Renewable Waste Water Filtration System with Phytoremediation Used in Aquaculture of Freshwater Ornamental Fish

Charlotte Palao, Glyda Aricon Marquez, Kenneth Ibasco, Lady Claudette Ferrer and Patricia Sagge
Industrial Engineering Department
Technological Institute of the Philippines
363 P. Casal, Quiapo Metro Manila, Philippines
misscjpalao@gmail.com, glydamarquez@gmail.com, engrkennethibasco@gmail.com, claudette.ferrer@gmail.com, pdsagge08@gmail.com

Maria Teresa B. Mendoza
Industrial Engineering Department
Technological Institute of the Philippines
363 P. Casal, Quiapo Metro Manila, Philippines
mariateresa.mendoza@tip.edu.ph

Abstract

For many years, researchers improve the maintenance system of all aquaculture technology including the best idea for water maintenance and sustainability. The study is coming from a premise that the prevalence of certain factors such as pH and temperature affects water quality for pond and aquarium system. With this epistemology, the study posits that the idea of combining five different existing filtration technologies to create a new filtration technology system that will minimize the effort of performing manual maintenance procedure of keeping freshwater ornamental fish. The logic behind this idea is to choose the best characteristics of existing design of filtration system and eliminate characteristics that contribute to the negative side. Using experimental method, the proponents considered material selection and system design in order to improve the potency of a design filtration unit which greatly affects amount of energy consumed and huge volume of water consumption. Testing was performed to validate the efficiency of materials along with their characteristics. Results of the study revealed that waste water can be renewed with the use of filtration media classified as mechanical, chemical and biological. The results of the study were contributory to improve the effectiveness of water treatment by introducing additional treatments in the mechanical filtration, proposing a chemical treatment in one of the stages, and boosting the biological absorbance of waste nutrients by applying Phytoremediation. The study suggests that water quality is the key to a healthy livestock.

Keywords
Aquaculture Technology, Aquarium System, Filtration Technology, Phytoremediation

Chapter 1
THE PROBLEM AND ITS BACKGROUND

1.1 Introduction

Aquaculture in the Philippines has a long history that involves many species and farming practices in diverse ecosystems. It is a controllable and manageable production system (Aypa 1995). Most of the production comes from the farming of fish and other marine organisms. Philippines is also known for breeding different ornamental fish which are later on used as pets, home decoration and as well as for business purposes. However, according to FAO, the

global position of the Philippines in aquaculture production has reduced and fallen from 4th place in 1985 to 12th place currently.

The future growth of Philippine aquaculture may not be sustained unless new markets are developed, market competitiveness is strengthened and farming risks are reduced. In this age of international trade and competition, the Philippine aquaculture industry needs to plan and implement a development and management program with a global perspective. The idea of creating an innovative way of keeping aquarium fish and providing them with the most natural environment will increase its quality, output, and production through breeding. The modification of a "typical" filtration of both household and Farm Aquarium and Concrete ponds will be an aid to cut off the quantity of waste and consumption of too much water. It also promotes the minimization of work and time consumed by people under maintenance system or could even increase the efficiency of performance.

1.2 Research Background

According to Environmental Management Bureau (EMB), 47% out of 127 freshwater bodies sampled were found to have good water quality. However, 40% of those sampled were found to have only fair water quality, while 13% showed poor water quality. With this being stated, fish farms are affected and also the quality, output, and production of freshwater fishes.

Nevertheless, some fish farms are built from concrete where consumption of water is of great extent due to maintenance. Waste water from fish farms can be harmful to the receiving water body due to contamination and large amounts of these is a significant problem. For that reason, having an efficient and effective water filtration system will not only reduce waste water production but will also reduce maintenance and other unnecessary costs. In addition, there are already targeted companies that will adapt this filtration system;

a) Pet City, Hobby Specialist; Located at Cartimar, Pasay
b) G.I.G Fish Island Aquarium Manufacturing and Accessories Corporation

The said companies see the effect of having poor water quality especially on their livestock. Mortality rate are high and could even reach up to 70% of loss if water qualities are not maintained according to G.I.G. And based on their experience, water quality requires an efficient water treatment system to avoid these cases. On the positives side, there are existing designs in the market that is used in water treatment but there are pro's and con's in using these technologies.

1.3 Statement of the Problem

The lack of proper water filtration system affects the quality and mortality of livestock that are kept in concrete ponds and tanks. The improper selection of filtration system affects the efficiency in removal of toxic nitrogenous compounds such as Ammonia, Nitrite, and Nitrate resulting to unstable water parameters and appearance of various water borne disease that kills livestock.

1.4 Objectives of the Study

General Objective
The overall aim of the study is to create an innovative filtration technology system that will minimize the effort of performing manual maintenance procedure of keeping freshwater ornamental fish.

Specific Objective
Specifically**,** the study aims:

- To construct an aquarium filtration system that combines vital features of existing water treatment technologies;
- To minimize the excessive use of water and provide better water quality;
- To stabilize TDS in water;
- To reduce the presence of toxic nitrogenous compounds from water.

1.5 Scope and Delimitation of the Study

This research covers the following concepts and field; This study focuses only in the water treatment for freshwater ornamental fish in identifying the best materials used in the filtration unit. Another consideration for this study is that there should be no other treatment or additives for aquarium fish involved because this is purely focused in mechanical, biological and solid chemical treatment conditions. The said research is focused only in the maintenance of keeping freshwater ornamental fish and not for breeding purposes. Also, the treatment used by this filtration eliminates nitrogen

containing compounds, or specifically ammonia, nitrite, and Nitrate only. Since this study involves phytoremediation, plants to be used for this treatment must be ornamental and not for human consumption.

1.6 Significance of the Study

To the Economy

Through this research, people will have an easy way of create and selecting the most appropriate type of filtration that they can install on their Aquarium or pond system. This material selection and system modification will help minimize the consumption of goods and man power on a certain task.

To the Field of Science and Engineering

Researchers will be encouraged to look for deeper concepts on which part of this study can be improved. Their knowledge and specialization will be very helpful and can create future breakthroughs in Science and in the Field of marine and Aquatic conservation as well as extend the flexibility in the field of Engineering.

To the Environment

Materials and processes from this study will lead to the conservation of natural resources particularly in water treatment where consumption is minimized with a small amount of waste to be released in the environment.

To the Government

This study could help the government to treat waste water with minimal use of chemical treatments and promote awareness that there is an existing specie of freshwater ornamental fish that needs an adequate source of water. Through this, it can also be a way of creating livelihood programs in the community.

To the Institution

This study can be a reference for those students who wanted to perform researches relative there to.

Chapter 2
REVIEW OF RELATED LITERATURE AND STUDIES

Considering the natural condition of water in ponds, rivers, lakes and other forms of water, fish waste, produced by breathing and eliminating, is diluted by vast volume of water and movement. In an aquarium system, the “keeper” must perform regular maintenance of water by doing regular nutrient level check-up, temperature checking, pH checking, algae removal, adding water conditioners, and consistent removal of waste and replenishing it back with clean water. There are certain techniques that can be used in order to minimize these conditions. Ideas could be manipulated or combined to produce a new way of restoring good water quality with lesser consumption of new stock and less maintenance. Considering the idea of filtration, the type applicable to an aquarium or pond system depends on the type of fish must be. There saltwater and fresh water condition. There are fish that thrives in Soft water (Lower pH) and hard water (higher pH). This is the challenging part- choosing the best filter that suit a specific condition.

The truth about renewing waste water is very difficult because a highly designed filtration system must be considered. For instance, the presence of high levels of Nitrogen compounds such as Ammonia, Nitrite and Nitrate are very dangerous because these compounds targets fish membranes and even blood cells of livestock. Therefore, in order to eliminate that, installations of equipment containing sufficient filter media must be taken seriously otherwise, fluctuations in pH and toxicity levels can be observed.

Another alternative way is through Phytoremediation. It is the used of aquatic plant to remove inactive metals and metal pollutants from contaminated soil and water. Phytoremediation is an effective and affordable technology, it is also environmentally friendly and economical. (Tangahu et al. 2011). Phytoremedation is the name given to a set of technologies that use plants to clean contaminated sites. [7] This is one of the most popular ways of eliminating toxins in water serving as natural filtration. This commonly known as Aquaponics. This is more popular in some agricultural industries because of the cutting cost in buying high-end filtration media. It is also popular in different country to remediate the problem in pollutions. In India they use phytoremediation technology to remove toxic chemicals that came from mines water. Some researcher use water hyacinth to remediate the water damaged that contains high level of toxic hexavalent chromium (Cr VI). This water plant that they use to remediate the water problem is called Eichhornia crassipes. This water hyacinth was observed to effectively remove 99.5 % of CR (VI) of the polluted water that came from mines in just 15 days. The plant also removes a high amount of total dissolved solids (TDS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) in water. (Saha et al. 2016). In Malaysia a research has found to remove turbidity up to 88% in Malaysian water using a natural coagulant that is called Moringa oleifera seeds. This shows that using phytoremediation is effective in eliminating toxins in water and use in water treatment industries. [8]. In Nigeria a study about the use of phytoremediation management in oil impacted land such as Ubeji and Alesa Eleme communities of Niger Delta region. They use a carpet grass called (Axonopus compressus) as a

treatment for the land area that is mostly impacted with crude oil. Their study resulted in 66% loss of hydrocarbon from crude oil-impacted soils of Ubeji and Alesa Eleme. [9]

The "core" of any types of aquarium or pond system is the Filtration (Chu 2016). As we all know filtration is a way of removing debris and other components inside water by the use of different medium. Filtration plays an important role in the natural treatment of groundwater as it percolates through the soil. It is also a major part of most water treatment. Groundwater that has been softened, or treated through iron and manganese oxidation, requires filtration to remove floc created by coagulation or oxidation processes. Since surface water is subject to run-off and does not undergo natural filtration, it must be filtered to remove particles and impurities. Filtration can be compared to a sieve or micro-strainer that traps suspended material between the grains of filter media. However, since most suspended particles can easily pass through the spaces between grains of the filter media, straining is the least important process in filtration. Filtration primarily depends on a combination of complex physical and chemical mechanisms, the most important being adsorption. Adsorption is the process of particles sticking onto the surface of the individual filter grains or onto the previously deposited materials. Forces that attract and hold particles to the grains are the same as those that work in coagulation and flocculation. In fact, coagulation and flocculation may occur in the filter bed, especially if coagulation and flocculation before filtration was not properly controlled. Incomplete coagulation can cause serious problems in filter operation. According to Shalini, a pond or any aquarium design must consist of three (3) stages; Mechanical, Chemical, and Biological filtration.

1. **Mechanical Filtration**. The purpose of mechanical filtration is to remove organic and inorganic matter suspended in pond/ aquarium water that causes turbidity and nitrate build-up once decomposed in water. Examples of materials which are used as mechanical filtration are the following:

- ***Micron Cartridges***. Cartridge filtration units generally operate most effectively and economically on applications having contamination levels of less than 100 ppm. For heavier contamination applications, cartridges are normally used as final polishing filters
- ***Poly Filter Pads***. Poly Filter is for filtering and purifying both fresh
- and saltwater aquariums. It is a formulation of a special patented material bonded to a synthetic matrix that can absorb and adsorb contaminants and other toxic materials. Poly Filter is nontoxic and harmless to biological filtration because it allows a sufficient amount of ammonia to reach the biological filter to sustain the bacteria culture. Provides a supplemental means of removing ammonia when the biological filter is unable to break down the excess ammonia.

- *Sponge and Foam Media*
- *Cleaning pads as filter media*
- *Coarse Gravel & Ceramic Rings*
- *Mechanical Filter Media Care*
- *Aquarium floss, wool, or fiber*

2. **Chemical Filtration**. An effective way of removing dissolved particles such nitrate, discoloration, foul smell and odor, and etc. The following are the most common materials used in treating these materials:

- ***Activated Carbon.*** Activated carbon for the aquarium is a form of carbon that is usually made from bituminous coal, lignite or wood. It is often abbreviated as AC on the forum. The primary use of activated carbon, or AC, is to filter the aquarium water of foul odors, yellowing compounds (DOC) and to remove medications from the water column. Some hobbyists use it regularly and some don't use it at all. Some swear at it and some swear by it. I'll try to give you the basic info to get you started and you can decide for yourself whether or not you think it's something you will want to use.
- ***Resins, ion exchangers, synthetic polymers, or adsorbents***. Polymeric adsorbent resins exhibit specific properties and selectivity for purification and extraction of target molecules, and are each very different from one another. Purolite products are available in a broad range of matrices and porosities, and our portfolio of adsorbent resins presents solutions for many industrial applications—such as the removal of organic compounds from aqueous streams—and are well established in industries such as food and pharmaceutical processing, flavor and fragrance extraction, and environmental applications.

- *Purigen*
- *Boyd's Chemi-Pure*
- *THE Poly Pad*
- *API Bio-Chem Zorb*
- *Fluval Clear Max*
- *AmmoChips (AmmoCarb, Zeolite)*
- *Mineral Blocks (Wonder Shells)*
- *Water Softening Products*

3. **Biological filtration**. The part where organic matter is decomposed by beneficiary bacteria in a form of

nitrification cycle. Good bacteria will host porous materials and multiplies rapidly from consuming dissolve organics in pond and aquarium water. Materials used in this type of filtration are as follows:

- *Cured Live Rock Crumbles*
- *Volcanic Rock*
- *Matrix*
- *Algone*
- *BioPlastics*
- *Aqua Clay*
- *MarinePure Blocks*
- *Bio Filter Media Care*

These are the three basic content of a freshwater aquarium set-up. But in some cases keepers install Fractional distillation units and UV-Bulb at the end of the filtration system. This will help in further removal of particles that was not captured in the mechanical filtration. UV-Bulb is capable of killing algae spores preventing ponds and algae to grow as well as pathogens that could infect/infest livestock.

In the current situation, there are different types of filtration available that is used to clean water inside the tank. It is classified into two (2) major categories; Internal; and External Filtration.

1. Internal Filtration

According to Jim C. Chu, a Senior Aquarist at Pro Aquariums, he stated that it is not highly recommended to use this kind of filtration because of inconvenience in maintaining the system. Also, it is not very efficient because it partially cleans the volume of water. This type of filtration consumes space of the aquarium required for the livestock to grow. Examples of Internal filtration are the Following:

A. Undergravel filters. Underground filters are the classic filters of the past. It is designed to sit in the base of the aquarium, between the glass/acrylic and substrate, such as gravel. Collecting bacteria that live on the gravel, the water is filtered as it passes over the gravel and up the lift tubes. (See pictured under gravel filter.)

Figure 2.1 General Overview of an Underground gravel filter

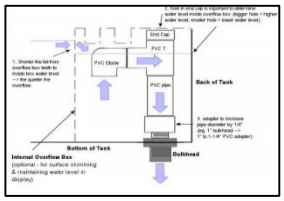

Figure 2.2 Mechanism of Undergravel Filtration

B. Sponge filtration. Sponge filtration is just a piece of sponge usually in the shape of a cylinder, with an open tunnel goes through in the middle. The sponge filter works when it is fully under the water. It can be powered by either an air stone or a water pump. The idea is to use the air pump or water pump to pull the water through the sponge filter, and thus starting a biological filtration. This is greatly used for breeding.

Figure 2.3 Sponge Biological Filtration

2. External Filtration

This type of filtration is found outside the aquarium. A pump or a device is installed to collect water from the tank and transfer it to the filtration unit. Water will return back on the tank with dirt and other particles removed. This is the most efficient and useful type of filtration for aquarium. Examples are the following

A. Canister Filtration

Figure 2.3 Canister Filtration

Canister Filters Canister filters are pressurized units that perform all three types filtration. Available in two types – either a complete unit that includes its own pump, or in a modular form that requires an additional pump. The modular units are useful when combined with other types of filtration, such as a wet/dry filter (discussed below). The complete units use a tube as the water intake and typically a spray bar for the water return. The water entering the filter will first pass through a mechanical media such as floss and will then be forced through the chemical media such as carbon. After the chemical filtration is complete, the water then enters the last chamber containing the biological media where the nitrogen cycle is completed prior to the water returning to the aquarium. Canister filters have become very popular choices for filtration. They have distinct advantages over other filter types. Point in case, they are housed underneath the aquarium in the cabinet stand, which leaves more room in the aquarium for fish and decorations. Without equipment in the aquarium, fish enjoy a more natural environment and less noise pollution in the water due to noisy hang-on filter motors.

A. Protein Skimmer

Also called a foam fractionator, a protein skimmer removes dissolved organic compounds that if not removed can breakdown in the aquarium or filter adding to the biological load on an aquarium. Protein skimmers remove these pollutants completely from the water using air bubbles, powered by water or air pump, or both. As air and water are mixed in the skimmer chamber the bubbles rise and take with them the dissolved organics that are attracted to the bubble surface. When the bubbles with the proteins, amino acids and pollutants bubble up the tube into the collection cup they are completely removed from the aquarium. A protein skimmer typically catches harmful matter that conventional filtration cannot remove.

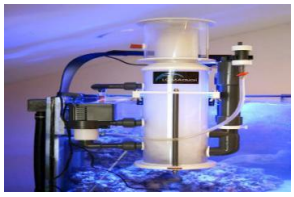

Figure 2.5 Protein Skimmer

B. Sump Filtration

A sump is not actually a filter; it just houses the filtration system of your choosing. You have to install a circulation pump inside of the sump if it is submersible or plum it adjacent to the sump if it isn't submersible. You can purchase sump setups or build one of your own. This will be the basis of this research but in a larger scale. Water is then pumped from the sump and into the aquarium and then back into the sump. If you do it this way, the pump can run constantly. If there isn't water getting into the sump, the pump will need to be switched on and off as the sump collects the water. To me, this just seems like a pain. You would have to install a float switch, as found in old school toilets, or switches that automatically turn on when the water begins to get lower.

Figure 2.6 Sump Filtration

Existing Filtration Designs

A traditional fish farm with ponds or tanks, has an inlet and outlet, and water is used a few times or it´s a simple flow through system. If water is treated to improve quality and used again, then it´s considered a re-use or recirculation

system. However, as simple it seems to define a recirculated aquaculture system (RAS), the more complicated it seems to have common nominations as how to evaluate the technology behind. The purpose of this booklet is to describe water purification technologies used in aquaculture facilities, with special emphasis on microfiltration. Bio filters combined with mechanical filtration are the essential parts of any water purification system. There are many variations and combinations. If there is a"vary" sign in above label, it means fluctuations, which is not acceptable in a commercial fish farm. Low, medium and high are relative figures, but it indicates water characteristics which may be critical for a given fish species. e.g. if you plan to operate a Tilapia farm, you may not worry about a high concentration of suspended solids, as long as BOD, ammonia and nitrite is low. A trout or hatchery manager will worry a lot about suspended solids and they will have to look for a combination of biological and mechanical filters to secure low turbidity.

Selection of Materials (States of Nature)
Enable for users to choose materials used in the filtration, different aspects must be considered;

a) ***Cost.*** Renewal of waste water must "Cut-Cost" in terms of consumption of energy and Water. Therefore, Choosing the most economical (both useful and cost sensitive)
b) ***Effectivity***. The key to effective filtration capable of eliminating toxic in water is the use of effective filter media. Materials that will be selected must confirm on the needs of naturalizing the environment and removes nutrients fast.
c) ***Significance.*** In order to increase efficiency in renewing water, materials must contribute an important function.
d) ***Convenience.*** The target of this aspect is to lessen the stress and work for the keepers who handle livestock.

2.2 Research Paradigm

Table 2.1 Research Paradigm

INPUT	PROCESS	OUTPUT
• Observing the environment • Identifying the problems • Collecting information • Brainstorming	• Material selection • Modification of existing designs • Testing • Records of data • Prototype	• Renewable Waste Water and filtration with Phytoremediation used in Aquaculture of Freshwater Ornamental Fish

Table 1 shows the research paradigm that is consisted of 3 stages which are the input, process and output. In input the researchers observe the environment in aquaculture industry especially in water filtration. Then identify the problems in water filtration, collect information and brainstorming. Then in process the researchers do a material selection, modification of existing designs in water filtration, records data and prototype. For the output the researchers come up for research paper with a title of "Renewable Waste Water and filtration with Phytoremediation used in Aquaculture of Freshwater Ornamental Fish".

Chapter 3
RESEARCH METHODOLOGY

3.1 Research Design

This Study is designed to create a filtration technology system that meets the requirement of freshwater ornamental fish with the help of Phytoremediation. The concept is made from the combination of five (5) different existing aquarium/pond filtration in the industry: Trickle filter, Sump Filter, Canister Filtration, R.O system, and Aquaponics. By selecting materials, the researchers can maximize the efficiency of filtration that targets the elimination of unwanted nutrient levels such as ammonia, nitrite, nitrate, and stabilize total dissolved solids (TDS) level of water. Considering this material selection and system design, it will help improve the potency of a design filtration unit which greatly affect amount of energy consumed and huge volume of water consumption. This will also help in man-power consumption to minimize maintenance task. This research will also be connected to Project Design created by Industrial Engineering Students of the Institution. Results from experimental testing will be obtained and used as a reference that confirms the theory and assumptions from the previous chapters.

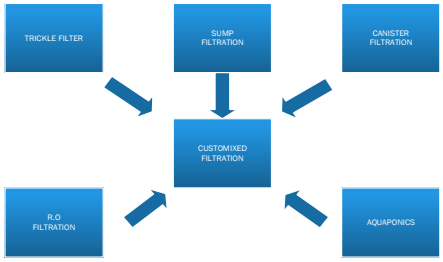

Figure 3.1 Concept of Filtration System

3.2 System and Process Diagram

Initial process from existing filtration in the market

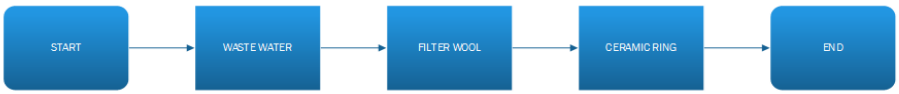

Figure 3.2 Existing Process of Filtration

On the initial investigation, the current market offers a three (3) step filtration which happens to be inefficient on the elimination of suspended dirt and nitrogenous matter in tank/pond aquarium system. Furthermore, it consumes a lot of water volume because accumulation of unremoved nutrients will occur and can only be prevented by multiple water changes. The given setting is temporary and requires manpower.

3.3 Proposed System and Filtration Process

The Researchers added three other process on the system from five (5) different filtration units used in the aquaculture and fish keeping community. The following process are described;

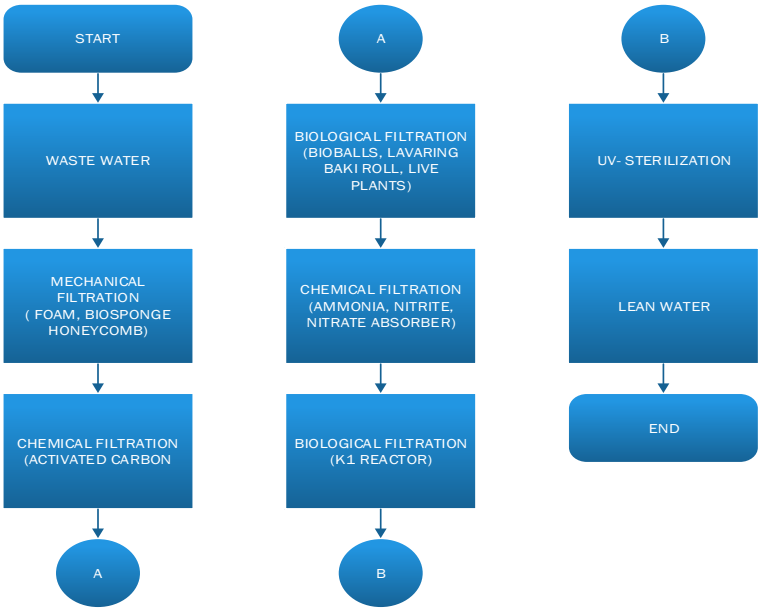

Figure 3.3 Proposed System of Filtration

3.4 Material Options

A. **Mechanical Filtration Process** - this process is found on the second process of Figure 3.2. It is highly suggested to put on the initial stage of filtration to prevent suspended materials on clogging and accumulating on other parts of filtration.

Table 3.1 Material Options for Mechanical Filtration Process

Stage	Material	Use/Purpose
1	Black Biosponge Color: Black	- Made from PU polyurethane - Traps larger size organic matter. Host Nitrifying Bacteria that consumes toxic nitrogenous materials
2	12-15 micron Filter Wool Color: White	- Made from Polyester fibers - Removes Small size particles suspend in aquarium water
3	Honeycomb Filter Matt Color: white	- Removes suspended materials - Host nitrifying bacteria - With anti-clog technology

B. Chemical Filtration - this is found on the third (3rd) and fifth (5th) process in system (Figure 3.2) Chemical Filtration is used to remove compounds dissolve in aquarium water which are not removed in the mechanical filtration. This part will support the efficiency of treatment;

Table 3.2 Material Options for Chemical Filtration Process

Process(refer to diagram B)	Material	Use
3rd	Activated Carbon	- Made from activated carbon - Removal of coloration and unwanted odor - Removes Organic Compounds in aquarium water
5th	Nitra-sorb material	- Made from Ion Exchange Resin - Removal of Ammonia, Nitrite and Nitrate from water - Clarifies water

C. Biological Filtration/ Phytoremediation - the use of nitrogen fixating bacteria is found in almost all process in the filtration system. However, there are two parts in the filtration where in biological process mostly concerned. Process 4 and process 6 focuses on this concept. Phytoremediation is also used in Process 4 as another aid of filtration-Phytoremediation.

Table 3.1 Material Options for Chemical Filtration Process

Process 4 (refer to Fig 3.2) STAGES	Material	Use/ Purpose
1	Photos Plant	- Adapted from the ideology of Aquaponics - This plant efficiently absorb the unwanted nutrients present in aquarium water to prevent from converting into other toxic compounds
2	BioBalls	- This honeycomb like plastic balls floats in water and cultures good bacteria that absorbs nitrate in water
3	Lava Ring	- Made from igneous materials that contains minerals that stabilizes water condition. It is porous in nature which host nitrogen fixating bacteria.
A	Baki Roll	- Made from Porous ceramic and placed at the bottom of the biological filtration. This materials prevent clogging of other media as well as hosting of nitrogen fixating bacteria.

For Kaldness(K1) Reactor,

Table 3.1 Material Options for Chemical Filtration Process

Process 6	Material	Purpose
	Kaldenss(K1) Media	- This material is circulating/floating inside an improvised K1 reactor. - This Materials host huge amount of Nitrifying bacteria that helps in the absorption f remaining nitrates in the water untreated from other stages of the filtration

D. UV Sterilization- this device is used to remove free swimming bacteria and pathogens that causes disease in the livestock and prevent green water (algae) bloom in the aquarium giving a clear water environment safe for fish and convenient for fish keepers during observation

3.5 Research Locale

Figure 3.2 *Research Locale*

This study is performed within the premise of Metro Manila specifically in Cartimar Pasay where materials and data for experimentations are obtained. Another Location to be considered is the Technological Institute of the Philippines where the course is taken and execution of ideas and knowledge for this research is compiled and presented as a formal scholastic research for the second semester. The map between two locations is shown above.

3.6 Research Instrument

To collect data, researchers used voice recorders to capture words from the consultant and used as a reference in determining what filtration materials can be used.

Testing tools

✓ ***pH Paper*.** Testing Procedure: Collect small volume of water from the main tank and from the outlet of the treated water. Put a piece of pH indicating paper on each sample and wait until changes in color occurs. Compare the color of each paper on the colorimetric table with its corresponding pH value.

✓ ***Nitrate Testing Reagent*.** Testing Procedure: Collect small volume of water from the main tank and from the outlet of the treated water. Add few drops of Nitrate color indicator on each sample and wait until changes in color occurs. Compare the color of each paper on the colorimetric table with its corresponding Nitrate value.

✓ ***Ammonia Testing Reagent*.** Testing Procedure: Collect small volume of water from the main tank and from the outlet of the treated water. Add few drops of Ammonia color indicator on each sample and wait until changes in color occurs. Compare the color of each paper on the colorimetric table with its corresponding pH value.

✓ ***Nitrate Testing System*.** Testing Procedure: Collect small volume of water from the main tank and from the outlet of the treated water. Add few drops of Nitrite color indicator on each sample and wait until changes in color occurs. Compare the color of each paper on the colorimetric table with its corresponding pH value.

✓ ***Electronic TDS tester*.** Testing Procedure: Collect small volume of water from the main tank and from the outlet of the treated water. Turn on the device and place the sensitive coil into the water samples and read the TDS value.

3.7 Statistical Tools

Mean. The collected data is added and the total will be divided by the number of samples attained from the experimentation of the design. Getting the mean of results would help in labelling the standard and basis of what value is common out of samples that are taken. Parts where mean is utilized are as follows; scores attained from choosing the materials, and on the mean of parameter readings.

Standard Deviation. There are some values that could be close or far from the mean. This computation allows the researchers to see whether the collected data are consistent or too dispersed. If the inconsistency will be judged as need of revision or change in the experiment to attain a more consistent result.

Chapter 4
PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

This part of the research will provide numerical and statistical value for the material selection. The method of scoring for alternatives will be considered in the selection of materials. The Scores are based on the importance of materials related to filtration design.

A. Biological Filtration. Criteria for Scoring: Selecting materials for Biological filtration must consider porosity and effect in pH. Scores are given by the researchers;

Table 4.1 Scoring (1- lowest; 5-highest)

Material	Student 1	Student 2	Student 3	Student 4	Average Score
Crushed Corals	2	3	1	1	1.75
Crushed Lava rock	3	3	3	3	3
Ceramic Ring	4	3	3	3	3.25
Lava Ring	5	4	5	4	4.5
BioBalls	4	4	5	5	4.5
Baki Roll	3	5	5	5	4.5

The highest score from averaging are Lava ring, Baki roll and Bioballs as best material for biological filtration. The least chosen was crushed corals. Lava ring is good for filtration because of the mineral content and the quality of porosity of this material is impeccably suited for the condition of Freshwater ornamental fish. Bioballs is lightweight and very good for Culturing Nitrifying Bacteria. Baki roll has a big surface area where good bacteria can grow abundantly. On the other hand, Crush corals is the least priority because looking on the quality that its best suited, it is better saltwater or brackish condition.

B. Mechanical Filtration. Criteria for Scoring: Selecting materials for Mechanical filtration must consider Good Mesh size and effect in pH. Scores are given by the researchers;

Table 4.2 Scoring (1- lowest; 5-highest)

Material	Student 1	Student 2	Student 3	Student 4	Average Score
Cotton Wool	4	5	5	5	4.75
Green Sponge	3	3	3	3	3
Black Biosponge	4	5	5	5	4.75
Hard mesh	3	2	2	4	2.75
Honeycomb	5	4	5	5	4.75

Three (3) of the materials are had equal scores; Cotton wool, Black Biosponge, and Honeycomb where the best materials because of the mesh size and capability to trap different sizes of particles suspended in aquarium water. While the lowest score was given to hard mesh because this is very difficult to use since it lacks flexibility.

C. Chemical Filtration

Criteria for Scoring: Selection of this material is based on how long it will last and the effectivity to eliminate nutrients from aquarium water.

Table 4.3 Scoring (1- lowest; 5-highest)

Material	Student 1	Student 2	Student 3	Student 4	Average
Activated Charcoal	5	5	4	4	4.5
Ion Exchange Resin	5	4	4	5	4.5
Zeolite	3	2	2	4	2.75
Pumice Stone	1	2	1	2	1.5
Purigen (SeaChem)	5	3	3	4	3.75

From the student evaluation, it was preferred to use Activated charcoal and Ion exchange resin as best option that the chemical filtration must have. Pumice Stone is least preferred because it has the least capability to remove nitrates.

D. Ammonia, Nitrite, Nitrate and TDS testing Results

Criteria for Scoring: The researchers performed 20 tests weekly to get the average values of the ammonia, nitrite, nitrate, and TDS after the combination of the selected materials.

4.1 Summary of the Seven-Week Testing for Nitrogenous toxic compounds

Table 4.4 Ammonia, Nitrite, Nitrate and TDS testing Results

Week 1	Ammonia	Nitrite	Nitrate	TDS
	4	5	160	950
week 7	Ammonia	Nitrite	Nitrate	TDS
test				
1	0.5	0.5	20	100
2	0.2	0.5	20	128
3	0.2	0.5	15	95
4	0.2	0.2	15	90
5	0.2	0.2	20	100
6	0.5	0.5	20	100
7	0.2	0.2	20	95
8	0.2	0.2	20	200
9	0.2	0.2	20	95
10	0.2	0.5	15	90
11	0.5	0.5	15	90
12	0.5	0.2	20	90
13	0.2	0.2	20	87
14	0.5	0.5	20	100
15	0.5	0.2	15	90
16	0.2	0.2	15	90
17	0.2	0.5	15	100
18	0.2	0.2	15	120
19	0.5	0.2	20	100
20	0.2	0.2	15	98
Average	0.305	0.32	17.75	102.9
Standard Deviation	0.14309	0.14697	2.48747	24.3555

This table contains the data gather from the initial testing and 20 continuous testing on the seventh (7th) day of testing. Standard deviation for Ammonia, Nitrite, and Nitrate are low indicating that the result is somehow consistent. On the other hand, testing for total dissolved solids has a very high standard deviation therefore shows that it has incoherent or inconsistent readings.

Table 4.5 Result for Nutrient Testing and Water Parameter reading (Summary)

Data and Results (Via Colorimetric Test) 7- weeks		
FACTOR	Initial (avg) BEFORE TREATMENT	Final (avg) AFTER CYCLE
Ammonia(Ppm)	4.0	0.2-0.5
Nitrite (Ppm)	5.0	0.2-0.5
Nitrate(Ppm)	160	20.2
TDS	950	100-150

With the combination of the selected filtration, there are significant decreases in the nutrient contents in water. The waste water treated was now safe for aquatic organisms used because the nutrient level is below the critical level.

Table 4.6 Record for Water change and Percent water removal on weekly basis

Data and Results (Water Change Record)		
FACTOR	Initial (ave) BEFORE TREATMENT	Final (ave) AFTER CYCLE
Week 1	Frequency: 3 % Water change: 50	Frequency: 3 % Water change: 50
Week 2	Frequency: 3 % Water change: 50	Frequency: 3 % Water change: 40
Week 3	Frequency: 3 % Water change: 40	Frequency: 2 % Water change: 40
Week 4	Frequency: 2 % Water change: 40	Frequency: 2 % Water change: 30
Week 5	Frequency: 2 % Water change: 30	Frequency: 1 % Water change: 0 (
Week 6	Frequency: 1 % Water change: additional due to evaporation	Frequency: 0 % Water change: additional due to evaporation)
Week 7	Frequency: 0 % Water change: additional due to evaporation)	Frequency: 1 % Water change: additional due to evaporation)

With the combination of the selected filtration, there are significant decreases in frequency of water change per week and volume consumed as per the filtration system is concerned.

CHAPTER 5
SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Summary of Findings

The researches have seen the importance of having good and proper filtration materials and system. The first finding is that the nitrogen containing compounds (Nitrate, nitrite, ammonia) is decreased more than the tolerance level if the proposed materials as mentioned in chapter 4 is combined in one (1) system. This leads to lesser consumption of water because water parameters are more stable and clarity is maintained. The results prove that it is an efficient upon activating the filtration on the second week and later on improves as good bacteria continues to culture in the biological system of the filtration. The plant which serves as the phytoremediation tool grows lush and fast indicating that it completely absorbs the nitrogen containing compounds and other nutrients found in tank water. TDS value also had significant changes which contributes on the benefit of the effect.

General Objective: The overall aim of the study is to create an innovative filtration technology system that will minimize the effort of performing manual maintenance procedure of keeping freshwater ornamental fish.
The conceptual framework of this study as well as its analysis has paved the way for the researchers to consider that the several parts involved in the conceptual framework also belong to those factors that the researchers considered in performing this study. The identified factors are the following:

1. ***Selection of the best materials and features from existing filtration units***
2. ***Effects of the design filtration system in managing toxic nutrient levels in water***
3. ***Reduction of water consumption for keeping fish***

This implicates that choosing the right filtration for a specific water condition is very important because some materials can affect other water parameters like pH and hardness which is not suitable in some other aquatic organisms. Checking the market for availability of materials as well as the function of that specific materials must also be considered to achieve full scale efficiency of the product.

Specific Objectives:

a. **To construct an aquarium filtration system that combines vital features of existing water treatment technologies.** The researchers were able to produce a prototype based on combining the following features of existing water treatment technologies, such materials were able to treat water from the aquarium used in Aquaculture:
   - Honey Comb
   - Cotton Wool
   - Resins
   - Activated Charcoal
   - BioBalls
   - Photos Plant

b. **To minimize the excessive use of water and provide better water quality.** By the use of this design, it is visible that in several weeks of cycling water, the volume of consumption has significantly reduced from one hundred (100) percent down to almost zero amount of water.
c. **To stabilize TDS in water.** The designed filtration was able to minimize the Total Dissolved Solid(TDS) in great amounts.
d. **To reduce the presence of toxic nitrogenous compounds from water.** The levels of Ammonia, Nitrite and Nitrate was almost undetectable down to the most tolerable values

5.2 Conclusion

From the current study, researchers conclude that used water from aquarium can be renewed with the use of filtration media classified as mechanical, chemical and Biological. The selected materials such as Lava ring, Honey comb Matt, K1-media, are the best used natural-biological removal of Nitrogen compounds such as Nitrate. In the chemical filtration, Addition of carbon and Resin can improve water quality. Phytoremediation in terms of using the POTOS plant is really effective because the fast growth of plant indicates absorbance of toxic nutrients. Lastly, it is best to use different types of filtering materials in the mechanical part of the filtration since particles have different sizes and a specific mesh is design to capture base on the size present in water. Water quality is the key to a healthy livestock. With this design it can help improve the Aquaculture society on the given problems.

5.3 Recommendation

We highly recommend this study to be used in designing filtration or water maintenance system because of its efficiency of removal. We strongly suggest that there should be more students who conduct research that includes the fusion of biological science and engineering concepts. The world needs to have advanced inventions that helps improve the quality of environment since nowadays, the major concern is the detrimental effects of pollution specifically, water pollution. If ever the design will get thorough improvement, there are such points that it could be a solution to this problem.

REFERENCES

Aypa, S. M. (1995). Aquaculture in the Philippines. *SEAFDEC,*137-147. Retrieved November 29, 2018.

Chu, J. C. (2016). Filtration. *ProAquariums,*8-16. Retrieved November 29, 2018.

E. Ighovie and E. Ikechukwu, "Phytoremediation of Crude Oil Contaminated Soil with *Axonopus compressus* in the
F. Niger Delta Region of Nigeria," *Natural Resources,* Vol.5 No.2,2014,pp.59-67.
doi: 10.4236/nr.2014.52006

Filtration and reuse of water in fish farming. (2018). Retrieved November 29, 2018, from https://aquafeed.ru/sites/aquafeed.ru/files/files/filtry_i_povtornoe_ispolzovanie_vody_v_rybovodnyh_hozyaystvahen.pdf

Introduction into a fascinating hobby. (2017). *EHEIM: AQUARIUM GUIDE,*10-13. Retrieved November 29, 2018

Narayasamy, S. and Saud, H. (2014) Water Phytoremediation by Sedimentation Using Moringa oleifera Seed Powder to Remove Water Turbidity in Malaysia. *Journal of Agricultural Chemistry and Environment*, **3**, 74-79. doi: 10.4236/jacen.2014.32009.

Saha P, Shinde O, Sarkar S.. "Phytoremediation of industrial mines wastewater using water hyacinth" 2016 Aug 23. *Lnt J Phytoremediation*. 2017 Jan 2:19(1):87-96.[PubMed]

Tangahu B, Abdullah S, Basri H, Idris M, Anuar N, Mukhlisin M. "A Review on Heavy Metals (As, Pb, and Hg)

Uptake by Plants through Phytoremediation". *International Journal of Chemical Engineering*. *Volume 2011*, Article ID 939161, 31 pages. http://dx.doi.org/10.1155/2011/939161

U. S. Environmental Protection Agency, "*Introduction to Phytoremediation*," National Risk Management Research Laboratory, EPA/600/R-99/107, 2000, http://www.clu-in.org/download/remed/introphyto.pdf.

Biographies

Charlotte Palao, Glyda Aricon Marquez, Kenneth Ibasco, Lady Claudette Ferrer and **Patricia Sagge** are the senior Industrial Engineering students of Technological institute of the Philippines, Manila. They are the advisees of Maria Teresa B. Mendoza under the course IE 506 IE Design Project 2, the culminating design course in the RE2012 Curriculum (a five-year curriculum) of the Industrial Engineering Program.

Maria Teresa B. Mendoza is the current head of Industrial Engineering Department of Technological Institute of the Philippines, Manila. She graduated Master in Industrial Engineering and Management at Polytechnic University of the Philippines. Currently she is writing her dissertation for PhD in Technology Management at Technological Institute of the Philippines, Manila. She handles IE students' design projects, community and company-based undergraduate researches as adviser.