRACT

This research paper shall experiment and discover the effects of water lilies in various water samples, based on their pH levels, transmittance, and absorbance before and after the experimentation. The water samples used were 15 in total and consisted of three different water treatments, which had 5 samples each. Treatment i had 100% greywater while treatment ii had 50% greywater and 50% tap water. Treatment iii had 100% tap water.

Many areas around the world encounter issues with water as there is an abundance of pollutants and contaminants present in many different forms. To address this problem, the sixth and fourteenth Sustainable Development Goals (SDGs), concerned with water, have been adopted in many countries such as the Philippines. With this in mind, the researchers experimented with the aforementioned water samples. The researchers had each water sample experimented with water lilies and pre-filter and post filter data were collected. The findings gained from the collected data showed that the average pH levels of all the water samples for post-filter were closer to pH level 7 than those for pre-filter. It also showed that the average absorbance of the post-filter samples were lower than pre-filter while the average transmittance of the post-filter samples were higher. Through the use of ANOVA, most of these findings were confirmed significant and concluded that the water lilies were indeed able to filter the water samples by making them more neutral in pH level and reducing the number of contaminants within, as indicated in transmittance and absorbance.

ACKNOWLEDGEMENTS

The researchers would like to give their special thanks to Ms. Agnes Panaligan, Mr. Richard Lasap, Mrs. Carmelita Estidola, Mr. Jonathan Sarza, and Mr. Fritz Ferran for their helpful guidance throughout this research. The researchers would also like to thank their friends and family for their strong support in this study.

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CHAPTER 1: BACKGROUND OF THE STUDY

I. Introduction

The Philippines is well known for its abundance in natural resources. It is home to several flora and fauna with 7,107 islands and yet, due to several problems and factors such as pollution, global warming, overpopulation, improper waste disposal, and depletion of natural resources, the country's biodiversity and economy are negatively affected (Datukon, 2016). With this, while the Philippines reflects the basic economic conditions, it is classified by the United Nations (2014) as only a developing country.

As the Millennium Development Goals (MDGs) expired in 2015, the Sustainable Development Goals (SDGs) were developed for participating world leaders of the United Nations Development Programme (UNDP). These SDGs take place in the years 2016 to 2030 in order to address the many global issues being faced in recent times. Although they are more ambitious than the MDGs, they are aimed to help further develop several countries worldwide (UN Report to the 2017 UPR of the Philippines, 2017). In the UN Report to the 2017 UPR of the Philippines (2017), the Philippines met the seventh of the Millennium Development Goals (MDG), which was ensuring environmental sustainability, particularly in improvement in use of drinking water; however, there is still a great discrepancy between the access and quality of water between urban and rural areas, particularly in Indigenous Peoples (IPs) and lower-income communities. According to the Asian Development Bank (ADB, 2013), the Joint Monitoring Program (JMP) reported that 43% of the country's population had access to water piped into private premise; yet, there is a disparity between rural and urban areas in terms of access of water. 61% in urban areas had access to water compared to only 25% in rural areas. In line with this research, the usage of cheaper and more accessible alternative filters in rural areas may help improve the quality and access to cleaner water.

In this research, the primary focus is based on the sixth SDG, along with the fourteenth SDG, wherein its goal is to "conserve and sustainably use the oceans, seas and marine resources for sustainable development" with the use of natural filters, specifically water lilies, that are generally less costly and less difficult to manage than man-made filters (Woodford, C., 2017). This SDG goal is also inline with the previous MDG goal of *"environmental sustainability"* but in a much more specific objective.

The SDG goal mentioned that aims in creating an ideal environment is crucial for survival of all species and yet, as human lifestyle continuously evolves, new pollutants are introduced, further showcasing the need of the SDGs to be implemented (Environmental Sciences Secondary Course, n.d.). These pollutants cause pollution that disrupts the original state of any environment both directly and indirectly. Several forms of pollution are caused by human activities, such as through garbage, plastic, vehicles, discovery of new harmful chemicals, oil spillage, etc. (Treacy, M., 2015). Pollution also increases rapidly as humans advance in technology (Ranga.nr, 2015). This occurrence affects all the spheres of the earth: hydrosphere (water), lithosphere (air), biosphere (living organisms), and atmosphere (vapor) (Rosenberg, M., 2016). Having mentioned that, this study's primary focus would be about the hydrosphere, specifically on greywater and tap water.

According to Gonzales (2017), tap water in the Philippines has been purified by chlorine and fluoride, which is why several people choose to not drink tap water as it can take a toll to one's health due to the presence of these elements; on the other hand, Maynilad, a water services company, stated that the water supplied by them has met the Philippine National Standards for Drinking Water, making tap water safe for consumption as of April 2017, which was aligned to the seventh goal of the MDG. Nonetheless, many Filipinos still choose to not consume tap water. Additionally, the presence of chemicals such as chlorine, fluoride, and possibly sodium can not only affect humans but can also damage plants by hindering their growth and development through the chemicals' contribution to the build-up of a white film on soil (Coleman, 2017).

With regards to greywater, it is wastewater that comes from all sources in residential homes other than the toilet. Sawadogo, B., Sou, M., Hijkata, N., Sangere, D., Maiga, A.H., and Funamizu, N., et al. (2014) showed that a large amount of laundry detergent can hinder plant growth and can aggravate soil salinity; however, a small amount of greywater can serve as fertilizers for cops, but not necessarily safe for aquatic life. Greywater can be filtered out through several processes, both natural and mechanical, but it is more eco-friendly to consider the natural process through the utilization of phytoremediation and biofilters. Notably, Kalia (2012) mentioned that water-based biofilters are better than land-based biofilters for water filtration.

With the previous studies mentioned before in mind, different freshwater aquatic plants are potentially able to act as a filter for water. This is possible because some can prevent algae production with their ability to take nutrients from the water (Raine, R., n.d.). If these nutrients are left untouched, algae would continue to flourish by consuming them, which could lead to toxin spread throughout bodies of water. As for tap water, there are several impurities that can be found and can be potentially dangerous in digestion for living beings that depend on it. Water lilies can prevent these particular harmful effects from happening and also do more. For example, they can absorb heavy metals such as cadmium, mercury, nickel, and cobalt (Affleap, 2010). This allows them to clear these poisonous elements and cleanse the aquatic ecosystem they are in for the benefit of the species living within it.

This study will specifically revolve on the effectivity of water lilies in filtering greywater and tap water by measuring pH level, transmittance, and absorbance of the water samples set up for the experiment. Though there were several related studies in line to this research, there were several gaps: the lack of use of hardy water lilies that thrive in cold environments (Kalia, 2012), the lack of consideration of tap water filtration (for comparison purposes), and the lack of attention to the transmittance and absorbance values of water.

II. Conceptual Framework

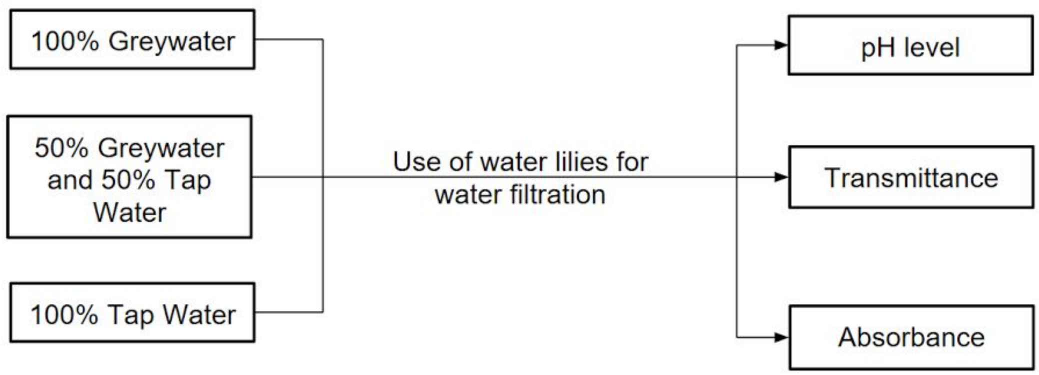


Figure 1.1. Conceptual framework

Figure 1.1 is the overview of the conceptual framework of this study, which briefly illustrates the representing dependent and independent variables. The independent variables are the samples with varying solutions: 100% grey water, 50% greywater and 50% tap water, and 100% tap water, while the dependent variables are the pH level, transmittance, and absorbance values of these samples. All these variables are interconnected and are supported by recent studies to be discussed in the succeeding paragraphs.

According to several articles such as by PhilStar (Crisostomo, S., 2011), Rappler (2012), and Philippine Primer (2016), tap waters in Metro Manila are not advisable for drinking since it may have contaminants and harmful microorganisms that can spread diseases to humans and other living species (Safe Drinking Water Foundation, n.d.). Its use in cleaning may also be harmful and unhygienic due to these contaminants. This shows a need for tap water to undergo water filtration.

An experiment conducted by Kalia (2012) concluded that water-based biofilters can purify common household water pollutants, also known as greywater. This study resorted to water lilies and floating duckweeds for the water-based biofilters, which outperformed land-based biofilters, specifically nut grass weeds. Chemical strips were also used to measure the nitrates, hardness, chlorine, alkalinity, pH, ammonia, and phosphates in the water-based biofilter and land-based biofilter environments.

The same research (Kalia, 2012) also tested live Daphnias, a type of small crustacean, on the water and land based biofilters, as several controlled environments with varying amounts of greywater were created by diluting the base solution of the greywater that were then subjected to different ratios: 2:1, 4:1, and 8:1. All the Daphnias survived in the water-based biofilters while some died in the land-based biofilter. Daphnias that were subjected to other controlled environments with varying amounts of greywater, died out. This experiment supports that water lilies are beneficial for filtering greywater; though it had shown no correlation between the filtration of pure tap water through the usage of biofilters, and there have also not been many studies that considered transmittance and absorbance, showing gaps in the topic of water-based biofilters.

Other similar studies such as by Boutilier, M. S., Chambers, V., Lee, J., and Karnik, R., & Venkatesh, V. (n.d.) also stated the importance of plants in water filtration since these plants have developed xylem tissues which help in filtering out pathogens. This study has proven the importance of aquatic plants in water filtration, and yet, did not utilize aquatic species for their study. It also proved that this ability of plants in water filtration is a biological process that does not necessarily discriminate its influence on varying types of water such as greywater and tap water.

With regards to the pH level, transmittance, and absorbance of water, these are some of the important criterias used to measure the purity of water and so, these were identified as the dependent variables of this study. According to the research by Shrestha, S., and Kazama, F. (2007), pH level, chloride concentration, and nitrate concentration are some of the many factors to be considered when determining the purity of water.

Element concentrations in water, have been measured through a spectrophotometer. Researchers Sumin, M., Wan, K., Ye, L., Zhou, S., and Zuo, S. (2014) resorted to this particular instrument to identify several specific concentrations, such as nitrate and chloride, in their water samples; however, these information are gathered from the transmittance and absorbance data provided by the spectrophotometer. These two data given by the spectrophotometer are able to show the overall idea of the composition of the water sample, specifically on the amount of its components, which can be an indicator of water quality wherein the less contaminants there are within, the less components should be indicated in the spectrophotometer. With regards to pH level, a highly acidic or basic water is considered to be of bad quality. By utilizing information on transmittance, absorbance, and pH levels, this helps in determining the potability or purity of the tap water and greywater samples in the study. Previous studies, such as by Kalia (2012), have made use of the mentioned variables in determining the level of effectivity of plants in water filtration.

III. Statement of the Problem

This study will probe to make an analysis on the effectivity of water lilies as a filter to greywater and tap water in order to extend existing researches that have already focused on the timely issue of water pollution and the effective processes of its filtration since there are few studies, such as the one conducted by Huang S.L., et al. (2010), that addressed this topic within the Philippine context.

Specifically, this study shall be answering the following questions:

1. What are the effects of using water lilies as a filtration instrument to the pH level, transmittance, and absorbance of five separate water samples with 100% greywater concentration (3.5 gallons) each?
2. What are the effects of using water lilies as a filtration instrument to the pH level, transmittance, and absorbance of five separate water samples with 50% greywater concentration (1.75 gallons) and 50% tap water concentration (1.75 gallons) each?
3. What are the effects of using water lilies as a filtration instrument to the pH level, transmittance, and absorbance of five separate water samples with 100% tap water concentration (3.5 gallons) each?
4. Is there a significance difference between the transmittance, absorbance, and pH levels of the three different water treatments (100% greywater, 50% greywater and 50% tap water, and 100% tap water)?

IV. Significance of the Study

This study is intended to address the effectivity of water lilies in filtering greywater and tap water based on the pH level, transmittance, and absorbance of the water samples. According to different studies such as by Kalia (2012), water-based biofilters, particularly water lilies can help in filtering greywater. If so, this will essentially help rural and urban communities to filter their water sources within their environment. This study will be able to provide everyday Filipinos an effective way to filter greywater and tap water for better quality as the contaminants within these liquids may be harmful to different organisms. The possible effectivity of water lilies in filtering water would be generally cheaper (Ambelu, A., Beyene, A., Megersa, M., and Woldeab, B., 2014) and a more natural alternative, allowing communities to be able to cultivate, advocate, and sustain a healthy plant environment around them.

Specifically, this study would be beneficial to rural and urban communities, water filtration system manufacturers, botanists, students and future researchers for the reasons stated herein:

Rural and Urban Communities. This may benefit the rural and urban communities residing near bodies of water as they may make use of this research in order to obtain more resources to improve their water quality. This could also help them to prevent obtaining waterborne diseases and waterborne parasites. The sustainability of the communities with regards to sanitation and hygiene may also be improved through the help of this study.

Water Filtration System Manufacturers . This may benefit manufacturers of water filtration systems as inspiration for the creation of their products, similar to other existing nature-inspired inventions.

Botanists. This may benefit the botanists by providing new discoveries or information, as well as a call to create future similar studies that can help to improve water quality around the globe.

Students. This may benefit the students of the future to search for more information, make their own discoveries, and add more knowledge to what is already known. Students may also be able to create similar scientific experiments in pursuance of more understanding of the different benefits various plants have.

Future Researchers. This may serve as a related literature, guide, and inspiration for further development of new studies that focus on the topic on the effectivity of water lilies in filtering greywater and tap water based on pH level, transmittance, and absorbance of water.

V. Scope and Delimitations

The study was conducted from November 8, 2017 to November 29, 2017. The experiment involved fifteen samples, which were placed and arranged in a household in Metro Manila. The setup included the primary subject, water lilies, which were placed in different pails with various concentrations of greywater and tap water based on three treatments. For the first treatment (i), the containers assigned to it were filled with 100%

grey water, each containing 3.5 gallons of the treatment, while the second treatment (ii) had a 1:1 ratio of greywater containing 1.75 gallons each pail and 1.75 gallons of tap water concentration in each pail. The second treatment was based on previous studies such as by Grewal, H., Maheshwari, B. and Pinto, U. (2010), who have also made a similar treatment with a mix of greywater and potable water in a 1:1 ratio for their paper regarding greywater and plants. For the third treatment (iii) of this study, it contained 100% tap water, containing 3.5 gallons for each of its assigned samples. For each treatment, there were five containers assigned to test consistency of results; thus, there are fifteen samples.

The research was limited to fifteen samples only and three dependent variables (transmittance, absorbance, and pH level of each water sample) to test due to time constraints. Moreover, this research was unable to further expound on topics related to water pollution and filtration since the study mainly focused on the level of effectivity of water lilies in filtering varying concentrations of greywater and tap water, based on the previously indicated details of the three treatments, as it is not a subject that has been studied upon as much in the Philippine context. The study helped to determine, through the experiment, whether or not the use of water lilies can be used as an exceptional filter alternative that is generally low-costing and promotes cleaner waters; although it is not expected that the water will be filtered enough for drinkable consumable usage, but beneficial for other purposes, such as improving fresh aquatic environments.

VI. Definition of Terms

The following terms are to be encountered in the study. For the benefit of the readers' understanding, the definitions are provided below.

- Absorbance - the amount of light absorbed by a sample (WARD'S Science, 2012)
- Biofiltration - a pollution control of breaking down pollutants present in the water system (Srivastaba, N.K., Majumder, C.B., n.d.), specifically "filters based on living plants" (Kalia, 2012)
- Greywater - it is wastewater that comes from all sources in residential homes other than the toilet (Kim, J., Song, I., Oh, H., Jong, J., Park, J., & Choung, Y., 2009).
- pH levels - it stands for a way of classifying acidity and alkalinity of a substance ("What is pH and why is it important?", n.d.)
- Phytoremediation - the use of plants in order to cleanup soil and water that has been contaminated (Pilipovic, A. et al., 2015)
- Tap water - "water as it comes from a tap (as in a home)" ("Tap water", n.d.)
- Transmittance - the passage of light through a sample (WARD'S Science, 2012)
- Water lily - popular decorative plants which grow naturally in swampy areas (Regevs, T., n.d.)

- Water Pollution - quality of water is affected negatively by human activities and is declining due to the rise of urbanization, population growth, industrial production, climate change and other factors. (Harder, J., & Islam, M., 2015)

CHAPTER 2: REVIEW OF RELATED LITERATURE

I. Introduction

Presented in chapter two is a discussion and synthesis of the literatures related to this study, utilized to give further background information and credibility. Included in this chapter are six main topics, namely: water pollution, greywater, tap water, water filtration instruments, freshwater aquatic plants, and determination of water quality.

On water pollution, the state of the Philippines is poor in regards to the current condition of the bodies of water around the country. Due to the Philippines being a third world country, it is harder to clean up or recover from the damage done from disasters and irresponsible disposal of liquid wastes such as greywater (Andipan, H., Dunga, J.Z., Ithoi, I., et al., 2014). Greywater is recycled water from baths, sinks, washing machines, and other kitchen appliances. This type of water contains substances that hinder plant growth and cause death to plants (Funamizu, N., et al., 2014). It can also affect other organisms with its ability to spread water borne diseases such as typhoid fever. Due to the adverse effects of contaminated water, there have been numerous filtration instruments created over the years. Among them are charcoal-based filters and electrically powered pumps (Woodford, C., 2017). There have also been filters such as different aquatic plants that have been observed to have filtering qualities. According to several researches such as by Kalia (2012) and Boutilier, M. S., Chambers, V., Lee, J., Karnik, R., & Venkatesh, V. (n.d.), plants are able to filter water due to the presence of xylem tissues (Boutilier, M. S., Chambers, V., Lee, J., Karnik, R., & Venkatesh, V., n.d.) that can affect the nitrates, hardness, chlorine, alkalinity, pH, ammonia, and phosphates of varying concentrations of greywater (Kalia, 2012). These properties of water can affect its purity and portability and thus, were measured by researchers such as Kalia (2012) in favor of determining the plants' ability in filtering. These variables can also be measured through different processes and instruments such as with the utilization of a spectrophotometer and pH sensor (Helmenstine, A.H., 2017).

Water Pollution

Water pollution is a posing threat to all life since almost every species on Earth is dependent on water. This study is focused on the general effect of greywater to freshwater forms for the sake of communities, particularly in the Philippines to realize its effects to their environment.

According to a study conducted by the United Nations Industrial Development Organization (UNIDO), unbelievable amounts of solvent wastes, heavy metals, infectious wastes, biological sludge, lubricants, intractable wastes, and acid or alkaline liquid wastes were found and not disposed properly in just Metro Manila. Not only is this dangerous to the environment, but to life on land as well. Due to the current state of the bodies of water, waterborne diseases such as typhoid fever and cholera are still viewed as a severe public health concern.

Furthermore, Andipan, H., Dunga, J.Z., Ithoi, I., et al. (2014) mentioned that the Philippines, being a third world country, has a harder time facing issues and recovering from disasters and factors like overpopulation, rapid industrialization, and urbanization. The irrigation issues prevalent in the country does not make the situation any better. This also causes a lack of availability of clean water, which exposes the people to waterborne diseases and parasites. Last 2004, the percentage of deaths that was caused by water, sanitation, and hygiene-related causes was 5.5%.

According to Greenpeace (2007), there are 525 bodies of water officially classified under terms of best usage and water quality. These bodies of water represent approximately 62.5% of the known bodies of water in the country of which 263 are major or principal rivers, 213 are minor rivers, 7 are lakes, and 42 are coastal and marine waters. There are a total of 5 classifications of water and its uses; Class AA which means that water is meant to be used as a water supply for the public requiring only approved disinfection to meet the Philippine National Standards for Drinking Water (PNSDW). Class A means that the water is suitable as a water supply requiring conventional treatment to the meet the PNSDW. Class B means that the water is primarily used for contact recreations such as swimming, bathing, etc. Class C means that the water is used for fishery, boating, and supply for manufacturing processes after treatment. Finally, Class D means that the water is used for the purpose of agriculture, irrigation, and livestock watering. 5 bodies of water fall under Class AA, 203 bodies of water fall under Class A, 149 bodies of water fall under Class B, 231 bodies of water fall under Class C, and 23 bodies of water fall under Class D which means only approximately 39% of the 525 bodies of water can be considered as useful sources.

Greywater

Greywater is recycled water from baths, sinks, washing machines, and other kitchen appliances. A study conducted by Funamizu, N., et al. (2014), showed that an amount greater than 1.0 g L^{-1} of laundry detergent can hinder plant growth and the application of high concentrate greywater on detergent can aggravate soil salinity. The experiment was conducted in a greenhouse with six liter cultivation pots, which had sandy-loam soil, that were used for crop cultivation at Ouagadougou, Burkina Faso, containing lettuce and okra. Four replicates were conducted for each chosen crop varying in different greywater solutions. 32 pots were used for the experiment during the seventy days of treatment. Some of the subjects were watered with distilled water and varying amount of concentrations of a commercial laundry detergent: 0.1 gram (low concentration), 1 gram (normal concentration), and 5 grams (high concentration). Electrical conductivity and pH levels were measured via conductivity meter and pH meter respectively while the concentration of sodium, calcium, and magnesium were determined by an atomic absorption spectrometry with a flame analyzer.

In the study done by Funamizu, N., et al. (2014), the previously mentioned subjects were measured weekly to observe the changes in the said chemical measurements. It was resolved that higher concentration of detergent led to higher pH and electrical conductivity of irrigation waters, causing slow growth and death to the plants; on the other hand, those of low concentration of greywater yielded the best results, being the tallest in both stem and fruit length, where distilled water came second, followed by normal concentration of greywater. This shows that a small amount of greywater can be beneficial for plant growth (Funamizu, N., et al., 2014). This study poses significance to this research in terms of how contaminated water can affect life such as plant growth; yet it does not address how varying amounts of detergent or greywater can be affected by freshwater aquatic plants, particularly water lilies.

Another similar study conducted by Grewal, H., Maheshwari, B. and Pinto, U. (2010) also researched on the effects of greywater in plant growth and soil. In their experimentation, they had four different irrigation treatments being the following: "(i) irrigating with 100% potable water (control treatment T_0), (ii) irrigating with 100% greywater (treatment T_1), (iii) irrigating with a mixture of greywater and potable water in 1:1 ration (treatment T_2), and (iv) irrigating alternate with potable water for one irrigation and greywater for the next (treatment T_3)." Every treatment had seven replications in its irrigation for silverbeet plants, with two pots having soil but no plants for each treatment. After the application of these procedures, the researchers were able to conclude that there were no adverse effects of varying concentrations of greywater and potable water to plant growth; however, they also acknowledged that there have been other studies that disagreed with these results, such as by (Wiel-Shafran et al., as cited in Grewal, H., Maheshwari, B. & Pinto, U., 2010). The researchers also mentioned that their result may have also been produced due to the ability of silverbeets in reducing the toxicity of greywater, which can be done by other plants as well, including cattails and duckweeds. Grewal, H., Maheshwari, B. and Pinto, U. (2010) also concluded that irrigating with greywater increases the affected soil pH, iron, manganese, phosphorus, copper, etc, showing the possible effects that may be detrimental to plants and organisms. Similar to the previous study conducted by Funamizu, N. et al. (2014), this research (Grewal, H., Maheshwari, B. & Pinto, U., 2010), also used crops as their subject without addressing on how aquatic plants can be affected if subjected to greywater as well.

According to an article by Meyers, J. (n.d.), there are two types of house bleach that come in two different forms: chlorine bleach (sodium hypochlorite) and oxygenated bleach (sodium percarbonate). Oxygenated bleach does not harm plants where as chlorine bleach is caustic and can cause damage in the overall development of the plant and soil nutrients. Meyers, J. (n.d.) also stated that a certain amount of chlorine is naturally produced in soil, having that said, excess amounts can degrade its nutrients. Undiluted sodium hypochlorite has a pH level of 11, which is highly dangerous for plant growth since it can cause the soil’s pH to rise; Thus, blocking important nutrients such as iron, calcium and magnesium that help sustain plant growth.

Other components that may hamper plant development is salt, such as from sodium hypochlorite. It can be disadvantageous for water quality, ecological health of streams, terrestrial biodiversity, soil erosion, flood risk, and irrigation (Queensland Government, 2013). Its effect on plants can be explained through the concept of osmosis since water tends to diffuse from a relatively high water concentration to a relatively low water concentration, which allows plants to absorb water ("How Salt Stresses Plants", 2013). An example of a high concentration water is pure water or pure distilled water containing no salts, while an example of water with low concentration is sea water. Plants tend to wither and die when the water contains salt since salt water has a lower water concentration. Since water molecules tend to move from a high to a low concentration, the salt water will take the water away from the plant ("How Salt Stresses Plants", 2013).

Tap Water

In most developed countries, water is supplied to numerous households and buildings through underground pipes (International Water Bottled Association, n.d.). Water is collected from untreated bodies of water either above or below ground. Before the water is sent into the city, it is brought to a treatment plant. In the treatment plant, the water goes through a number of processes to become clean for the consumption of the population. According to the Metropolitan Waterworks and Sewerage System of the

Philippines (n.d.), these processes include: screening of large debris, pre-chlorination, rapid mixing, flocculation, coagulation, sedimentation, filtration, and disinfection.

In countries such as the US, they make use of tap water for drinking (Kumar, 2014) but in the Philippines, drinking water is usually bought in plastic bottles from a water station. The tap water in the Philippines has been purified by chlorine and fluoride, which is the reason as to why many people do not drink tap water since it poses as a health concern, as well as because the locals do not like the taste of chlorine (Gonzales, 2017). In contrast to the reports given by Maynilad, the Metro Manila Drinking Water Quality Monitoring Committee has pronounced that the water supplied by Manila Water and Maynilad has met the Philippine National Standards for Drinking Water making tap water safe for consumption as of April 2017.

Even if tap water is safe to consume for humans, the same cannot be said for plants. Tap water contains the chemicals chlorine and fluoride which are harmful for the plants (Coleman, 2017). Tap water may also contain sodium when there is a build-up of a white film on the soil that hinders plant growth.

Water Filtration Instruments

Water is a necessity in daily survival of humans, plants, animals, and other organisms. Compelling purpose of the utilization of gadgets for giving safe drinking water is desperately needed to decrease the worldwide burden of waterborne illness. The shortage of safe drinking water is one of the reasons for human mortality on a worldwide scale. With its great value, there have been numerous instruments and strategies that have been created and practiced over the years for the purpose of gaining and fully maximizing the benefits of clean and filtered water. For instance, according to the Fisheries and Aquaculture Department of the Food and Agriculture Organization (FAO) of the United Nations (n.d.), there is a flow-through system in aquaculture that involves allowing fresh water to enter a pond while the old, polluted one is dispelled through a drainage gate, in order to remove contaminants such as fish feces. The FAO department also mentioned that there is a need for a sufficient amount of oxygen in bodies of water; therefore, several ponds/tanks also include aeration instruments such as paddlewheels in order to provide for this. Pond water was also said to be regulated as well with the use of basic parameter measurements such as dissolved oxygen, salinity, and pH.

Woodford, C. (2017) also provided additional information about water management, specifically in water filtration. He mentioned four main types of water filters that utilize physical, chemical or a mixture of both for filtration. The first type mentioned is activated carbon, wherein granules based on charcoal are used to trap contaminants within it through the process of adsorption. Although it is effective, it regularly needs replacements as it has a limit on how much it can absorb from the water. Similar to this, reverse osmosis is another reliable filter that also proves to be quite costly as it involves electrically powered pumps. It also usually produces more wastewater than filtered. Other water filters pointed out by Woodford, C. (2017) are the ion exchange and distillation filters.

Besides from the use of certain man-made controlled methods for filtering water, there are also biofilters that make use of natural materials, specifically plants, to filter water. While normal innovations for water sanitization, including chlorination, filtration, UV-sterilization, purification or bubbling, and ozone treatment, are effective when done in a substantial scale, they are costly when done in a smaller scale like in modest villages; thus, there exists the utilization of alternative systems such as with biofilters (Boutilier, M. S., Chambers, V., Lee, J., & Karnik, R., & Venkatesh, V., n.d.). For years, there have been thousands of studies on the efficiency of millions of plants worldwide. They are essential to everyday living for all organisms and have been one of the salient factors in sustaining a healthy environment. Accredited organizations and departments have made their efforts into maximizing the use of plants including the National Aeronautics and Space Administration (NASA). Macdonald, C. (2015) once discussed about NASA's combined efforts with the Associated Contractors of America (ALCA) in the usage of plants in air filtration. This study, which was led by Dr. B. C. Wolverton, discovered that certain plants such as Boston Fern, Peace Lily, and English Ivy, are able to decrease the number of benzene, ammonia, and formaldehyde from the air (Macdonald, C., 2015). With this, it can be assumed (as has already been by numerous researchers) that plants, with the right properties, can also be exploited in different other aspects, including water filtration.

An experiment by Kalia (2012), tested this assumption on whether or not biofilters can purify common household water pollutants, also known as greywater. The experiment involved live daphnia subjected in seven controlled environments involving greywater— the first environment was purely greywater, the second, third and fourth solutions were all created by diluting the base solution of the greywater that was subjected to different ratios: 2:1, 4:1, and 8:1. The fifth controlled environment had a land-based biofilter, specifically nut grass weeds (Cyperus rotundus), while the sixth controlled environment had a water-based biofilter, in particular a dwarf hardy water lily (Nymphaea) and floating duckweed (Lemna minor) plants. The seventh environment had pure water. Chemical strips were also used to measure nitrates, hardness, chlorine, alkalinity, pH, ammonia, and phosphates in the water-based biofilter and land-based biofilter environments. The experiment took a week in pursuance of generating results and monitoring the changes in the amount of the mentioned variables, through chemical strips measured in parts per million (ppm) of each of the biofilter environments.

Based on the results, the land-based bio filter removed most of the phosphate and ammonia, although it was not perfectly filtered out. The nitrates and chlorine immediately lowered on the second day to almost negligible levels. It also raised alkalinity from 40 to 80 ppm, which are significantly lower than the ideal levels of 120 to

180 ppm for an ecosystem, and had a slightly acidic final pH of 6.9. Meanwhile, the water-based biofilter took two to three days longer to filter out the nitrite and nitrate levels, but brought it to 0 ppm, which is a good measurement. The phosphate and ammonia gradually reached a number close to 0 ppm in a span of six days. 15 daphnias were also each introduced into the seven controlled environments (Kalia, 2012).

In regards to the survival of the live daphnias, the results showed that the said species thrived the most in the sixth controlled environment, which had a water-based biofilter (Kalia, 2012). Only 2 out of 15 daphnias in the land-based biofilter died, while the pure water had 4 deaths. The controlled environments that were either fully or half exposed to greywater all died in the 12 hour mark. The remaining controlled environments, the 1:4 greywater environment had 6 surviving daphnias on the 12 hour mark but all died when it reached the 24 hour mark, and the 1:8 greywater environment had only 4 surviving daphnias that reached the 12 hour and 24 hour mark of survival. This shows that water-based bio filters are best for the survival of aquatic species, specifically daphnia. It was implicitly stated in this experiment to use a larger tank for the controlled environments, particularly for the subjects with water-based biofilters since the water lilies decomposed after two weeks (Kalia, 2012). Kalia's (2012) study was able to address the effects of greywater to waterlilies by measuring pH level but was unable to measure the transmittance and absorbance in the controlled environments as well as the effect of tap water to water lilies. Furthermore, the experiment (Kalia, 2012) used dwarf hardy water lilies which are found in cold regions which cannot adapt to the tropical environment in the Philippines.

There have also been other articles and studies aside from Kalia (2012) that support the utility of aquatic plants in water filtration. According to Boutilier, M. S., Chambers, V., Lee, J., Karnik, R., & Venkatesh, V., (n.d.) a potential filtration process exists from plants due to their xylem – a permeable material that conducts liquid in plants. Plants have developed specific xylem tissues to direct sap from their foundations to their shoots. The study employed branches from white pine (pinus strobus) in the construction of the bio filter. These have developed under the contending weights of offering insignificant protection from the rising of sap while keeping up little nanoscale pores to avert cavitation. The size dispersion of these pores – normally a couple of nanometers to a maximum of around 500 nm, contingent upon the plant species – additionally happens to be perfect for filtering out pathogens, which brings up the idea that plant xylem can be utilized to make economical water filtration gadgets (Boutilier, M. S., Chambers, V., Lee, J., Karnik, R., & Venkatesh, V., n.d.).

A paper by Chauhan S., Gupta, K.C. and Singh, J. (2015) also assessed plant seeds and leaves extracts as coagulants and reported a sparing and ecologically safe technique for improving water quality within rustic regions. The paper furthermore observed the appropriate usage of other privately created seeds, for example, peanuts, cowpeas, urad, and corn, which have comparative sorts of cationic polyelectrolytes as in Moringa seeds, in their ability to filter water. It was concluded in their study that the seeds and leaves concentrates of the Moringa plants, peanuts, cowpeas, urad, and corn altogether decreased the aggregate microscopic organisms greatly. It likewise helped in the coagulation of the substantial metals like lead, copper, nickel, and so on found in the treated water tests. This work presumed that the utilization of seeds and leaves extracts can be exceedingly suggested for the refinement of household drinking water wherein this system can be connected in improving nations that have individuals whom have been forced into drinking contaminated, turbid water (Chauhan S., Gupta, K.C. & Singh, J., 2015).

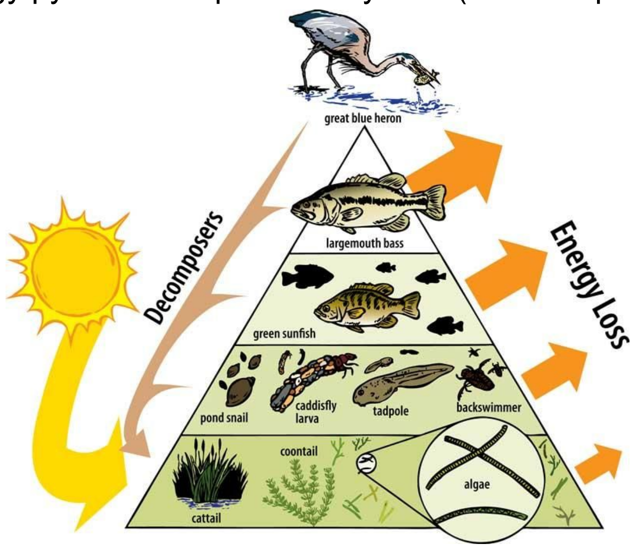
Similarly, Ambelu, A., Beyene, A., Megersa, M., and Woldeab, B. (2014) also stated that the seeds from Moringa oleifera have stood out amongst the best essential coagulants for water treatment, particularly in provincial groups. They also said that common coagulants create less slop volume compared to Alum and they require no pH modification. They are a great interest for low cost water treatment and help provide purified water to world populace, particularly to developing nations that scarcely get this. The use of common items likewise lessens the formation of disinfectants that deteriorate human wellbeing and their byproducts are natural and biodegradable (Ambelu, A., Beyene, A., Megersa, M., and Woldeab, B., 2014).

Freshwater aquatic plants

Terrestrial plants are essential for the survival of terrestrial animals while similar principles also apply to their aquatic counterparts. According to New Hampshire Department of Environmental Services (2010), aquatic plants provide food, shelter, and air. It also contributes to the removal of carbon dioxide and production of oxygen through photosynthesis, as well as acting as a filter for water pollution.

An article by Raine, R. (n.d.) stated how aquatic plants can absorb nutrients from the water. This reduction of nutrients enables a cleaner environment, as well as downsizing the amount of algae, which benefits the aquatic species residing in the ecosystem. These plants can also prevent soil erosion, chemical cycling, and stabilize the sediments around lakes and ponds. This ability of plants has been acknowledged and used in several studies such as by Pilipovic, A. (2015) under the term called 'phytoremediation.' Phytoremediation means the "direct use of living green plants for in situ, or in place, removal, degradation, or containment of contaminants in soils, sludges, sediments, surface water and groundwater" (United Nations Environment Programme [UNEP], n.d.).

Figure 2.2: Energy pyramid in a pond ecosystem (Texas Aquatic Science, n.d.)



As shown in figure 2.2 (Texas Aquatic Science, n.d.), plants act as producers in the ecosystem, which is dependent on the energy emitted from the sun; thus, being the largest in terms of population size. As energy levels go up, larger species require more energy to feed off from species below the energy pyramid, which also in return loses more energy. Each of the species in the energy pyramid plays an integral role for survival of all species since living organisms have the ability to reproduce in large quantities; yet, due to its dependency on resources and other species, its population can easily increase or decrease in size.

Floating plants, in particular water lilies, are considered to be the jewels of the pond as their flowers fill the pond with color and vibrancy (“Water lilies”, n.d.). This perennial plant grows in dense groups with their leaves floating on the surface of the water. They can be found growing on the edges of ponds, lakes and streams. Their leaves can grow up to 12 inches in diameter while their stems can reach all the way into the mud floor, rooting them in place and allowing them to withstand strong currents (Russel, S., n.d.). These stems also act as habitats for many micro invertebrates which provide food for fish and other aquatic life, showing an integral role in the aforementioned energy pyramid.

Water lilies are not only attractive as display pieces, but they are also capable of purifying water by absorbing nutrients through their roots (Irene, n.d.). According to a research conducted by The Hebrew University of Jerusalem's (“Water lilies water purification”, n.d.), this aquatic species is capable of absorbing toxic metals through its roots and leaves. It can absorb up to 16% of its dry weight. The research team at the university showed that water lilies can thrive in water with high concentrations of heavy metals such as cadmium, mercury, nickel, and cobalt. Heavy metals possesses detrimental effects in environment and overall health of those aquatic species that are exposed to it; thus, aquatic ecosystems that have water lilies have an advantage of clearing these poisonous elements. The researchers tested the water purification capabilities of the water lilies at the Haifa municipal wastewater treatment plant and results showed a reduction of cadmium in the sludge after being exposed to the water lilies. In another study by Wang, X.Q. Tang, S.L. Huang, S.H. Zhang, C. Lin and D.W. Liu (2010), the researchers had used water lilies and cattails in the restoration of the Haihe River Basin in China. In the project, they planted water lilies and cattail at the upper reaches of the river. This resulted to an increase of water purification, ecology, and overall landscape aesthetic.

Another aquatic plant that is useful in the filtration of water is the Cattail, also known as Typha. This emergent aquatic plant is known for its “hotdog” shaped flower. Its name originated from the plants blooming state when the flower is covered with a cloud of seeds which gives its cat tail appearance (Wykes, 2012). This plant can grow up to 10 feet in height and can be found standing tall in shallow bodies of water such as marshes, ponds, shallow bays of lakes and other depressions. They are able to thrive as long as their roots are not 40-60 centimeters deep in water (Liquid Assets, n.d.). The same source also stated that under certain conditions, cattails can be hard to control, as their seeds can be blown away by the wind and spread to many different areas of the water. If they are not controlled they tend to grow in thick groups that block the view of the water and can take over a pond.

The usefulness of the cattail is unbounded as they can be used to purify water from harmful substances/contaminants. In many poor countries, a quality filtration system for water is vital but the people in those countries are unable to afford it, which is where cattails come in. There is a filtration system designed by Jeremiah Jackson mentioned in Richard, M.G.’s article on “Inexpensive Arsenic Filtration System Based on Cattails Could Help Clean Up the Drinking Water of 57 Million People” (2009) that makes use of cattails to purify water. He used his design to aid the people in eastern

India and Bangladesh with their problem with arsenic contaminated water which had given clean drinking water to 57 million people. According to Tina Casey (2009), Cattails are also able to purify the water as they can take in arsenic and other toxic substances such as phosphorus, mercury, pharmaceuticals, and even explosives, “as if it were a nutrient.”

Determination of Water Quality

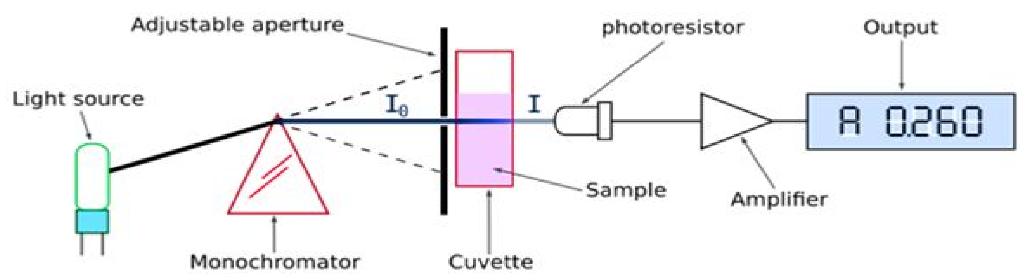
With water filtration, positive results are expected in the quality of water. The level of quality that a body of water has can be determined by various characteristics and properties, such as pH level, transmittance, and absorbance. According to a news article by the Daily Star (2015), good quality water, especially that of drinking water, should have a pH level ranging around 6.5-8.5 pH in favor of the Environmental Protection Agency’s standards; with that said, even within the range, water may still have its risks. As also stated by Gehrels, J. (2013), the water quality can be defined by its chemical, physical, and biological contents. He also said that “good quality (potable) drinking water is free from disease-causing organisms, harmful chemical substances and radioactive matter, tastes good, is aesthetically appealing and is free from objectionable colour or odour.”

Among the different characteristics that can be measured in order to test water quality is the pH level. This is the measure of hydrogen concentration to express acidity or alkalinity in a solution, ranging in a logarithmic scale from 0 to 14, 7 being the base (Helmenstine, A.H., 2017). Values below 7 are more acidic than the higher value, while values above 7 are more alkaline and basic than the lower values. pH levels can be measured in several ways. The simplest method for measuring it is through pH strips. pH strips react when in contact with an aquatic substance changes in color depending on its alkalinity and acidity; though accuracy may be an issue if the colors are hard to distinguish (Kollias, H., 2016).

A better alternative for measuring pH levels accurately is through availing and using a pH sensor, which can automatically measure the acidity or alkalinity of a liquid with the logarithmic scale from 0 to 14 pH level (Helmenstine, A.H., 2017). According to Woodford, C. (2016), the potassium chloride inside the glass electrodes of pH sensors have a neutral solution with a pH of 7, which act as a basis for their measurement of pH levels in several liquids. Also, one concept with regards to liquid is that the more acidic it is, the more hydrogen atoms there are present in its solution. The gas electrodes of pH sensors apply this concept and measure the difference in hydrogen atoms of samples in order to yield accurate results regarding pH levels. With regards to water lilies, the optimal pH level must be slightly acidic, or above 7 pH (Mac, E., n.d.).

Moreover, in favor of fully handling a pH sensor, a LabQuest should also be utilized, According to Vernier (n.d.), LabQuest is a simple, standalone computer surface interface that can be used in a number of ways. The most useful and frequently used feature of LabQuest is the amount of information it can collect simultaneously. This instrument can be connected to pH sensors in one of its six ports so that it can automatically set itself to data collection mode, wherein which researchers can gather information on the pH levels of samples and other variables.

Figure 2.3: Spectrophotometer



A spectrophotometer measures the transmittance and the absorbance of a sample at a given wavelength in order to achieve its function of measuring the components of the sample, capable of showing how much a water sample is concentrated. According to the Michigan State University (n.d.), “the amount of light absorbed is directly proportional to the concentration of absorbing compounds in that sample, so a spectrophotometer can also be used to determine concentrations of compounds in solution.” With regards to transmittance, the more light that is shown to transmit through the water sample, the less compounds there are in the solution. These two factors are normally compared to a reference blank which is similar to the tested solution but lacks the substance that is being measured in the other sample. (Michigan State University, n.d.). For example, if a detergent powder is dissolved within water and the concentration of this powder’s components are being measured, the reference blank would contain only water for comparison. The reference blank would have 100% transmittance.

The spectrophotometer is mainly made up of two components: a spectrometer and a photometer (Spectrophotometer Principle, 2017). The purpose of a spectrophotometer is to produce a light of any wavelength, while the photometer is used to measure the intensity of the light. With this, the spectrophotometer is created for allowing water samples can be placed in between the spectrometer and the photometer. As presented in figure 2.3, a light source shines towards the monochromator, an optical device that mechanically transmits a certain beam of light from in the narrow band of wavelengths of light with an adjustable aperture, towards the cuvette, a test tube used for optical analysis which holds liquid samples, then the contents are processed and measured by the photoresistor, which is then amplified and in the output as numerical values (Vo, K., 2015).

The Beer-Lambert Law, also known as the Beer’s Law, is the basis for determining the concentration of an unknown solution. The law refers to the attenuation of light through materials where the light source is passing through (Clark, J. and Gunawardena, G., 2017) and the linear relationship between the absorbance of a material and the concentration of the absorbing substance (Molecular Spectroscopy, n.d.).

III. Synthesis

Based on the related literature, it was found that in numerous studies and articles that biofilters, specifically aquatic plants, are effective in filtering out unwanted/toxic substances from water.

The usage of plants as filters of contaminants can be more effective than the man-made methods of filtering water as these methods can be quite expensive even if they are done at a small scale like in modest communities (Boutilier, M. S., Chambers, V., Lee, J., Karnik, R., & Venkatesh, V., n.d.). Not only that but using plants instead of chemicals or machinery would increase the ecology and overall landscape aesthetic of the area (Wang, X.Q. et al., 2010). According to an article by Boutilier, M. S., Chambers, V., Lee, J., Karnik, R., & Venkatesh, V., (n.d.), aquatic plants have a potential water filtration process due to the presence of the xylem. The research done by The Hebrew University of Jerusalem backsed this up by showing that water lilies are capable of thriving in water with high concentrations of heavy metals while at the same time filtering those metals from the water. In an article by Richard, M.G.(2009), Jeremiah Jackson had designed a water filtration system that utilizes the aquatic plant, cattail, in filtering out the arsenic from bodies of water, making it safe for usage/consumption. Kalia (2012) also made a study that supported the idea that plants, specifically daphnias, have the ability to filter water.

Aside from biofilters, there are also other water filtration instruments such as electrically powered pumps and charcoal based filters (Woodford, C., 2017). These instruments and processes are highly valued because contaminated water is known to have several adverse effects. According to the United Nations Industrial Development Organization (UNIDO), there are high amounts of unhealthy wastes and metals in water that can cause diseases such as typhoid fever. With regards to this, the related literatures emphasized the need for proper water filtration and one of the more economically beneficial instruments that can be effectively utilized are aquatic plants such as water lilies.

CHAPTER 3: METHODOLOGY

Exhibited in chapter three of this research paper is a general outlook on the methods that were used in the study in pursuance of the results from the variables and experiments. This chapter is divided into five parts, namely: research design, research locale and set-up, research instruments and materials, data collection procedure, and the statistical treatment that was utilized in the study.

I. Research Design

This research made use of the Experimental research design. Blakstad, O. (n.d.) stated that experimental research designs use manipulation and controlled testing to speculate causal processes. This type of research design observes the different effects various types of setups of the experiment have on the final results; thus, this study revolved on the effectivity of water lilies in filtering greywater and tap water by measuring their pH levels, transmittance, and absorbance, before and after the experiment was conducted. This study observed these mentioned variables in fifteen samples that were manipulated to include water lilies in different containers and varying concentrations of greywater and tap water, based on the treatments they were applied with. The experimental research design helped to answer the study's research questions, which were aimed to determine the effect of water lilies on the mentioned water samples, by allowing an actual experimentation and observation to occur.

Appropriate scientific instruments were also used for the experiment, specifically a pH sensor, labQuest, and spectrophotometer, which also allowed the researchers to reach a conclusion based from the gathered data on the effectivity of water lilies as a filter.

II. Research Locale and Set-up

For the purpose of the study, three different treatments were applied to test the effectivity of water lilies in filtering greywater and tap water, based on their pH levels, transmittance, and absorbance. These three treatments were also performed with five samples each to allow the researchers to observe consistency within the experiment; therefore, having fifteen samples all in all. For the containers with the first treatment (i), they were each filled with 100% greywater, having created a solution with 1 cup of local detergent and 3.5 gallons of tap water, while for those with the second treatment (ii), they were each filled with a 1:1 mixture of 1.75 gallons of greywater, which has a ½ cup of local detergent, and 1.75 gallons of tap water, wherein the tap water was further added to the pre-made greywater within their containers, allowing the greywater to be diluted and to adjust the concentration of its contaminants. The pails with the third treatment (iii) applied to them contained 3.5 gallons of 100% tap water each. These were done to analyze the amount of influence water lilies have on both kinds of water, along with a mix of them, that have different levels of concentration in terms of contaminants in their compositions. These treatments were also based from other previous studies such as one conducted by Grewal, H., Maheshwari, B. and Pinto, U. (2010).

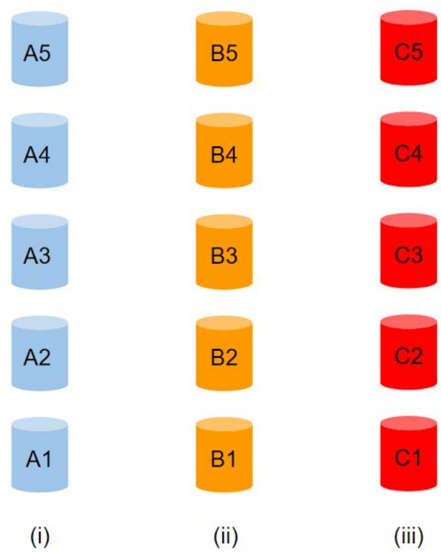


Figure 3.1. Setup of the experiment with the three treatments of 100% greywater (i), 1:1 ratio of tap water and greywater (ii), and 100% tap water (iii)

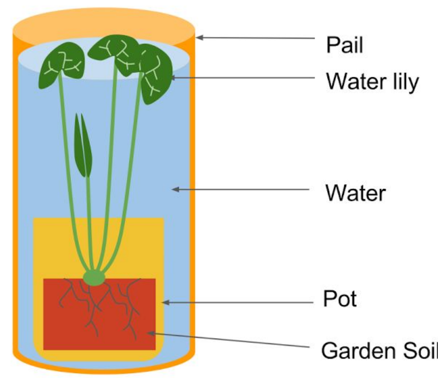


Figure 3.2. General setup per sample

As shown in figure 3.1, the experiment involved was set-up with fifteen pails of the same measurements, specifically 12 inches in diameter and 15 inches in height. The size of these containers allowed the researchers to fill each with an estimated amount of 3.5 gallons of water, applied to all three treatments. Figure 3.2 presented above showcases the general set-up per sample, wherein inside each of the containers are pots (10 inches in height and 6 inches in diameter) that were each filled with three inches of garden soil. The roots of the water lilies were rooted to the soil, as in accordance with instructions of how water lilies are taken care of, provided by The Water Garden (2017).

All the containers were subjected to the same environment and organized according to their three different treatments as shown in figure 3.1. Each of these pails are labeled by a corresponding letter and number. The letter represents the treatment, while the number represents the sample number per treatment. Letter A represents the 100% greywater (i), while letter B represents the 1:1 ratio of tap water and greywater (ii). Letter C represents the 100% tap water (iii). This setup also allowed the subjects to have a fairly equal amount of treatment in terms of abiotic factors, such as sunlight and air, since they were placed side by side.

III. Research Instruments/Materials

Presented below are the following instruments and materials that were used for the experiment of this study.

Spectrophotometer

In this study, a Ward's Science Spectrophotometer, obtained from and used in a science laboratory in De La Salle Santiago Zobel - Vermosa, was utilized to identify the transmittance and absorbance of the water samples (*see appendix G*). As stated by the Michigan State University (n.d.), the higher the absorbance of a water sample, the more compounds, such as contaminants, there are within it. With regards to transmittance, a higher value indicates that there are less compounds that block the light from passing through the water. Distilled water was also provided by the laboratory as a reference blank for the spectrophotometer. The samples analyzed were the water samples before and after they were exposed to water lilies.

The spectrophotometer was used in a number of studies to determine the quality of water such as the one conducted by Barakat, A., El Baghdadi, M., Rais, J., Aghezzaf, B., and Slassi, M. (2016). These researchers have used the spectrophotometer in measuring the concentration of substances in water.

pH Sensor

In this study, a Vernier pH sensor, obtained from and used in a science laboratory in De La Salle Santiago Zobel - Vermosa, was availed by the researchers in order to measure each water samples' pH level (*see appendix H*). Additionally, to fully use the pH sensor, a LabQuest was also utilized, which came from the same source mentioned.

A similar instrument was used to measure the pH level of water in a research conducted by Barakat, et al. (2016), as pH level is a factor to be considered when determining the quality of water.

Water Lilies Set-Up

The water lilies were placed in fifteen separate large containers that had a height of 15 inches and a diameter of 12 inches while the roots of each aquatic plant were embedded into a pot with a height of 10 inches and a diameter of 6 inches. For the sake of keeping the plant stable, three inches of soil were added into each pot (*for more details, see research locale and setup, and appendix A and D*).

Water

Two types of water were utilized for this experiment, namely greywater and tap water. The greywater's composition was controlled by the researchers, utilizing a common Filipino household-used commercial detergent brand, specifically Tide. The greywater's solution for each bucket with the second treatment (ii) was composed of a ½ cup of the said detergent while those with the first treatment (i) had a greywater solution containing 1 cup of the same detergent each. Meanwhile, the tap water was collected from a tap in one household in Metro Manila that was being serviced by the Maynilad water company during the gathering of materials for the experiment.

IV. Data Collection Procedure

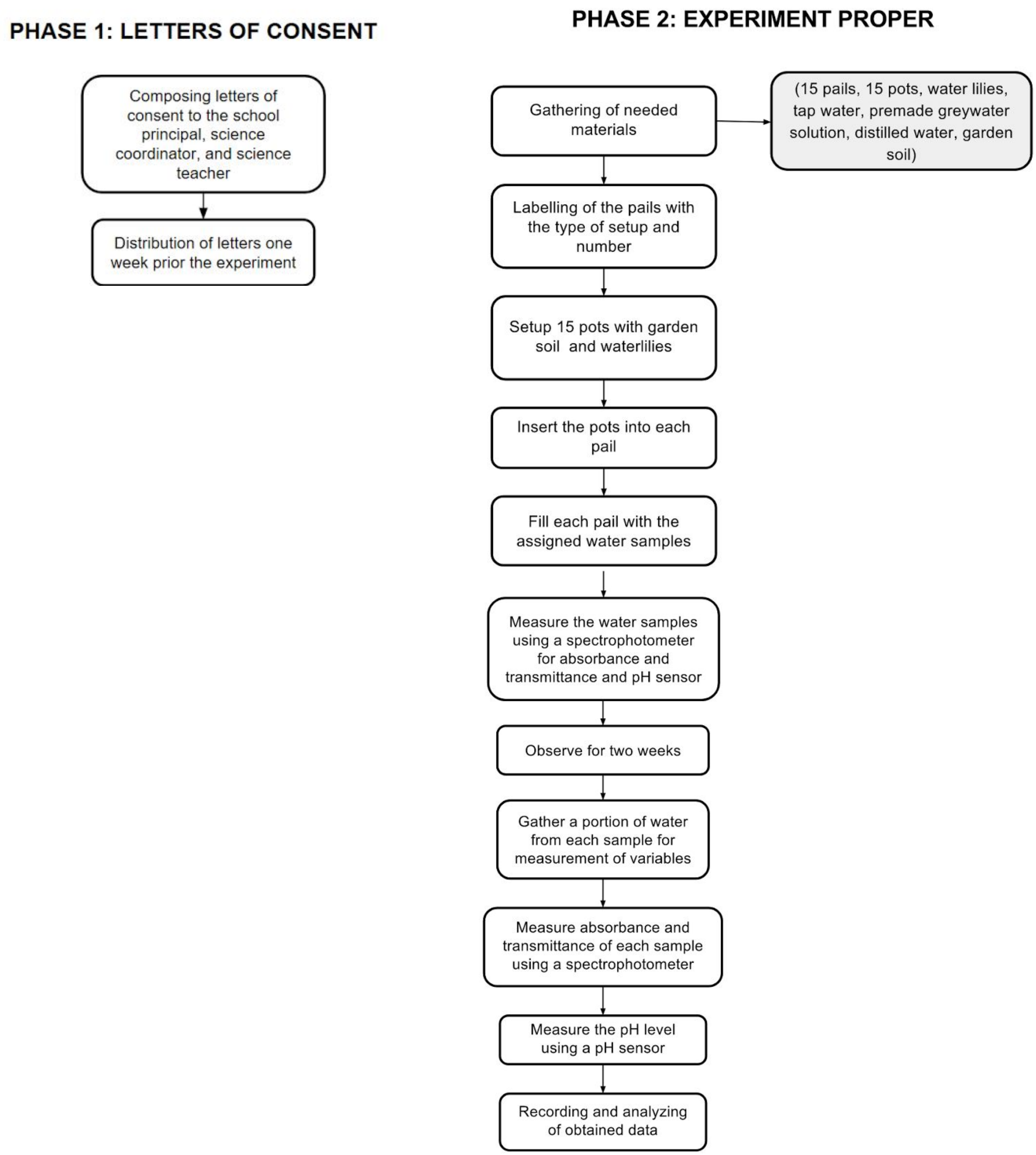


Figure 3.3. Data Collection Procedure

Presented in figure 3.3 is the overall flow of the data collection procedure. For the first phase of the experiment, days prior to the actual experiment, letters of consent were composed for the respective authorities in the De La Salle Zobel-Vermosa school, namely: the school principal, overall strand coordinator, science coordinator, and science teacher, who was overseeing the experiment in the laboratory (*see appendix K*). The letters were then delivered to the respective authorities 2-3 days prior to when the school laboratory was needed.

For the second phase of the experiment, the researchers obtained all the needed materials for the experiment. This included fifteen identical pails, water lilies, fifteen pots, tap water, greywater, and garden soil. The researchers obtained water lilies from the Laguna Bay and kept them in a container, filled with water, before they were placed in their respective treatment areas (on November 8 and 12, 2017). The fifteen pails and pots were bought from the Alabang Market, while the garden soil was taken from a supplier in the Batangas province. The first three samples, each representing the three different water treatments, were set-up on November 8, 2017, followed by the twelve other samples that were later set-up on November 12, 2017.

For the greywater, different amounts of cups of Tide were mixed with several separate tap water samples for the first (i) and second (ii) treatments, as this solution is commonly found in several Filipino households, considering that Tide is a popular commercial detergent and tap water is easily obtainable. Tide was also chosen because it did not contain bleach. The presence of bleach would have considerably decreased the lifespan of the water lilies (Meyers, J., n.d.), which would have shortened the amount of time for the observation and experimentation of this study. Additionally, while adding the detergent, the researchers wore gloves while transferring and mixing it to its respective containers to prevent skin irritation from the chemical compound.

In many Filipino households, greywater has been recycled for several purposes, such as for watering the soil and plants in their surroundings; however, considering that this has many harmful components, such as phosphorus from laundry products, it can hamper growth and collapse soil structures (Greywater Industry Group [GWIG], 2011). Due to the proven possible harmful effects that come with the greywater being used in the experiment, the researchers made certain that nobody drank from it and used proper sanitation after handling. Subsequently, the buckets with the first treatment (i) had a greywater solution consisting of 1 cup of Tide each (3.5 gallons) while the buckets with the second treatment (ii) consisted of a greywater solution with ½ cup of Tide each (1.75 gallons) that were diluted with 1.75 gallons of tap water.

With regards to the tap water used, it was obtained from a Filipino household located in Metro Manila. The tap water mentioned came from a tap, which uses water from a closeby Maynilad facility. This was chosen since Maynilad water is utilized by a great number of Filipino citizens. In fact, according to a 2014 Maynilad annual report, this water services company was mentioned to be the "largest water concessionaire in terms of customer base in the Philippines." (Maynilad, 2014). This water was also used because although the company has been using filtration instruments and purifying it with several treatment plants (Maynilad, 2014), there have also been many accounts of diseases born from the tap water, which has caused some distrust among the Filipino citizens.

Esmaquel II, P. (2011), mentioned that the water pipes may be one of the causes of contaminated tap water. Gonzales, E. (2014) stated that the contaminants may have also been the disinfection by-products (DBPs) of chemical reactions in the use of chlorine for water treatment. While it is a cost-effective treatment that helps to reduce harmful ammonia, hydrogen sulfide, and the like, it also creates chloroform, bromoform, etc., which can cause health risks such as cancer; thus, showing need for the researchers to apply filtration on this specific tap water.

For each pail previously mentioned, they were filled with pots that each contained three inches of garden soil, for the nutrition of the water lilies. Afterwards, the water treatments were provided to each pail. With regards to which pails had which treatment, it was done so randomly to avoid any possible kind of preference in the results of the study. For five pails, they were each filled with 3.5 gallons of 100% greywater for the first treatment (i). In five other containers, they were each provided with a solution of 1.75 gallons of greywater that was diluted with 1.75 gallons tap water for the second treatment (ii). The amount of greywater and tap water used for the second treatment (ii) were made equal in order to have the water sample have a 1:1 ratio composition. For the last five remaining pails, they each had 3.5 gallons of 100% tap water for the third treatment (iii). These three different treatments were implemented on the samples in order to compare how effective water lilies actually are in different situations/water samples, considering that greywater and tap water have different concentrations of contaminants. This procedure is also based from previous studies such as one conducted by Grewal, H., Maheshwari, B. and Pinto, U. (2010).

Notably, the dates for the setup of the samples were done on two separate days. The first three samples were accomplished on November 8, 2017 while the other twelve samples were setup on November 12, 2017.

After the setups for the experiment were completed (*see figures 3.1 and 3.2*) and the pails were placed in a safe area, small portions of the unfiltered tap water and greywater were taken from each pail after 15-20 minutes of their initial completion since the experiment first needed the soil particles to affect the water samples of each container in order to achieve more realistic results. The gathered portions of water were then placed into separate labelled containers (*see appendix E*) and were properly preserved in a refrigerator until they were brought to a laboratory in De La Salle Santiago Zobel - Vermosa for measurement of their pH levels, transmittance, and absorbance. For the pH levels, they were determined through the use of a Vernier pH sensor and LabQuest while the transmittance and absorbance of each sample in different wavelengths were measured by the Ward's Science spectrophotometer provided. Distilled water was also provided and used as a reference blank for the spectrophotometer. This step in the experiment was done for a comparison between pre-filtration and post-filtration of the water samples and to see how much of an influence the water lilies had on them based on any notable differences between the results. This part of the process was done on two separate days due to time constraints on the researchers. The first three samples were tested in the laboratory on November 9, 2017 while the twelve other samples were tested for pre-filter data on November 21, 2017.

Each of the water samples that were kept in each pail with the water lilies were observed for two weeks and three days while they were left mostly undisturbed. The wait time provided for the filtration of the samples was merely a little more than two weeks, which is due to a consideration of an experiment by Kalia (2012) whose water lilies that were used in the study started to biodegrade right after two weeks because of their placement in an insufficient container. The first three samples representing each of the three different water treatments were observed from November 8, 2017 to November 25, 2017 while the other twelve samples were observed from November 12, 2017 to November 28, 2017. During this period, it was also observed that the water lilies subjected to the buckets with statistical treatments i and ii, which have greywater portions, died after a week of their set-up. The observation of these samples was still continued in order to keep with the plan and show the effectivity of water lilies in water filtration over the scheduled time duration, which was applied to all samples.

Once the provided time was over, the researchers immediately took a portion from each sample, placed them in clean containers, and preserved them in a refrigerator until they were transported to the science laboratories in the De La Salle Santiago Zobel - Vermosa campus (*see appendix I*). Certain instruments were then used on each of the samples for determining the transmittance, absorbance, and pH levels, as it is within the goals of the study to observe these variables in order to conclude how effective the water lilies were in filtering water. For the purpose of measuring the transmittance and absorbance of the water samples in different wavelengths, the previously mentioned spectrophotometer was again utilized, while the pH levels were measured by a Vernier sensor, with the data quantified by a LabQuest. Notably, this step of the process was executed on two separate days due to time constraints. The first three samples were tested in the laboratory on November 28, 2017 while the twelve other samples were tested for post-filter data on November 29, 2017. After all the data had been recorded, they were compared to each other, especially between pre-filtration and post-filtration results, with the use of the study's statistical treatment.

Safety Procedures

Presented below are the several guidelines regarding safety procedures applied before, during, and after the experiment in order to minimize potential risk.

1. When creating the greywater solution with the detergent, wear protective gloves. Be sure to avoid direct eye contact with it as the detergent may cause severe chemical injury.
2. When transferring the water lilies, transfer them to the pot with utmost care to prevent their stems from breaking.
3. Be sure to wear gloves for protection and sanitary purposes when transferring the water lilies into their containers.

4. While handling the spectrophotometer, LabQuest, and pH sensor, be sure to familiarize its function for the sake of preventing damage to the instrument.
5. Avoid spilling the samples, especially when near electricity sockets and when using the spectrophotometer.

V. Statistical Treatment

The statistical treatments applied on the data gathered from the survey were the one-way ANOVA, comparison of the samples' percent changes and averages on the variables pH level, transmittance, and absorbance. One-way ANOVA allowed the researchers to find recognition and to confirm the significance of the relationships observed between the variables, before and after the experiment, and to answer the research questions which have been previously mentioned in chapter 1.

One-way ANOVA

According to Statistics Solutions (2013), ANOVA is a type of statistical treatment that evaluates possible differences in a scale-level dependent variable by a nominal-level variable having 2 or more categories. The independent variables in this research are the water samples with tap water, greywater, and those with varying amounts of these two kinds of water. Water lilies were used to filter the water samples to test if they have an effect on the dependent variables. The dependent variables used in the research are the pH levels, absorbance, and transmittance of the water samples measured during the pretest and post-test phases.

The specific type of ANOVA used in this research paper is the One-Way ANOVA. As mentioned by Laerd Statistics (2013), the one-way analysis of variance is used to decide whether there are any particular statistically significant differences between the averages of three or more independent and unrelated groups. To determine which specific groups are different from another, a post test must be used. The water samples were tested for their pH level, absorbance, and transmittance before the water lilies started to work and affect them, and after a certain amount of time the water lilies were placed. This was done to compare if there is a significant difference in the pH level, transmittance, and absorbance of the water samples before and after having the water lilies take effect.

Percentage

The statistical treatment applied on the data gathered from the experiment was the comparison of the pH level, transmittance, and absorbance of the water samples before and after the experiment with the use of percentages. Comparing the samples before and after the experiment helped in determining the effects of water lilies as a filtration instrument to pH level, transmittance, and absorbance, of greywater, tap water, and the mixture of both. Any differences noted in the comparisons were summarized with the percentages that represented the amount of change that occurred between the pre-filter and post-filter data.

Average

The percentages mentioned beforehand were based from the statistical treatment of calculating the averages for each of the values of the transmittance, absorbance, and pH levels of the water samples. The averages for the variables during the pre-filter and post-filter phases helped to represent the general results that came from the experiment.

CHAPTER 4: DATA ANALYSIS AND INTERPRETATION

Presented in Chapter 4 is a summary of the data collected during the pre-filter and post-filter of the water samples, along with their interpretations. The data was analyzed to carry out the purpose of the study, which is to determine the effect of water lilies on the pH level, absorbance, and transmittance of greywater and tap water. IBM SPSS statistics software was also used to perform the appropriate statistical treatments to answer the research questions.

Research Question 1: What are the effects of using water lilies as a filtration instrument to pH level, transmission, and absorbance of tap water with 100% greywater concentration (3.5 gallons) each?

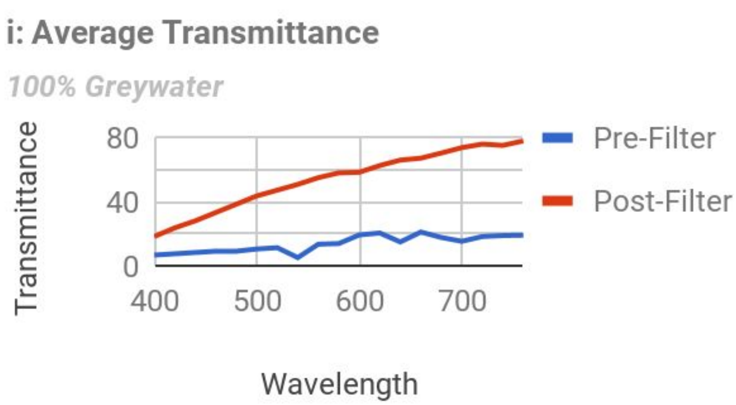
Table 4.1: pH levels of five samples with treatment i (100% Greywater)

i: 100% Greywater	**Pre-filter pH levels**	**Post-filter pH levels**
A1	10.47	8.75
A2	10.66	8.57
A3	9.65	8.17
A4	10.3	8.35
A5	10.22	7.95
Average	10.26	8.358

As shown in table 4.1, the five water samples with treatment i (100% Greywater) had very acidic pH levels ranging from 9.65 to 10.66 before they were experimented with the water lilies. After the experiment, it was observed that the pH levels decreased, ranging from 7.95 to 8.75. It is consistent for each of the five samples that their acidity decreased, due to the presence of water lilies, and approached the ideal pH range of water, which is stated by a Daily Star news article (2015) to be from 6.5 to 8.5 pH.

While it is shown that the average pH level decreased by 18.54%, the water lilies were unable to fully filter the water in terms of this variable since the pH levels obtained after the experiment were still in the extremities of the ideal pH range of water. The data values for post-filter are still bordering on the high acidic side of the ideal pH range and so, it is possible that the samples still have their health risks but nonetheless improved its pH levels prior to having water lilies.

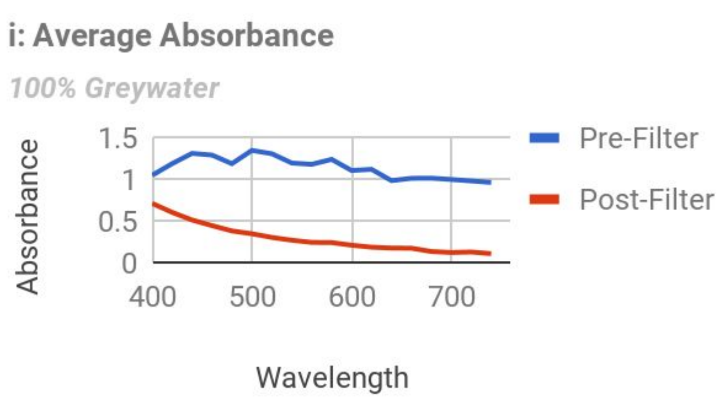
Figure 4.1: Average transmittance of five samples with treatment i (100% Greywater)



As presented in figure 4.1, most of the values of both pre-filter and post-filter data increase as the wavelengths change from 400 to 760. Notably, the average transmittance of the five samples with 100% greywater have larger values in the post-filter, compared to their pre filter data. This overall data of the samples is consistent with each individual samples' information. This shows that with all five samples with treatment i, their transmittances were increased by water lilies; specifically a 316% increase.

According to the Michigan State University (n.d.), the Beer-Lambert Law states that the more the light from a spectrophotometer is able to transmit through a water sample, the less compounds there are in the solution that are capable of blocking this passage of light. Based from the data given in figure 4.1 then, it can be observed that the water samples after the filtration had less compounds than during their pre-filter phase. This comparison indicates that the samples were filtered through the water lilies that were able to reduce the particles that blocked the passage of light.

Figure 4.2: Average absorbance of five samples with treatment i (100% Greywater)



While it is shown in figure 4.2 that most of the values of both pre-filter and post-filter results decreased as the wavelengths changed from 400 to 760, the average absorbance of the post-filter samples were lower than that of pre-filter by 71%. This comparison between pre-filter and post-filter is consistent in each individual sample with treatment i. This change in values shows that the samples were most likely affected by the presence of the water lilies. Beer-Lambert Law, states that the amount of light absorbed is directly proportional to the concentration of absorbing compounds in that sample, so a spectrophotometer can also be used to determine concentrations of compounds in solution. It is then most likely that the samples and their absorbing particles were filtered through and decreased by the water lilies.

Overall, the data presented in table 4.1, figures 4.1 and 4.2 show that the water lilies were able to affect the pH levels, transmittance, and absorbance of the samples with treatment i (100% Greywater). In particular, the pH levels and absorbance values were lessened while the transmittance values increased. All these effects of the water lilies suggest that they were able to improve the water quality to an extent; however, it must be noted that these water lilies died a week after during the duration of the experiment. This may be due to several factors such as the detergent concentration, size of the container, and environment the water lilies were subjected to. Similarly, other studies also have encountered similar circumstances, particularly the study conducted by Kalia (2012), whose own experimental water lilies, exposed to greywater, also died within 12 to 24 hours. Kalia (2012) stated that larger tanks should be used in the future.

Research Question 2: What are the effects of using water lilies as a filtration instrument to pH level, transmission, and absorbance of five separate water samples with 50% greywater concentration (1.75 gallons) and 50% tap water concentration (1.75 gallons) each?

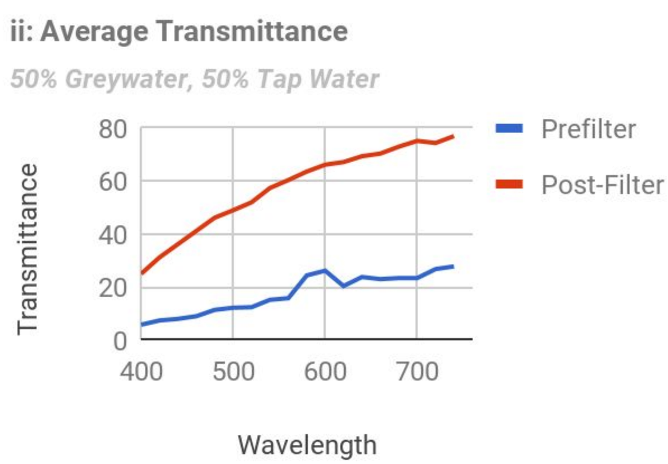
Table 4.2: pH levels of five samples with treatment ii (50% Greywater and 50% Tap water)

ii: 50% Greywater and 50% Tap water	**Pre-filter pH levels**	**Post-filter pH levels**
B1	10	8.29
B2	10.19	8.05
B3	10.1	8.03
B4	10.25	7.91
B5	10.1	8
Average	10.128	8.056

As shown in table 4.2, the five water samples with treatment ii (50% Greywater and 50% Tap water) had pre-filter test results showing high acidic pH levels ranging from 10.00 to 10.25, compared to the post filter results wherein it can be observed that the average pH level decreased by 20.46%. It is shown to be consistent for all the five samples that their acidity decreased due to the presence of water lilies. Table 4.2 also further indicates that the pH levels of the samples changed and approached the ideal pH range of water, which has mentioned to be from 6.5 to 8.5 (Daily Star, 2015); thus, showing that the water lilies were able to filter and improve the quality of the samples.

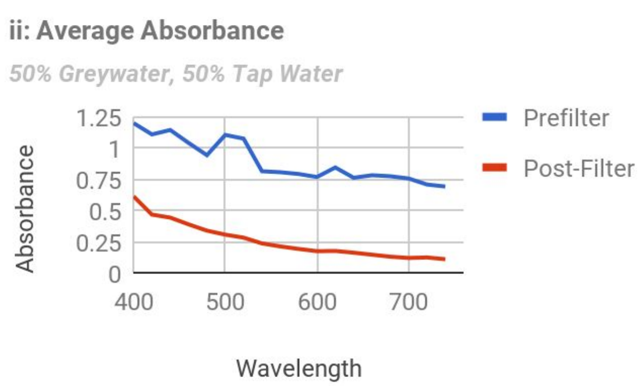
While the water lilies were able to filter the samples enough to be within the ideal ph range, there are still health risks involved since their pH levels remain on the more acidic side. Nonetheless, it can be observed that the water lilies were effective in filtering the water samples with treatment ii, specifically in terms of decreasing the pH levels.

Figure 4.3: Average transmittance of five samples with treatment ii (50% Greywater and 50% Tap water)



It can be observed in figure 4.3 that the values of both pre-filter and post-filter results increased as the wavelengths changed from 400 to 760; however, the average transmittance of the post-filter samples reached higher values compared to pre-filter by 257%. With concerns to each individual sample, it is consistent to all that their transmittances were of higher value in post-filter. This change between pre-filter and post-filter shows that the samples were most likely affected by the presence of the water lilies. It also shows that there were less compounds in the samples after they had water lilies because, the Beer-Lambert Law states that the more that light is able to pass through a sample, the fewer compounds there are that are able to block this. This hints that the water lilies were able to filter and reduce the different particles within the water samples.

Figure 4.4: Average absorbance of five samples with treatment ii (50% Greywater and 50% Tap water)



As displayed in figure 4.4, most of the values of both pre-filter and post-filter data decrease as the wavelengths change from 400 to 760. Notably, the average absorbance of the five samples with 100% greywater have smaller values in the post-filter, compared to their pre filter data. This overall data of the samples is consistent with each individual samples' information previously mentioned. This shows that with all five samples with treatment i, their absorbance values were decreased by water lilies; specifically a 70% decrease.

As stated by the Michigan State University (n.d.) regarding the Beer-Lambert Law, “the amount of light absorbed is directly proportional to the concentration of absorbing compounds in that sample, so a spectrophotometer can also be used to determine concentrations of compounds in solution.” Based from the data given in figure 4.4 then, it can be observed that the water samples after the filtration had less compounds while in their pre-filter phase, they had more. This comparison indicates that the samples were filtered and improved through the waterlilies that were able to reduce the particles that absorbed the light provided by the spectrophotometer.

Overall, the different data presented show that the water lilies were able to affect the pH levels, transmittance, and absorbance of the samples with treatment ii (50% greywater and 50% tap water) as shown in table 4.2, figures 4.3 and 4.4. Specifically, the pH levels and absorbance values were reduced while the transmittance increased. All these changes made by the filtration of water lilies in the samples suggest that these were able to improve the water quality to an extent. It must also be said however that these water lilies died after a week of their application in the water samples. This is possibly due to the greywater detergent concentration, size, and environment the water lilies were subjected to. This occurrence is also similar to those of other related studies such as by Kalia (2012), whose own experimental water lilies, exposed to greywater, also died within 12-24 hours. Kalia (2012) stated that larger tanks should be used in the future. Since the water lilies in the study lived longer than those of Kalia's, it must be said that a tank larger than 15 x 12 inches would be advisable.

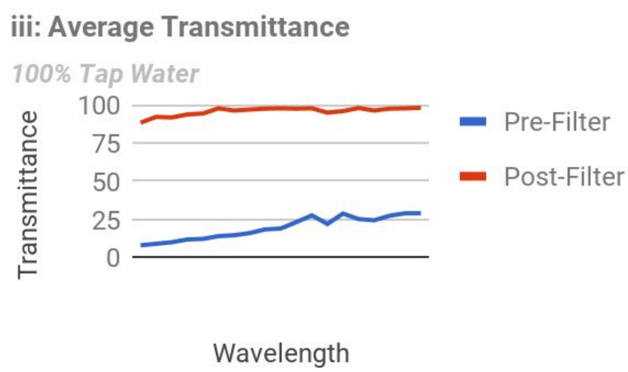
Research Question 3: What are the effects of using water lilies as a filtration instrument to pH level, transmission, and absorbance of five separate water samples with 100% tap water concentration (3.5 gallons) each?

Table 4.3: pH levels of five samples with treatment iii (100% tap water).

iii: 100% Tap water	Pre-filter	Post-filter
C1	8.43	7.3
C2	8.58	7.47
C3	7.81	7.62
C4	8.35	7.35
C5	8.55	7.57
Average	8.344	7.462

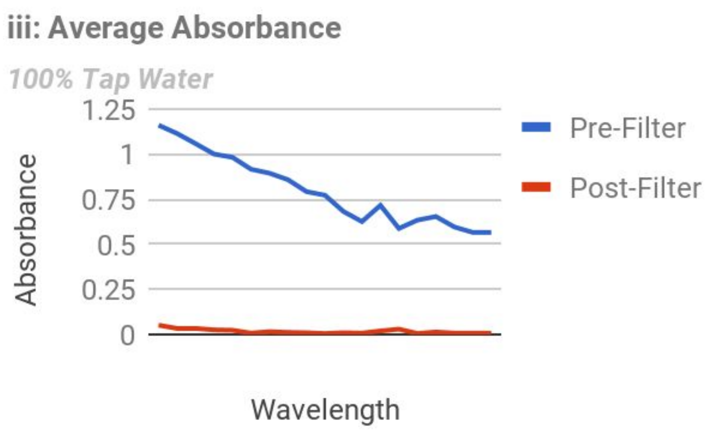
As shown in figure 4.3, the five water samples with treatment iii (100% tap water) had acidic pH levels ranging from 7.81 to 8.58 prior to their experimentation with water lilies. These values are on the more acidic side of the ideal pH range of good water, which is stated by a Daily Star news article (2015) to be from 6.5 to 8.5 pH, showing that there are possible health risks in the tap water samples; however, after the experiment, the risks may have been reduced as it was observed that the average pH level decreased by 10.57%. The values were affected and reduced to reach a more favorable range within the ideal pH levels stated, wherein most of the samples wherein the equal state of being basic and acidic. Figure 4.4 also suggests that it is consistent for all the five samples that their acidity decreased due to the presence of water lilies in each sample.

Figure 4.5: Average transmittance of five samples with treatment iii (100% Tap water)



While it is shown in figure 4.5 that most of the values of both pre-filter and post-filter results increased as the wavelengths changed from 400 to 760, the average transmittance of the post-filter samples were higher than that of pre-filter by 478%. This comparison between pre-filter and post-filter is consistent in each individual sample with treatment iii. This change in values shows that the samples were most likely affected by the presence of the water lilies. As the Michigan State University (n.d.) stated about the Beer-Lambert Law, the more that light is able to pass through a sample, the fewer compounds there are that are able to block this and with the presence of the water lilies, which differed post-filter from pre-filter, it was most likely that the samples and their compositions were affected with these plants, specifically with having their amount of compounds decreased as their transmittances increased.

Figure 4.6: Average absorbance of five samples with treatment iii (100% Tap water)



It can be observed in figure 4.6 that the values of both pre-filter and post-filter results generally decreased as the wavelengths changed from 400 to 760; however, the average absorbance of the post-filter samples reached lower values compared to pre-filter. With concerns to each individual sample, it is consistent to all that their absorbances were of smaller value in post-filter. This change between pre-filter and post-filter shows that the samples were most likely affected by the presence of the water lilies. It also shows that there were less compounds in the samples after they had water lilies because, according to the Beer-Lambert Law, the amount of light absorbed is directly proportional to the concentration of absorbing compounds in that sample, so a spectrophotometer can also be used to determine concentrations of compounds in solution. This hints that the water lilies were able to filter and reduce the absorbing particles within the water samples.

Overall, the various data shown indicate that the water lilies were able to affect the pH levels, transmittance, and absorbance of the samples with treatment iii (100% tap water). In particular, the pH levels and absorbance values were lessened while the transmittance values increased. These changes then suggest that the water lilies were able to affect the water samples and improve their quality to an extent.

Research Question 4: Is there a significant difference between the Pretest and Posttest of the transmittance, absorbance, and pH level of the three different water treatments (100% greywater, 50% greywater, and 100% tap water)?

Table 4.4: ANOVA results on transmittance, absorbance, and pH level of all samples with all treatment

Method	Wavelength	TRANSMITTANCE LEVEL			ABSORBANCE			pH		
		Mean			Mean			MEAN		
i		Pretest	Post test	Sig	Pretest	Post test	Sig	Pretest	Post test	Sig
	400	6.6	18.2	0.277	0.902	0.738	0.192	10.26	8.358	0
	580	13.8	58	0.005	1.18	0.71	0.005			
	760	19	78	0.003	0.962	0.602	0.001			
ii										
	400	5	20.4	0.021	1.112	0.722	0.043	10.128	8.056	0
	580	15.8	60.4	0	0.808	0.216	0.001			
	760	27.8	77	0	0.694	0.114	0.028			
iii										
	400	8	88.4	0.192	1.16	0.052	0.277	8.344	7.462	0
	580	19	97.8	0.005	0.772	0.006	0.005			
	760	29	98.2	0.001	0.566	0.008	0.003			

Table 4.4 is a numerical representation of the data gathered from the samples indicating if the results gathered posed significance at different wavelengths. The significance values given to the transmittance and absorbance of the 3 treatments are lower than the alpha value ($p < 0.05$) at wavelengths 400, 580, and 760, except in treatments i and iii, at wavelength 400, the significance value of the transmittance and absorbance is greater than the alpha value ($p > 0.5$) ; 0.277, 0.192, 0.192, and 0.277 respectively. This indicates that there is a significant difference between the pre and post tests of the transmittance and absorbance with the 3 treatments except for treatments i and iii at wavelength 400. Included in this table are the ANOVA results on the pH levels of the 3 treatments indicating whether or not the data given is significant or not. In all treatments, the given significance values are less than the alpha value ($p < 0.05$), this shows that there is a significant difference between the pretest and posttest for all 3 treatments.

These results support the findings of the previous questions of this research paper where the transmittance, absorbance, and pH levels had changed by a large margin between the pre and post tests. Overall, the results show that water lilies are able to affect the quality of water, particularly improving its pH level and purity.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

Introduction

Presented in this chapter is an overview of the conclusions of the results produced for each research question of the study, based on the data gathered from the previous chapter. Recommendations are also provided for future studies.

Conclusions

With the use of ANOVA, average, and percentage, the researchers were able to gain results from the data which are then summarized in this chapter. This chapter will also discuss the four research questions which were previously stated in chapter 1, namely:

1. Research Question 1: What are the effects of using water lilies as a filtration instrument to pH level, transmittance, and absorbance of five separate water samples with 100% greywater concentration (3.5 gallons) each?

    1.1. To answer research question 1 with regards to the pH level, the researchers calculated the average pH of the five samples from the 100% greywater. It was concluded that based on the results obtained, there is a significant change with the pH values wherein the pre-filter pH level average was 10.26 and its post-filter pH level average was lowered to 8.358. This data suggests then that the samples were able to achieve lower basic pH levels due to the presence of water lilies.

1.2. As for the transmittance and absorbance of the 100% grey water samples, it was observed that there was a significant difference as the wavelengths changed from 400 to 760. To be specific, the average absorbance of the post-filter samples was lower than the average pre-filter. The decrease of values was likely affected due to the presence of water lilies. As for transmittance, the values increased from pre-filter to post-filter. These data suggest that the water samples, with the use of water lilies, were able to reduce their number of particles in their compositions.

2. What are the effects of using water lilies as a filtration instrument to pH level, transmittance, and absorbance of five separate water samples with 50% greywater concentration (1.75 gallons) and 50% tap water concentration (1.75 gallons) each?

2.1. To answer research question 2 with respect to the 50% greywater and 50% tap water concentration, similar as to the results of the 100% greywater from research question 1, the pH levels had a significant difference from pre- and post-filter wherein the average of the pH values decreased from 10.128 to 8.056. With this information, it can be concluded that with the presence of water lilies, the samples were able to approach more neutral pH levels.

2.2. As for the transmittance and absorbance of the samples with 50% greywater and 50% tap water concentration, similar as to the results of 100% greywater concentration from research question 1, the absorbance of the samples lowered from the pre-filter to the post-filter results whereas the transmittance of the sample increased from the pre-filter to post-filter results as the wavelengths changed from 400 to 760. As mentioned previously, this kind of data indicates that the samples were filtered by the water lilies as there were less particles in the samples.

3. What are the effects of using water lilies as a filtration instrument to pH level, transmittance, and absorbance of five separate water samples with 100% tap water concentration (3.5 gallons) each?

3.1. To answer research question 3 with regards to the pH levels of the samples with 100% tap water, it was observed that the pH levels had a significant change from pre- and post-filter wherein the average of the pH values lessened from 8.344 to 7.462. It can be concluded with this that the water lilies were able to affect the samples by having them reach a more neutral pH level.

3.2. Similar as to the results from research questions 1 and 2, the transmittance of the samples with 100% tap water increased from pre-filter to post-filter, whereas their absorbance were significantly decreased from the pre-filter to the post-filter data as the wavelengths changed from 400 to 760. It can be concluded through this that the water samples were affected by the water lilies by having their particles in their compositions lessened.

4. Is there a significant difference between the Pretest and Posttest of the transmittance, absorbance, and pH level of the three different water treatments (100% greywater, 50% greywater, and 100% tap water)?

4.1. With the use of SPSS, the researchers had observed from the ANOVA tables that there is a significant difference between the pre- and post-filters for all treatments, except for treatments i and iii at wavelength 400, with regards to the transmittance and absorbance of the samples.

4.2. Through the use of SPSS, the researchers had observed that there is a significant difference of pH levels between the pre- and post-filters for all treatments.

Recommendations

Presented below are recommendations provided for future use and reference:

1. It is recommended that the water lilies, or any other kind of plant, utilized for future studies are grown and cultured at the same conditions in order to remove the possibility of error in data due to differences in growth.

2. It is recommended that the samples with plants have larger containers and more natural and favorable conditions in order to avoid the decay of these plants and to fully maximize a longer time for the experiment and gathering of data.

3. It is recommended that future studies have a larger sample size experimented with in order to have more credibility and observe consistency and patterns of results important in the topic.

4. It is recommended that there be a more comprehensive experiment on the capability of water lilies to filter more kinds of water samples with varying concentrations in order to assess how effective it is in different situations.

5. It is recommended that biologists, particularly botanists, use this study to further increase their knowledge and understanding of the benefits of water lilies, especially in terms of their ability to filter water. It is also suggested that this study will be used as further motivation for more comprehensive research on various plants that can work as water filters.

6. It is recommended that manufacturers of water filtration systems and those in need of them use this study as inspiration for new, efficient water filters.

7. It is recommended that this research be used to confirm the consistency and credibility of results of other studies such as those by Kalia (2012).

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APPENDIX A: 15 CONTAINERS (15X12)

APPENDIX B: SAMPLES WITH THREE DIFFERENT TREATMENTS

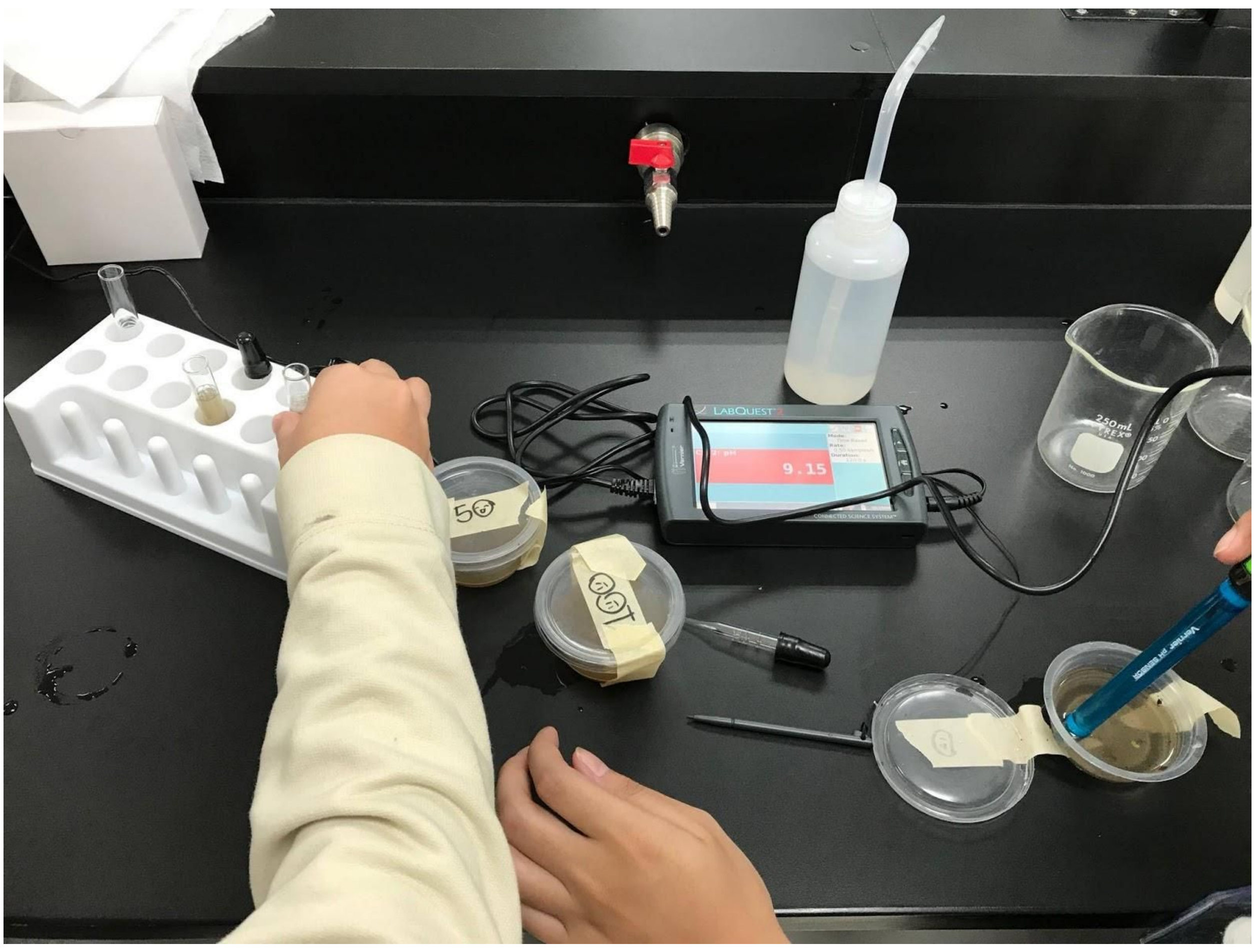
APPENDIX C: SAMPLES WITH WATER LILIES

APPENDIX D: 3 INCHES OF SOIL PER CONTAINER

APPENDIX E: PORTIONS OF SAMPLES FOR LABORATORY PRE-TEST

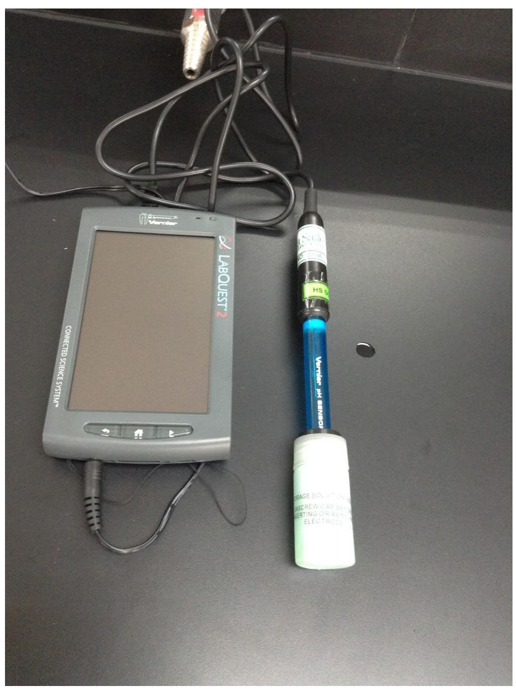
(100 = treatment i, 50 = treatment ii, 0 = treatment iii)

APPENDIX F: USE OF pH SENSOR AND LABQUEST



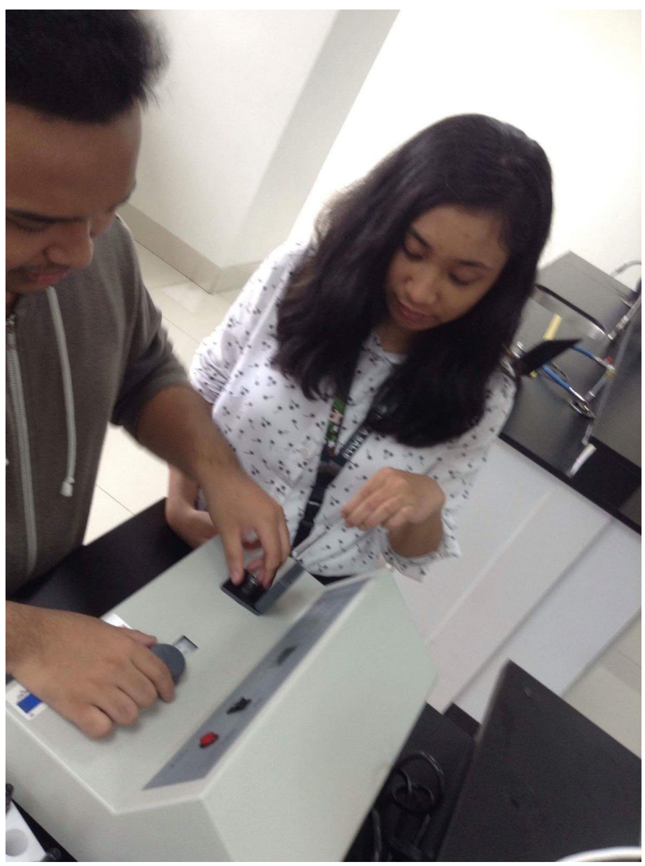
APPENDIX G: SPECTROPHOTOMETER

APPENDIX H: LABQUEST AND pH SENSOR



APPENDIX I: LABORATORY POST-TEST SAMPLES

APPENDIX J: USE OF SPECTROPHOTOMETER



APPENDIX K:PERMISSION LETTERS FOR LABORATORY USE

Mr. Jonathan Sarza
Grade 12 Chemistry Teacher
De La Salle Santiago Zobel - Vermosa

Dear Mr. Jonathan Sarza:

Greetings of Peace!

The undersigned are senior high school students under the STEM strand at the De La Salle Santiago Zobel School – Vermosa. We are currently conducting their research titled, **“Water Lilies: Its Effect on the pH Level, Chloride and Nitrate Content of Greywater and Tap Water Samples”**.

In line with this, the undersigned would like to request permission and endorsement to use a spectrophotometer and pH sensor in one of the science laboratories at De La Salle Santiago Zobel - Vermosa, under your supervision, on November 29, 2017 (Wednesday), specifically during 8:25am-9:25am and 10:25am-11:05am. The undersigned shall be making use of these particular instruments to collect data on pH level, nitrate and chloride content of several water samples and shall need a science teacher supervising them as they collect data in the laboratory. Data that will be gathered from the aforementioned procedures will be very significant to achieve the objectives of this study.

Rest assured that confidentiality of the data gathered will be strictly observed and will be solely used for the above mentioned purpose.

We are truly grateful in anticipation of your favourable response to this request.

Respectfully yours,

Allyson Tracie Bejar (Leader)
STEM Student

Willbourn Cabulisan (Member)
STEM Student

Joshua Ranjo (Member)
STEM Student

Anna Royeca (Member)
STEM Student

Layla Sevilla (Member)
STEM Student

Noted by:

Mr. Fritz Ferran
Research Adviser

Approved:

Mr. Jonathan Sarza

Ms. Agnes Panaligan
High School Principal
De La Salle Santiago Zobel - Vermosa

Dear Ms. Agnes Panaligan:

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Noted by:

Mr. Fritz Ferran	**Mr. Richard Lasap**	**Mr. Jonathan Sarza**
Research Adviser	Overall Strand Coordinator	Grade 12 Chemistry Teacher

Approved:

Ms. Agnes Panaligan

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Science Coordinator
De La Salle Santiago Zobel - Vermosa

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In line with this, the undersigned would like to request permission and endorsement to use a spectrophotometer and pH sensor in one of the science laboratories at De La Salle Santiago Zobel - Vermosa, under the supervision of Mr. Jonathan Sarza, on November 21, 2017 (Tuesday) specifically during 12:30pm-3:30pm. The undersigned shall be making use of these particular instruments in order to collect data on water samples, in particular about their pH level, nitrate and chloride content. Data that will be gathered from the aforementioned procedures will be very significant to achieve the objectives of this study.

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We are truly grateful in anticipation of your favourable response to this request.

Respectfully yours,

Allyson Tracie Bejar (Leader)
STEM Student

Willbourn Cabulisan (Member)
STEM Student

Joshua Ranjo (Member)
STEM Student

Anna Royeca (Member)
STEM Student

Layla Sevilla (Member)
STEM Student

Noted by:

Mr. Fritz Ferran
Research Adviser

Mr. Richard Lasap
Overall Strand Coordinator

Mr. Jonathan Sarza
Grade 12 Chemistry Teacher

Approved:

Ms. Agnes Panaligan

Ms. Carmelita Estidola
Science Coordinator
De La Salle Santiago Zobel - Vermosa

Dear Ms. Carmelita Estidola:

Greetings of Peace!

The undersigned are senior high school students under the STEM strand at the De La Salle Santiago Zobel – Vermosa School. We are currently conducting their research titled, **"Water Lilies: Its Effect on the pH Level, Chloride and Nitrate Content of Greywater and Tap Water Samples"**.

In line with this, the undersigned would like to request permission and endorsement to use a spectrophotometer and pH sensor in one of the science laboratories at De La Salle Santiago Zobel - Vermosa, under the supervision of Mr. Jonathan Sarza, on November 9, 2017 (Thursday) specifically during 1:30pm-2:30pm. The undersigned shall be making use of these particular instruments in order to collect data on water samples, in particular about their pH level, nitrate and chloride content. Data that will be gathered from the aforementioned procedures will be very significant to achieve the objectives of this study.

Rest assured that confidentiality of the data gathered will be strictly observed and will be solely used for the above mentioned purpose.

We are truly grateful in anticipation of your favourable response to this request.

Respectfully yours,

Allyson Tracie Bejar (Leader)
STEM Student

Willbourn Cabulisan (Member)
STEM Student

Joshua Ranjo (Member)
STEM Student

Anna Royeca (Member)
STEM Student

Layla Sevilla (Member)
STEM Student

Noted by:

Mr. Fritz Ferran
Research Adviser

Approved:

Ms. Carmelita Estidola

Mr. Jonathan Sarza
Grade 12 Chemistry Teacher
De La Salle Santiago Zobel - Vermosa

Dear Mr. Jonathan Sarza:

Greetings of Peace!

The undersigned are senior high school students under the STEM strand at the De La Salle Santiago Zobel School – Vermosa. We are currently conducting their research titled, **"Water Lilies: Its Effect on the pH Level, Chloride and Nitrate Content of Greywater and Tap Water Samples"**.

In line with this, the undersigned would like to request permission and endorsement to use a spectrophotometer and pH sensor in one of the science laboratories at De La Salle Santiago Zobel - Vermosa, under your supervision, on November 9, 2017 (Thursday) specifically during 1:30pm-2:30pm. The undersigned shall be making use of these particular instruments to collect data on pH level, nitrate and chloride content of several water samples and shall need a science teacher supervising them as they collect data in the laboratory. Data that will be gathered from the aforementioned procedures will be very significant to achieve the objectives of this study.

Rest assured that confidentiality of the data gathered will be strictly observed and will be solely used for the above mentioned purpose.

We are truly grateful in anticipation of your favourable response to this request.

Respectfully yours,

Allyson Tracie Bejar (Leader)
STEM Student

Willbourn Cabulisan (Member)
STEM Student

Joshua Ranjo (Member)
STEM Student

Anna Royeca (Member)
STEM Student

Layla Sevilla (Member)
STEM Student

Noted by:

Mr. Fritz Ferran
Research Adviser

Approved:

Mr. Jonathan Sarza

Ms. Agnes Panaligan
High School Principal
De La Salle Santiago Zobel - Vermosa

Dear Ms. Agnes Panaligan:

Greetings of Peace!

The undersigned are a senior high school students under the STEM strand at the De La Salle Santiago Zobel School – Vermosa. We are currently conducting their research titled, **"Water Lilies: Its Effect on the pH Level, Chloride and Nitrate Content of Greywater and Tap Water Samples"**.

In line with this, the undersigned would like to request permission and endorsement to use a spectrophotometer and pH sensor in one of the science laboratories at De La Salle Santiago Zobel - Vermosa, under the supervision of Mr. Jonathan Sarza, on November 9, 2017 (Thursday) specifically during 1:30pm-2:30pm. The undersigned shall be making use of these particular instruments in order to collect data on water samples, in particular about their pH level, nitrate and chloride content. Data that will be gathered from the aforementioned procedures will be very significant to achieve the objectives of this study.

Rest assured that confidentiality of the data gathered will be strictly observed and will be solely used for the above mentioned purpose.

We are truly grateful in anticipation of your favourable response to this request.

Respectfully yours,

Allyson Tracie Bejar (Leader)
STEM Student

Willbourn Cabulisan (Member)
STEM Student

Joshua Ranjo (Member)
STEM Student

Anna Royeca (Member)
STEM Student

Layla Sevilla (Member)
STEM Student

Noted by:

Mr. Fritz Ferran
Research Adviser

Mr. Richard Lasap
Overall Strand Coordinator

Mr. Jonathan Sarza
Grade 12 Chemistry Teacher

Approved:

Ms. Agnes Panaligan

Ms. Carmelita Estidola
Science Coordinator
De La Salle Santiago Zobel - Vermosa

Dear Ms. Carmelita Estidola:

Greetings of Peace!

The undersigned are senior high school students under the STEM strand at the De La Salle Santiago Zobel – Vermosa School. We are currently conducting their research titled, **"Water Lilies: Its Effect on the pH Level, Chloride and Nitrate Content of Greywater and Tap Water Samples"**.

In line with this, the undersigned would like to request permission and endorsement to use a spectrophotometer and pH sensor in one of the science laboratories at De La Salle Santiago Zobel - Vermosa, under the supervision of Mr. Jonathan Sarza, on November 29, 2017 (Wednesday) specifically during 8:25am-9:25am and 10:25am-11:05am. The undersigned shall be making use of these particular instruments in order to collect data on water samples, in particular about their pH level, nitrate and chloride content. Data that will be gathered from the aforementioned procedures will be very significant to achieve the objectives of this study.

Rest assured that confidentiality of the data gathered will be strictly observed and will be solely used for the above mentioned purpose.

We are truly grateful in anticipation of your favourable response to this request.

Respectfully yours,

Allyson Tracie Bejar (Leader)
STEM Student

Willbourn Cabulisan (Member)
STEM Student

Joshua Ranjo (Member)
STEM Student

Anna Royeca (Member)
STEM Student

Layla Sevilla (Member)
STEM Student

Noted by:

Mr. Fritz Ferran
Research Adviser

Approved:

Ms. Carmelita Estidola

APPENDIX L: DATA TABLES

100% Greywater

(i) A1

Wavelength	Transmittance	Absorbance
400	1	1
420	1	1
440	1	1
460	1	1.77
480	1	1.72
500	2	1.59
520	2	1.54
540	3	1.49
560	4	1.28
580	4	1.32
600	4	1.33
620	5	1.28
640	5	1.26
660	6	1.2
680	6	1.17
700	7	1.15
720	7	1.13
740	7	1.11
760	8	1.07
pH	10.47	

(i) A2

Wavelength	Transmittance	Absorbance
400	0	1
420	0	1
440	0	1
460	0	1
480	0	1
500	0	1
520	1	1.81
540	1	1.77
560	2	1.64
580	2	1.62
600	1	1.45
620	3	1.48
640	2	1.55
660	4	1.38
680	3	1.41
700	4	1.36
720	3	1.45
740	3	1.43
760	3	1.41
pH	10.66	

(i) A3

Wavelength	Transmittance	Absorbance
400	0	1
420	1	1
440	1	1.82
460	1	1.75
480	1	1.73
500	2	1.59
520	2	1.55
540	3	1.5
560	4	1.4
580	4	1.35
600	6	1.22
620	7	1.5
640	5	1.26
660	7	1.1
680	8	1.09
700	8	1.08
720	8	1.06
740	8	1.06
760	9	1.04
pH	9.65	

(i) A4

Wavelength	Transmittance	Absorbance
400	1	1
420	1	1.77
440	1	1.7
460	2	1.66
480	2	1.63
500	2	1.53
520	2	1.53
540	3	1.48
560	4	1.38
580	4	1.36
600	6	1.2
620	6	1.18
640	5	1.29
660	7	1.15
680	6	1.21
700	6	1.19
720	6	1.18
740	7	1.14
760	7	1.12
pH	10.3	

(i) A5

Wavelength	Transmittance	Absorbance
400	31	0.51
420	34	0.47
440	38	0.42
460	41	0.38
480	41	0.38
500	46	0.23
520	49	0.31
540	15	0.3
560	53	0.28
580	55	0.25
600	79	1
620	81	0.09
640	57	0.24
660	81	0.09
680	65	0.18
700	51	0.29
720	67	0.17
740	69	0.16
760	68	0.17
pH	10.22	

50% Greywater

(ii) B1

Wavelength	Transmittance	Absorbance
400	0	1
420	0	1
440	0	1
460	0	1.11
480	0	1.12
500	1	1
520	1	1.95
540	1	1.9
560	1	1
580	1	1
600	1	1.71
620	1	1.71
640	2	1.68
660	2	1.64
680	2	1.62
700	2	1.58
720	2	1.57
740	2	1.54
760	3	1.52
pH	10	

(ii) B2

Wavelength	Transmittance	Absorbance
400	2	1.63
420	3	1.52
440	3	1.42
460	4	1.35
480	4	1.31
500	6	1.18
520	6	1.16
540	7	1.1
560	9	1.01
580	8	1.06
600	15	0.8
620	17	0.77
640	13	0.87
660	19	0.71
680	16	0.79
700	13	0.87
720	18	0.73
740	19	0.7
760	20	0.69
pH	10.19	

(ii) B3

Wavelength	Transmittance	Absorbance
400	7	1.12
420	7	1.11
440	11	0.94
460	10	0.98
480	14	0.83
500	17	0.76
520	19	0.72
540	16	0.78
560	23	0.62
580	25	0.59
600	38	0.42
620	40	0.4
640	31	0.5
660	34	0.46
680	35	0.45
700	36	0.43
720	28	0.54
740	40	0.4
760	41	0.38
pH	10.1	

(ii) B4

Wavelength	Transmittance	Absorbance
400	15	0.81
420	17	0.75
440	20	0.69
460	22	0.65
480	23	0.62
500	27	0.57
520	28	0.55
540	30	0.52
560	33	0.47
580	34	0.46
600	50	0.3
620	53	0.27
640	40	0.39
660	41	0.38
680	43	0.36
700	45	0.34
720	46	0.32
740	48	0.31
760	49	0.31
pH	10.25	

(ii) B5

Wavelength	Transmittance	Absorbance
400	1	1
420	2	1.62
440	3	1.5
460	4	1.6
480	4	1.33
500	6	1.21
520	7	1.15
540	8	1.08
560	10	0.98
580	11	0.93
600	18	0.74
620	20	0.7
640	16	0.79
660	23	0.63
680	19	0.7
700	21	0.66
720	23	0.63
740	25	0.6
760	26	0.57
pH	10.1	

100% Tap Water

(iii) C1

Wavelength	Transmittance	Absorbance
400	10	1
420	11	0.95
440	12	0.91
460	13	0.87
480	14	0.84
500	16	0.8
520	16	0.77
540	18	0.74
560	19	0.7
580	21	0.68
600	17	0.77
620	22	0.64
640	23	0.63
660	24	0.61
680	25	0.59
700	26	0.58
720	27	0.55
740	28	0.54
760	28	0.54
pH	8.43	

(iii) C2

Wavelength	Transmittance	Absorbance
400	10	0.97
420	11	0.93
440	13	0.87
460	16	0.8
480	17	0.77
500	19	0.71
520	20	0.69
540	23	0.62
560	27	0.57
580	28	0.54
600	30	0.51
620	47	0.32
640	33	0.48
660	46	0.33
680	37	0.43
700	38	0.41
720	41	0.38
740	42	0.37
760	42	0.37
pH	8.58	

(iii) C3

Wavelength	Transmittance	Absorbance
400	14	0.83
420	16	0.78
440	18	0.73
460	21	0.67
480	20	0.68
500	23	0.62
520	25	0.6
540	25	0.59
560	29	0.53
580	29	0.52
600	43	0.36
620	44	0.33
640	33	0.47
660	44	0.36
680	36	0.44
700	30	0.52
720	39	0.41
740	41	0.39
760	41	0.39
pH	7.81	

(iii) C4

Wavelength	Transmittance	Absorbance
400	2	1.67
420	2	1.63
440	2	1.55
460	3	1.49
480	3	1.48
500	4	1.37
520	4	1.35
540	5	1.3
560	6	1.21
580	6	1.18
600	9	1
620	10	0.99
640	7	1.1
660	11	0.94
680	10	0.99
700	9	1.04
720	12	0.92
740	12	0.89
760	12	0.89
pH	8.35	

(iii) C5

Wavelength	Transmittance	Absorbance
400	4	1.33
420	5	1.28
440	5	1.23
460	6	1.17
480	7	1.14
500	8	1.08
520	8	1.06
540	9	1.04
560	11	0.95
580	11	0.94
600	17	0.77
620	15	0.85
640	14	0.9
660	19	0.7
680	18	0.72
700	19	0.72
720	18	0.72
740	22	0.64
760	22	0.64
pH	8.55	

100% Greywater

(i) A1

Wavelegth	Transmittance	Absorbance
400	11	0.93
420	18	0.74
440	22	0.64
460	29	0.53
480	33	0.47
500	40	0.39
520	48	0.34
540	49	0.3
560	53	0.27
580	57	0.24
600	44	0.35
620	62	0.2
640	65	0.18
660	67	0.17
680	69	0.16
700	70	0.15
720	74	0.13
740	76	0.12
760	76	0.11
pH	8.75	

(i) A2

Wavelegth	Transmittance	Absorbance
400	2	1
420	5	1.3
440	8	1.07
460	12	0.89
480	17	0.76
500	22	0.65
520	26	0.58
540	31	0.5
560	36	0.44
580	41	0.38
600	46	0.33
620	47	0.32
640	52	0.28
660	54	0.27
680	60	0.31
700	66	0.18
720	70	0.15
740	72	0.14
760	73	0.13
pH	8.57	

(i) A3

Wavelegth	Transmittance	Absorbance
400	19	0.72
420	24	0.61
440	29	0.52
460	34	0.46
480	39	0.41
500	44	0.35
520	46	0.34
540	50	0.3
560	54	0.27
580	57	0.24
600	60	0.22
620	62	0.21
640	63	0.2
660	66	0.18
680	69	0.16
700	74	0.13
720	74	0.13
740	74	0.13
760	76	0.12
pH	8.17	

(i) A4

Wavelegth	Transmittance	Absorbance
400	32	0.48
420	39	0.41
440	44	0.35
460	49	0.3
480	55	0.26
500	60	0.22
520	62	0.2
540	66	0.17
560	70	0.15
580	71	0.15
600	74	0.13
620	73	0.14
640	78	0.11
660	78	0.1
680	81	0.09
700	82	0.08
720	83	0.08
740	82	0.09
760	85	0.07
pH	8.35	

(i) A5

Wavelegth	Transmittance	Absorbance
400	27	0.56
420	32	0.49
440	37	0.43
460	42	0.37
480	48	0.31
500	52	0.28
520	54	0.26
540	58	0.23
560	62	0.2
580	64	0.19
600	68	0.16
620	69	0.16
640	72	0.14
660	71	0.14
680	73	0.13
700	77	0.11
720	79	0.1
740	72	0.14
760	80	0.09
pH	7.95	

		(ii) B1			(ii) B2			(ii) B3			(ii) B4			(ii) B5	
	Wavelegth	Transmittance	Absorbance	Wavelegth	Transmittance	Absorbance	Wavelegth	Transmittance	Absorbance	Wavelegth	Transmittance	Absorbance	Wavelegth	Transmittance	Absorbance
	400	18	0.74	400	11	0.95	400	17	0.76	400	38	0.42	400	18	0.74
	420	26	0.58	420	15	0.8	420	23	0.64	420	40	0.39	420	21	0.67
	440	30	0.51	440	21	0.68	440	29	0.3	440	49	0.3	440	27	0.56
	460	37	0.43	460	26	0.57	460	34	0.46	460	52	0.28	460	32	0.49
	480	41	0.39	480	31	0.5	480	40	0.4	480	58	0.23	480	36	0.44
	500	47	0.34	500	36	0.43	500	44	0.35	500	63	0.2	500	41	0.39
	520	48	0.31	520	41	0.39	520	48	0.31	520	64	0.19	520	44	0.35
	540	45	0.34	540	46	0.34	540	53	0.27	540	68	0.17	540	48	0.31
	560	58	0.23	560	50	0.3	560	57	0.24	560	70	0.15	560	52	0.28
50% Greywater	580	62	0.2	580	53	0.27	580	60	0.22	580	72	0.14	580	55	0.25
	600	64	0.19	600	57	0.25	600	64	0.19	600	75	0.12	600	58	0.23
	620	64	0.19	620	63	0.2	620	66	0.18	620	77	0.11	620	61	0.21
	640	67	0.17	640	62	0.21	640	66	0.18	640	78	0.11	640	63	0.23
	660	70	0.15	660	65	0.22	660	68	0.17	660	79	0.1	660	65	0.19
	680	71	0.14	680	67	0.17	680	67	0.17	680	80	0.1	**680**	**67**	**0.17**
	700	71	0.14	700	71	0.15	700	72	0.14	700	80	0.09	700	71	0.15
	720	74	0.13	720	71	0.15	720	77	0.11	720	83	0.08	720	71	0.15
	740	77	0.11	740	71	0.15	740	74	0.13	740	81	0.09	740	69	0.16
	760	78	0.11	760	74	0.13	760	78	0.11	760	83	0.08	760	72	0.14
	pH	8.29		pH	8.05		pH	8.03		pH	7.91		pH	8	

		(iii) C1			(iii) C2			(iii) C3			(iii) C4			(iii) C5	
	Wavelegth	Transmittance	Absorbance	Wavelegth	Transmittance	Absorbance	Wavelegth	Transmittance	Absorbance	Wavelegth	Transmittance	Absorbance	Wavelegth	Transmittance	Absorbance
	400	85	0.07	400	84	0.07	400	93	0.03	400	89	0.05	400	91	0.04
	420	96	0.02	420	88	0.05	420	95	0.02	420	93	0.03	420	89	0.05
	440	91	0.04	440	89	0.05	440	91	0.04	440	94	0.02	440	94	0.02
	460	92	0.03	460	93	0.03	460	95	0.02	460	94	0.03	460	95	0.02
	480	91	0.04	480	94	0.02	480	96	0.02	480	95	0.02	480	96	0.02
	500	97	0.01	500	97	0.01	500	99	0	500	98	0.01	500	98	0.01
	520	98	0.01	520	95	0.02	520	96	0.02	520	97	0.01	520	96	0.02
	540	97	0.01	540	96	0.02	540	97	0.01	540	98	0.01	540	97	0.01
	560	98	0.01	560	97	0.01	560	97	0.01	560	98	0.01	560	98	0.01
100% Tap Water	580	98	0	580	97	0.01	580	97	0.01	580	99	0	580	98	0.01
	600	98	0.01	600	97	0.01	600	98	0.01	600	97	0.01	600	98	0.01
	620	99	0	620	95	0.02	620	98	0.01	620	98	0.01	620	99	0
	640	99	0	640	89	0.05	640	93	0.03	640	97	0.01	640	97	0.01
	660	98	0.1	660	92	0.03	660	96	0.01	660	98	0	660	96	0.01
	680	99	0	680	95	0.02	680	99	0	680	99	0	680	98	0.01
	700	99	0	700	94	0.02	700	97	0.01	700	98	0.01	700	94	0.03
	720	98	0.01	720	99	0	720	100	0	720	99	0	720	92	0.03
	740	99	0	740	97	0.01	740	98	0.01	740	98	0.01	740	97	0.01
	760	98	0.01	760	98	0.01	760	98	0.01	760	99	0	760	98	0.01
	pH	7.3		pH	7.47		pH	7.62		pH	7.35		pH	7.57	