WATER TREATMENT TECHNOLOGY AND WASTE WATER PURIFICATION

WATER BIOFILTER

THE GRADUATION PROJECT REPORT SUBMITTED
TO THE
DEPARTMENT OF BIOENGINEERING
OF
NEAR EAST UNIVERSITY

BY

RIDA IDLIBI

MTHABISI T.G MOYO

In Partial Fulfillment of the Requirements for
The Degree of Bachelor of Science
in
Bioengineering Department

NICOSIA 2017

WATER TREATMENT TECHNOLOGY AND WASTE WATER PURIFICATION

WATER BIOFILTER

THE GRADUATION PROJECT REPORT SUBMITTED
TO THE
DEPARTMENT OF BIOENGINEERING
OF
NEAR EAST UNIVERSITY

BY

RIDA IDLIBI

MTHABISI T.G MOYO

In Partial Fulfillment of the Requirements for
The Degree of Bachelor of Science
in
Bioengineering Department

NICOSIA 2017

DECLARATION

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name:
Signature:
Date:

ACKNOWLEDGEMENTS

We would like to thank the Chairperson of Bio and Biomedical Engineering Department Assoc. Prof. Dr. Terin Adali who has groomed us to be educated individuals who evidently has become our mentor as she has been with us for the past 4 years.

We would like to thank our supervisor MSc Chidi W Nwekwo who has shown a constant source of encouragement, patience, and support as he guided us through this project. We are also thankful for the contributions and comments the teaching staff of the Department of Bio and Biomedical Engineering.

We are especially grateful to our parents for confiding in us as being constant sources of encouragement and helped lift our self-esteem. Here also we would like to thank our colleagues and friends at the Department of Bio and Biomedical Engineering who helped us in one way or the other.

This research was generously supported by the Department of Bio Engineering of the Near East University. We are grateful to all supporters.

ABSTRACT

Improving water quality almost always involves some sort of filtration process. Filtration barriers remove larger particles from water, including those formed by coagulation. This process (filtration) is insured by a different methods and systems including Biofilters. Biofilter is one of the most vital separation techniques that can be utilized to expel organic pollutants, natural toxic compounds and contaminants from waste water. Despite the fact that, it has been utilized over a century, it is still hard to clarify theoretically all the biological procedures happening in a biofilter. In this report, the fundamental of biological processes involved in biofilter is discussed in details. In addition to the critical review of the operating components and the design of the whole system.

Keywords: Biofilter, Biological Filtration, Contaminants, Impurities, Waste water, Design specifications, Backwashing.

Table of Contents

List of Tables

List of Figures:

INTRODUCTION

For decades now, expansive numbers of pollutants released from industrial sites have been released into large water bodies in the environment. Environmental health threats have risen due to water pollution, these chemicals that are so foreign to the environment have progressively accrued in the environment, and not only in the water but air and soil too, their toxicity is alarming and facets as variant health hazards (Anon, 2017). Water filtration is a crucial process for the treatment of waste water to make its presence a mortal concern in the community's environment. The main purpose of water filtration is to produce effluent of high quality so that the county may be able to reuse what was once untreated water in a domestic and fundamental manner. Over the years water filters have trended and through expansive research, different materials have been found to be vital in filtration (Waterworld, 2017).

CHAPTER 1: IMPURITIES AND DISEASES

1.1. Impurities present in waste water:

Impurities present in waste water may be of different forms and from different sources. Impurities are introduced into water when the water gets in contact with industrial waste or industrial waste. Industrial waste water contains dissolved minerals like sodium bicarbonates, calcium, sulphide, irons, magnesium's and chlorides, and also contains granular suspended impurities of sand like, rocks, leaves grass and other organic matter (Common Waterborne Bacteria and Cysts - Global Hydration, 2017).

Impurities present in waste water may be classified into two, Suspended impurities and Microscopic impurities (Common Waterborne Bacteria and Cysts - Global Hydration, 2017).

Suspended Impurities are organic and inorganic, while microscopic impurities are fungi, algae and bacteria (Common Waterborne Bacteria and Cysts - Global Hydration, 2017).

There are several sources of water impurities such as Gases picked up from the atmosphere by rainwater. Dissolvent impurities the get in contact with the water when it touches the ground from precipitation following are the sources of impurities in water. Remains of decomposed plants and animals produce impurities witching water bodies or when water bodies get in contact with these materials via sub bodies like streams. Impurities are also introduced in water when it comes in contact with sewage or industrial waste (Common Waterborne Bacteria and Cysts - Global Hydration, 2017).

<u>River water</u> does not have a content composition of material in the water. Contacts of the soil is a major deepening factor for the amount of characteristics of material or contents of river water The amount of dissolved impurities in it depends on its contacts of the soil. If there is a great duration in the contact of water with the river bed layer then there will be more dissolvable impurities. Much of wastewater, treated or untreated, eventually ends up in rivers, streams, lakes, and oceans-sometimes via groundwater, the underground water source we tap for well water (Common Waterborne Bacteria and Cysts - Global Hydration, 2017).

<u>Lake water</u> has more organic matter within it than the amount of but lesser of dissolved minerals, though its chemical composition is also constant (Common Waterborne Bacteria and Cysts - Global Hydration, 2017).

<u>Rain water</u> is obtained after evaporation from open water bodies on the earth'ssurface and of all natural sources of water, rain water is the purest. Although during precipitation on its downward journey through the atmosphere it dissolves a considerable amount of industrial gasses and organic and inorganic suspended particles. Rain water is expensive

to collect and is irregular in supply because of its seasonality (Common Waterborne Bacteria and Cysts - Global Hydration, 2017).

Underground stream water is impurity and is clearer in appearance due to soil filtration; however it still contains a lot of salt (Common Waterborne Bacteria and Cysts - Global Hydration, 2017).

Sea water is very impure due to two reasons, it has very high salinity, causing it to be inappropriate to use for industrial usage other than cooling. Constant evaporation adds onto the dissolved impurities content. After precipitation into the sea, the impurities are further increased by the impurities obtained from contact with other water bodies or the ground (Common Waterborne Bacteria and Cysts - Global Hydration, 2017).

Pathogens from human waste can easily enter a community's mainstream water source if it gets in contact with wastewater from patients at hospitals, or any sickly person (Common Waterborne Bacteria and Cysts - Global Hydration, 2017).

Animal waste processing and meat packaging wastewater often pollutes mainstream water from farm rush offs, facilityprocessing and from rodents or other living organisms around sewage or sewers. These substances can include pesticides and chemicals like chlorinated hydrocarbons, phenol, PCBs (polychlorinated biphenyls), and benzene (Common Waterborne Bacteria and Cysts - Global Hydration, 2017).

Significant health threatening risks arise when untreated wastewater reaches water used as a drinking water source for the community. Treating the contaminated water is the only way to reduce the effectiveness of heavily contaminated water with waste (Common Waterborne Bacteria and Cysts - Global Hydration, 2017).

Pathogens such bacteria, viruses, and parasites (including worms and protozoans) as in wastewater may be transmitted by direct contact with sewage for illustration: drinking contaminated water or eating food contaminated with sewage. Physical contact with infected animals, insects or humans may be different modes of transmission (Common Waterborne Bacteria and Cysts - Global Hydration, 2017).

Waterborne and food borne diseases are diseases contracted by drinking contaminated water or eating contaminated food (Common Waterborne Bacteria and Cysts - Global Hydration, 2017).

1.2 Diseases Caused by Bacteria:

Typhoid, Paratyphoid and Cholera are examples of common water borne diseases, only to name but just a few. Water borne diseases are not limited to the listed (Common Waterborne Bacteria and Cysts - Global Hydration, 2017).

The mentioned illnesses have signs and symptoms of infection which are similar but the variant factors of these symptoms are what help the doctors give a prognosis and prescription for drugs and treatment where need be (Common Waterborne Bacteria and Cysts - Global Hydration, 2017). The common symptoms are diarrhea, fatigue, nausea, excessive perspiration, throwing up and piercing headaches, just to name a few, this is due to the fact that the mentioned parasites find host and thrive in the digestive tract (Water Science and Technology, 1997).

Areas with a dense human population and have poor water supply and sanitation often find themselves infested with cholera as it highly contaminates areas with inadequate amounts of clean water. The outbreak of this disease which has caused pandemic destruction in so many countries is easily spread by consumption of contaminated food and water (Water Science and Technology, 1997).

1.3 Diseases Caused By Viruses:

Virus, parasitic microorganism may only be seen using a microscope, not just a regular microscope but one that beams elections, an electron.

Presence of viruses in water bodies to be used by humans for domestic uses around the home such as cooking, washing or merely consuming may be a leeway for individuals to be infected by the bacteria and experience a whole lot of unpleasant symptoms.

Water borne diseases that may be attained by contact with infected water include viral gastritis, Hepatitis A and polio, only to name a few (Common Waterborne Bacteria and Cysts – Global Hydration, 2017).

1.4 Parasites in Wastewater:

Eggs of parasitic worms such as round worms and tape worms may cause symptoms such as tiredness and sweating if introduced into the human body. Whilst doing this, it is the stage where the body faces various signs and symptoms of infection. Water borne diseases are caused by parasites such as helminths and protozoans and even tape worms, these are commonly found in waste water, when these microbes which are foreign organisms enter the bloodstream of the human body, they find it to be a conducive host environment to thrive and reproduce over and over again, at this point the human body starts releasing antibodies to protect itself from these parasites (Common Waterborne Bacteria and Cysts - Global Hydration, 2017).

Boiling consumable water may prevent water borne epidemics but the key solution to totally eradicating the possibility of this is to steer away untreated water from water bodies that are to be treated for human consumption and domestic usage (Water Science and Technology, 1997).

1.5 Other waste water related concerns:

Excessive nitrogen in water may be harmful for humans. Presence of nitrogen in water may cause methemoglobinemia, which is a condition that prevents the normal uptake of oxygen in the blood of young babies and miscarriages (Common Waterborne Bacteria and Cysts - Global Hydration, 2017).Material such as copper, lead, zinc, nickel and cadmium may be present in wastewater. These metals are needed in moderation by the body but an excess may be harmful (Water Science and Technology, 1997).

Communities may construct prototypes like ours to produce usable water from wastewater for domestic usage.

CHAPTER 2: PROJECT MATERIALS AND LAYERS

2.1 Upgraded Design:

For the second graduation project, we changed several elements of our water biofilter to optimize the designs filtration efficiency, filtrate quality and ergonomic convenience for the user.The mechanics of any type of filtration is simply removal.

In this report we will highlight all the adjustments and additions of our new design to add clarity on its difference from the first one.

2.1.1 Material Used:

- 15 Liter container
- PVC pipe with perforated caps on either end
- Tap & Washers
- Handles
- Ceramic cutlets
- Granular Activated Carbon
- Powdered Activated Carbon
- Fine Sand
- Charcoal
- Synthetic fiber
- Organic cotton fiber
- Gravel

2.1.2 Assembly:

i. We marked a 1.5cm diameter on the surface of the 6 gallon bottling bucket just above the base, with the intention to allow the user to collect the water freely over a ledge. We dedicated a spot for a tap spigot by threading and marking to allow accurate drilling

ii. We used a dermal drill with a screw bit and used a chisel bit to cut out the hole close to the marked circle. We switched to a lower speed to enable preside fining and a smooth finishing of the hole

iii. We inserted the screw bit nozzle end of the tap into the bucket and fastened it from inside with two washers and coupling nipples to prevent leakage.

iv. To stack the layers we chose a 1m long PVC pipe with a diameter of 10cm. The PVC pipe was inserted into the bucket to be held by a metal ring to prevent the base of the PVC pipe from touching the base of the bucket. The PVC pipe was designed to hang freely and give the filtrate space to drip without upward flow.

v. We inserted a drilled cap at the bottom of the PVC pipe to allow the layers to sit without escaping.

vi. We then stacked the layers from the bottom and filled it to the top and closed the top of the PVC pipe with another perforated cap.

2.1.3 General working Function:

Contaminated water is poured through the top opening of the PVC pipe and the contaminated water then filters through the bed sediments, seeping through layer by layer. Each layer having a specific function and significant purpose, the filtrate then reaches the bottom end of the PVC and leaks through the drilled holes of the bottom cap into the water collection bucket. The water filtrate at this point is pure and may be used for domestic purposes. The tap is to regulate outflow of the water.

The treated water is stored in the container until needed, protecting it from recontamination. The user simple opens the tap at the base of the container when they need water.

Natural, Biological, Physical and processes combine to provide treatment for wastewater as it sieves slowly through the filter media. Most of the treatment occurs in the first 6 to 12 inches of the filter surface.

2.2 Significance of Each Material Used:

2.2.1 Bottling Bucket:

We included this bucket into the design mainly so that it could hold the filtrate as it filters out of the PVC pipe and act as a collecting can. The bucket holds 15lts which adds convenience to the user.

When we went through a phase of analytical planning, we wanted to choose a holding bucket that is affordable for the user and the primary attribute being that carcinogens will not leach into the water regardless of the temperature range. High Density Poly Ethylene plastic fit the mold of exactly what we went out seeking for. The material does not produce a bad smell when water is in storage, neither is it toxic.

We undeniably chose an HDPE bottling bucket because of its resistive properties to UV light aswell. Any other material would leach into the water when under the exposure of Ultra violet rays. The buckets safety was also indicated by the food grade standard that it was suitable to be used for consumables. We saw this through a sign of a fork and cup at the bottom.

2.2.2 Tap:

We modified the design to have a tap for safe storage and the main purpose of the tap is to regulate outflow of the water. The user will be able to collect the water through the snug faucet without having to pour water over the rim of the bucket.

2.2.3 PVC Pipe:

Post vigilant research and studying, we discovered that filtration is optimized if the filtering beds are thick. The idea of having thick filtration beds was a vital factor in coming up with the design, that's why we opted to use a PVC pipe because of its shape and the form the layers would take when inserted into the pipe

2.2.4 Ceramic layer:

We opted for filtration media that are conducive at withstanding high temperatures and are able to stand an abrasive surrounding.

This layer of ceramic cutlets serves as an antibacterial which:

- Eradicates pathogens before they hatch out of their eggs
- Suffocates pathogens by inhibiting the enzyme they use to prey oxygen.
- Dispatches barren pathogens
- Electrically executes pathogens

The ceramic layer also removes globular inorganic substances, while doing this, the ceramic layer scratches the cell membrane of the pathogen, causing all organelles to be exposed thus dying.

We chose to use the ceramic layer not only because of its biological attributes only, but for other factors such as: (Peter Schneider, 2015)

- Removes both inorganics and microbes
- Maximal disinfectant
- Economic availability
- Improves taste and smell of water
- Cost effective

Figure 1: Ceramic Rings

2.2.5 Activated Carbon:

Catalytic reduction and adsorption are two modus operandi of activated carbon for sifting pollutants from infiltrate (Aquasis, cewas international centre, 2008).

Catalytic reduction is a series of actions where ions that attain a negative charge which is present in the media contaminating the water attracts particles of the activated carbon because the ionic charge is opposite, it is positive. Adsorption is a systematic series of chemical operations wherein ions, molecules or atoms of gas or liquid media are attracted to the carbon surface (Aquasis, cewas international centre, 2008).

Catalytic reduction removes organic compounds such as chlorine only to name a few. Organic chemicals may be substantially removed from water by activated carbon. The organic chemicals that are filtered out may decay within and the particles inkling to the gaps between the carbons, alongside this, other chemical reactions may be carried out aswell (Activated Carbon Treatment, Michigan State University, 1990).

Adsorption and catalytic methods of filtration may surely remove a great number of pollutants in wastewater but are surely not the most prominent in removing material that has leached into the water and remains inorganic such as salt, minerals and metals. However other methods of filtration may be used to remove these inorganic substances such as reverse osmosis or a distiller (Activated Carbon Treatment, Michigan State University, 1990).

Chromium, benzene, lindane and mercury are a few of many elements that may be filtered by Activated carbon (Cuffari, 2016).

Granular Activated carbon in most cases is shaped in a rod like demeanor. The speed per unit time of which the water will flow is solemnly dependent on the ratio of the pore size of the activated carbon with respect to gravity (Cuffari, 2016).

Fluidization has not been recorded as a limiting factor when dealing with filters that are dependent on gravity for the directional water flow to be efficient. The direction of water flow per unit time has neither implicated nor diminished the fixed bed establishment and a reign of in filters of eloquence (Cuffari, 2016).

Carbon particles that are loose that are present in activated carbon may drawback the best function of the filter although it retains very adsorbent (Water Treatment Using Carbon Filters, n.d.).

Figure 2: GAC (Granulated Activated Carbon)

2.2.6 Powdered Activated Carbon:

Powdered Activated Carbon is Activated carbon that has been ethereally and thoroughly ground to fine powder, the solemn point of this being to exhibit a surface area more stupendous than that of the unground Granular Activated Carbon. At this state of being finely powdered the Activated Carbon has an astounding property of sieving impurities that is much greater than that of Granular activated carbon (Mazille, M. & Spuhler, D., 2011).

In most cases but to name a few, a typical carbon filter may have traces of silver particulate present in it, need being too withhold bacteriostaticity which is an antibacterial (Mazille, M. & Spuhler, D., 2011).

The relative extent of the particle distribution in the carbon block is a crucial factor to be noted when using powdered Activated carbon as filter media. During water filtration, the carbon particles remain intact which prevents water channeling, something commonly prevalent in filters using Activated carbon of the granular sort (Activated Carbon Treatment, 1990).

Figure 3: PAC (Powdered Activated Carbon)

2.2.7 Gravel:

To our layers we incorporated gravel because of its extensive filtration properties.

Infiltrating water through a layer of gravel takes out impurities, residues &molder while ejecting unpleasant smells. An adequate layer of gravel also refines the water to reach a stage where it is usable (Gannon, 2011).

The gravel is made up of siliceous material that happens to be hard, long lasting and is granular. The rigidity and angularity are essential characteristics that we took into notion when selecting one of the filtration layers to assure adequate filtering (“*Filter Gravel - Water Filtration Media - Danville, California - Kleen Industrial Services”*, n.d.). The gravel layer has a precise ability to restrain sediments comprising impurities thus is a highly functional filter media

Gravel prevents precipitates and silts from passing through its layer by holding them back and ejecting them from the water; it settles these particles between its grains and here where it can be therefore broken down by a plethora of serviceable microorganisms that burgeon on the surface of the gravel bed that is refining the water. This is why gravel has an instant effect on purity and filtered water quality (Gannon, 2011).

Figure 4: Natural Gravel

2.2.8 Sand Filtration:

The process of sand filtration includes percolating water through a sand bed. This is a method of waste water treatment that is effective, economical and ecofriendly.

Grains of sand form a layer to be penetrated by water and will stop bigger particles in the gaps between sand grains and sieve them. The grain surface will absorb the smaller particles as they touch the grain while passing through the filter, by doing this the longer particles remain in the sand layer while the smaller particles pass through the diameter of the gaps in the wall effect and move onto the next layer where they will be sieved. The smaller the diameter of the grains is, the higher the filter's stopping power will be.

There are three types of sand filtration:

- Slow
- Semi Rapid
- Rapid

("A23 - Sand filtration for raw water or wastewater treatment - Wikiwater", n.d.)

The Rapid and Semi Rapid types of sand filtration require use of chemicals and pumps. We chose to go conventional and use a slow filtration, which not only ensures maximum filtration but is economically friendly for the target demographic. Slow sand filters do not require pressure and are systems that use biological processes to clean water. The main objective of our project is to use as many organic and biological materials that may be available in the most remote areas in the world. Unlike the Rapid and Semi Rapid Sand filtration methods without using any chemicals, we can treat water and reduce the presence of viruses, bacteria, microbes

A prominent percentage of the sand filters treatment is accomplished through biological processes. Filtering through sand handles a variety of organisms. Many of which contribute to treatment by consuming organic matter in the wastewater. Bacteria breakdown takes place in the filters as they are the most abundant organisms in the, and they do most of the work. There are other organisms, such as worms and protozoa, which also contribute to treatment.

Favorable filtrate quality will be produced if a fine sand layer is used, even when filtering water with a very tardy influx. We searched for specific sand that was experimentally shown to be 0.15 mm effective. Before usage the sand should be ad then rinsed until the water runs lucid. The deepness of the layer is a crucial feature to assure proper refinement. It was vital to us that each bed layer is about 8cm high to ensure maximum filtration (Guy, 2014; Cuffari, 2016).

Figure 5: Fine Sand

2.2.9 Charcoal Filtration:

Charcoal is composed of black carbon which. In the graphite form carbon is characterized by high surface area per volume.

The principle behind charcoal filtration to impurities found in water goes back to van der Waals interactions which are come about due to the vital attractions of the carbons polar surface to the non-polar organic molecules dissolved in water while polar compounds will remain in aqueous solution.

Carbon filters are effective for removing inorganic compounds, iodine, chlorine, mercury, and some organic contaminants such as volatile organic compounds, hydrogen sulphide, formaldehyde, which may be problematic to the user (Kearns, 2007).

Figure 6: Charcoal

2.2.10 Organic Cotton Fiber &Synthetic Fiber:

For filtering of visible pollutants, organic cotton fiber &syntheticfibers are ultimate to use, we crammed them fairly tightly in-between each layer, then secured it so that the flow won't move it. When we flowed water through the organic cotton & synthetic fiber in the PVC, large particulate matter got tangled in the cotton fibers and failed to exit the layer.

The organic cotton & synthetic fiber will do nothing to things like bacteria, chemical impurities and salt or most chemical impurities, etc. But for physical garbage visible enough for the naked eye, this should do a pretty good job.

Above thefibers is a biomat which is a thick layer of granular organic material, usually the first to be filtered out, which is the most significant part of the filter ecosystem, it is forms eventually near the surface of the filter. This microbiological layer deals with bacteria which consume particles in the wastewater. Simultaneously protozoa help to prevent the bio mat from becoming dense and clogging the filter.

Figure 7: Synthetic Fiber

CHAPTER 3: BACKWASHING OPERATION

3.1 Filter Backwashing:

Backwash or backwashing is the operation of greatly cleaning the biofilter by a technique of reversing the flow of water to flush out debris and contaminated particles. Backwashing is not only crucial to the vitality of the biofilter, it is essential to the quality of water leaving the filter. Eventually, all filters need to be backwashed or supplanted ("How Backwashing Filters Work – Pure Water Products, LLC", 2017).

The filtering procedure involves two essential physical principles. Starting with the first, generally huge suspended particles get stuck between the grains and granular substances as the water moves through the filter media (mechanical straining). Second, tinier particles adhere to the surface of the grains due to the impact of the van der Waals forces (physical adsorption).

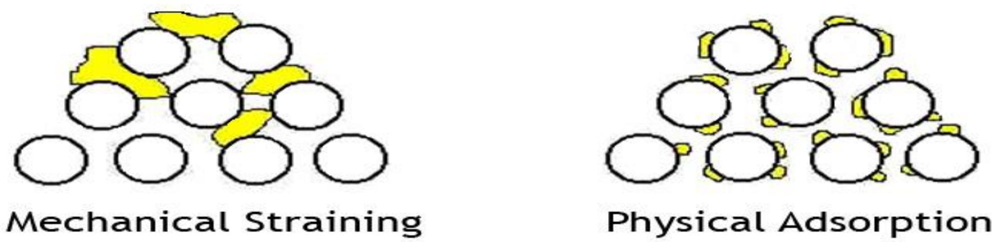

Figure 8: SCHMITT & SHINAULT 1996 Schematic of Basic Filtration Principles

Over the span of these procedures, a cumulative number of particles aggregate in the filter media, progressively leading to blocked filters and low purification effectiveness. Original purifying activity can be re-accomplished through a cleaning of the filter bed. This is generally carried out by a backwashing process: the stream of water is flipped, so that clean water flows in reverse through the filter (Bruni &Spuhler, n.d.; "Filtration", n.d.).

3.2. When to Backwash?

- The cleanliness or turbidity of the water leaving the biofilter at the exit opening just before it goes to the collecting chamber is the most ideal approach to decide when to backwash.
- Head loss on the filter also shows the need to backwash. Head loss is normally determined by a negative pressure measurement. As the biofilter gets obstructed, more negative pressure is formed. The more clogged the filter the greater the head loss.
- A filter run attains a given duration of service.

- If the activity of the filter was stopped for specific purpose, it should surely be backwashed before being returned to operation.
  The decision to backwash the filter should not be based on only one of the above conditions. If a filter is not backwashed until the head loss exceeds a specific quantity, the turbidity may break through and cause the filter to surpass the standard of turbidity. In addition, depending on filter effluent- turbidity alone can cause high head loss and decreased filter flow rate, which can cause the pressure in the filter to drop and affects the filter's activity (Satterfield, 2005).

3.3. How long to backwash?

Backwashing too often can mix up the layers and permit little particles to go through the filter leading to disorders in the filter's activity and the filtration can no longer execute at its full potential. A biological filter should regularly be backwashed for at least 3 minutes and a most extreme of 5 minutes or until the water appears clear relying upon the extent of the filter. Backwash for a minimum of 3 minutes even if water dropping out of the filter to the site tank is clear. When inspecting the water leaving the filter you may notice it looking filthy. This is the dirt and debris being expelled from the layers in the filter. (Satterfield, 2005; "How Often Should I Backwash My Filter? How Long? ", n.d.).

3.4. Backwash water:

Backwash water is extremely filthy, and there is no sense in taxing the water system if it's not necessary. The most excellent, effective, and desirable process to dispose backwash water is to have a backwash line with appropriate backflow avoidance connected to the nearest sanitary sewer.

Backwash recycling capability is another choice that can be useful in times of need, for example, drought. If it is standard procedure or if state laws require systems to recycle backwash water, a different tank or tanks equipped for holding several backwashes can be utilized to settle out sediments and return the water slowly to the treatment process (Satterfield, 2005).

CHAPTER 4: DESIGN SPECIFICATIONS AND EXPERIMENTS

The biofiltration system will operate so that water will infiltrate into the filter media and move vertically down through the profile. It will go through the sediments beds, each with a specific filtration purpose.

The filter media is required to sieve out pollutants from the water. The material should be based on natural material that is easily available without purchase or if purchased found at cost effective prices. All of the filter media should have an appropriately high permeability especially when in compact and should be pollutant free and not hyrsophobic.

The filter prototype should have durable maintenance measures. It should also be handy for the user, thus making it mobile and easy to carry around. The project should hold a reasonable amountt of filtrate for the user to utilize comfortably.

To ensure long-term treatment efficiency of the system maintaining an adequate infiltration capacity is crucial.

4.1 EXPERIMENTS: TOTAL COLIFORM EXPERIMENTS, ECOLI & FECAL

Experiment Objective: Observation of coliform colonies that are present in the water samples, before and after water biofiltration (Hach Company, 2006).

Apparatus:

1. A water treatment Incubator
2. An Electron microscope
3. Solution of m-endo Broth ampule
4. Dilution water that is buffered and sterile
5. 0.45 micron filter,
6. 47 mm absorbent pad in a Petri dish
7. Pipets
8. Aspirator.
9. One sterilized forcep.

Sample collection:

1. Use sterilized sodium thiosulfate in a sterilized container
2. Close the container immediately after collecting the water sample. Follow several safety precautions after that such as not putting the lid down or rinsing the containers before.
3. Use the collection beaker to store the water
4. Store 30mL of water sample at least.

Presumptive test for total coliforms:

1. Homogenise the broth by turning it into a beaker several times then open the ampule and pour the contents into the absorbent pad.
2. Switch on the aspirator
3. Use the forceps to set the membrane filter as instucted in the lab manual
4. Make sure the sample is homogenised by pouring it in and out of the beaker several times.
5. Pour the sample into the funnel to a minimum volume of 30mL and vaccume the funnel until its empty
6. Vaaccume the funnel twice more after cleaning it with sterile buffered dilution water.
7. The vaccume must be halted once the funnel is empty and remove all apparatus.
8. Place the membrane filter onto the absorbent pad.
9. After placing the lid on the petri dish, invert it.
10. After incubating the peridish at 35 degrees for about 24 hours, remove it form the incubator.
11. Count the numbr of colonies on the membrane filter using an electron microscope at 10X or 15X.

Confirmation test of total coliforms:

1. After touching an inoculating needle that has been sterilized, place the needle in a Lauryl Tryptose broth tube.

2. Repeat the first step but only this time it’sto the same coliform, the sheen colony growth. Place the needle in a Brilliant Green Bile (BGB) broth tube.
3. Remove air from the inner vials by inverting and swirling gently.
4. Inner vials have to be full of air and not bubbles, so examine that.
5. Incubate the inoculated media
6. After 60 minutes, remove the air from the inner vials by inverting and be sure there are no bubbles.
7. At 35 degrees incubate the media.
8. Remove the samples from the incubator after 24 hours, if the broth appears to be cloudy and the inner vials have gas bubbles then that means coliform bacteria is present. If no gas is present, incubate again and observe.

4.2 PH EXPERIMENT:

(Howard Perlman, 2016)

1. The pH electrode must be dipped into the neutral buffer solution and stirred with a magnetic bar for the most optimal results...
2. Press the 'calibration (standardization)' function on calibration settings and alter the buffer pH to 7.00.
3. When the pH reading stops alternating press ENTER
4. After rinsing the pH electrode with distilled water, rinse it with the buffer solution.
5. Dipped bulb in unfiltered water sample, the pH meter read 8.2
6. Rinsed and wiped bulb, then dippedin filtered water sample that read 7.2

4.3 TEST FOR WATER HARDNESS:

We used two different techniques to test the hardness of our water samples, sample before filtration and sample after filtration. The first technique that was used was Atomic Absorption Spectroscopy. We utilized two seperate AA instruments, one being for calcium and the other being for magnesium.Each concentration was determined by calibrating the instruments reading by the use of a controlled table of data (Krehbiel, 2017).

Post data graphing and determining the line equation, we used the values of absorbeence to calculate the concentration of each element. Accurate technique number two was the EDTA titration method (Krehbiel, 2017).

Results:

Water samples: We used samples for before and after filtration

Sample 2: Before filtration

Sample 1: After filtration

Sample 1 was expected to be extremely soft because filtered water undergoes an intensive purification process.

Sample 2 was found to be relatively hard as predicted because it undergoes no purification process, therefore, the calcium and magnesium captions absorbed into the water from sources such as limestone are able to remain in the water.

CHAPTER 5: INDUSTRIAL OVERVIEW

5.1. Industrial Schema:

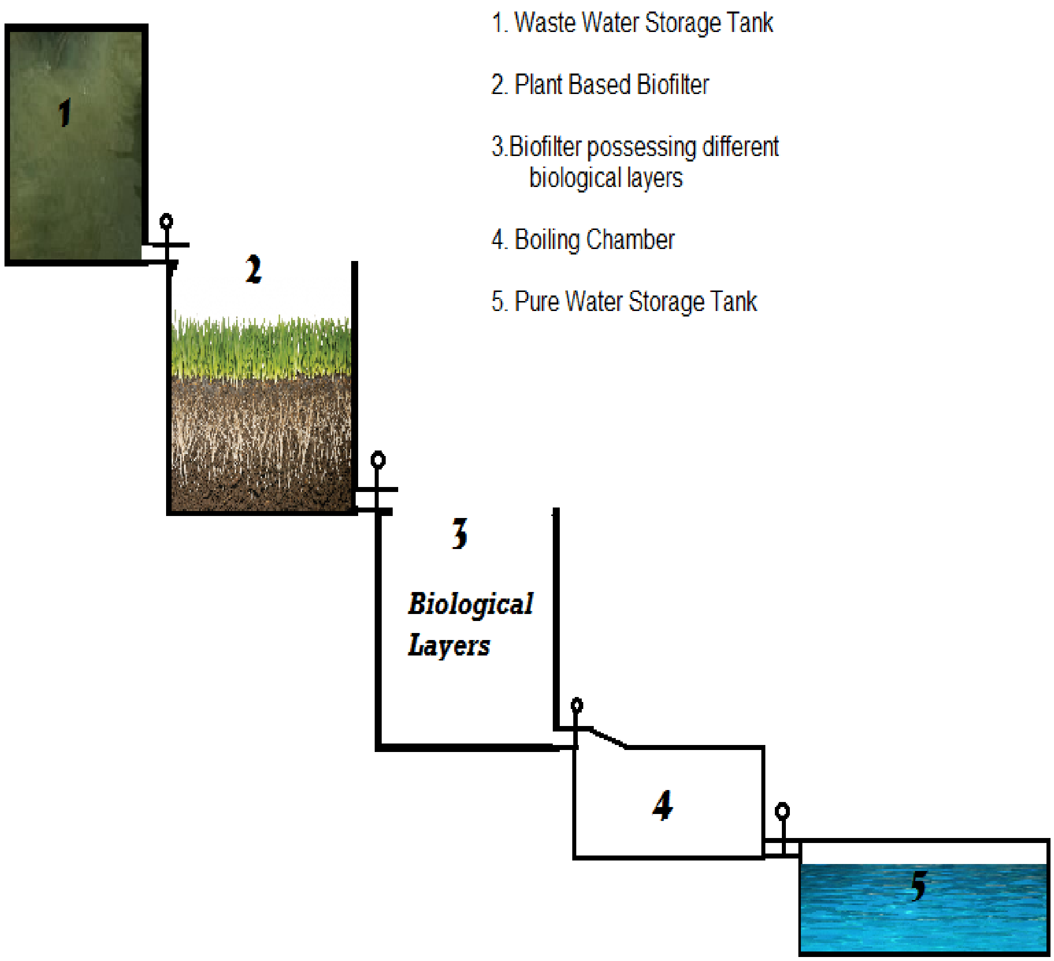

Figure 9

5.2. Plant-based Biofilters:

Pure water from plant is nothing modern. The earth is continually utilizing both soil and vegetation to rinse itself. Water is a dynamic liquid. It is dependably in movement and is being used by plants, soil, clouds, truly everything. As water passes through and over plant roots and leaves, the fluid is absorbed into the plant's tissues. There is an ordinary cycle in which water is initially absorbed then discharged from the plants leaves and roots ("Water Purification Using Plants. How To Purify Water Using Plants", n.d.)

5.2.1. Filtration by Plants:

Biofilters that are based in their filtration mechanism on the existence of plants show a great effect in the ejection of phosphates, nitrates, nitrites and ammonia. The growth of plants requires some substances that are fatal to other organisms. These substances include chemicals such as ammonia, phosphates and nitrates that are present in most synthesized fertilizers. The development of algae and other plant species may be a result of high concentrations of these chemicals. Furthermore, extremely high concentration of these substances may lead to the death of the plant itself. However, the solution is present in specific type of plants. Duckweed, nut grass, and water lilies are productive in removing such chemicals by expanding to obtain the phosphates. Other plants may help by locking damaging substances such as lead, zinc and cadmium to save various species or to stand in the way of them getting into the underwater. According to a study done by a group of researchers, the superb results obtained from cleaning the wastewater from a nuclear power plant shows that Duckweed excel at retaining phosphorous and perilous heavy metals which enables it to be an efficient component in plant-based filters ("Using Plant-Based Biofilters to Purify Household Wastewater", 2012).

5.2.2 Wastewater Treatment with Aquatic Plants:

A shallow tank containing floating or submerged aquatic plants is the head constituent of an aquatic plant treatment system. Nowadays, one of the most popular and widespread wastewater systems is the one employing Duckweed. Based on the dominant plant types, treatment systems are classified into two categorize. The first and main category comprises floating plants. Those plants absorb minerals from the water. Moreover, the amounts of carbon dioxide and oxygen captured from the air sufficient to fulfill floating plant desire. The second category is the submerged plants that are distinctive for being able to soak up their needs od carbon, oxygen and minerals directly from the water. Due to having their photosynthesis parts underwater, these plants are characterized by high levels of turbidity (Frers, 2014).

5.2.3 The Use of Specific Plants:

Particular plants such as:

1) Water Lily
2) Reed
3) Bur-Reed
4) Iris
5) Club-Rush
6) Sedges
7) Water Soldier
8) Water Poppy
9) Sweet Flag

These plants have a great affinity for water and are known for cycling and recycling water through their root system. All plants have this common phenomenon through them, but the water species specified are particularly intended for this water cycle ("Water Purification Using Plants. How To Purify Water Using Plants", n.d.).

5.2.4 Removed Impurities:

Using the right plants to purify and filter water will clean and remove:

1) Heavy metals
2) Harmful Bacteria
3) Parasites
4) Radioactive Isotopes
5) Chemicals

These impurities are absorbed by the plant. Some of the taken contaminants will naturally decompose with the plant. However, others including few chemicals, radioactive isotopes and heavy metals will demand particular treatments ("Water Purification Using Plants. How To Purify Water Using Plants", n.d.).

5.3 Biological layers:

Explained thoroughly in the beginning of this report (Chapter 2)

5.4 Purifying water by Boiling:

Boiling water has long been recognized as the most ideal method for ensuring that water is free of bacteria water contamination and fit for drinking. This concept has been passed on from generation to generation and is one of the basic water purifying systems that is still held as absolute truth in society today ("Which Common Water Purifying Technique is better, Boiling or Filtration? | Live Healthy", 2015).

The least expensive and most effective solution for water purification is boiling. Boiling will kill bacteria, parasites, and viruses. Many people advise bringing water to a hard boil for 5 minutes, and perhaps longer at higher elevation. More current literature, however, suggests merely reaching the boiling is sufficient and effective ("How to purify water - Boil, Chemical, Filter, UV | HowToWilderness.com ™", n.d.).

CONCLUSION

In all embracing prospects it may be said that there is a booming perspective in utilizing the water biofiltration systems which has an immobilized connotation of sustained purification and removal of pollutants, impurities, chemicals and parasites through the application of biofiltration media. Noting that a filter system that produces a conducive environment for remnant bacteria to thrive and further proliferate is critical and may affect the agenda in general so whatever the case may be it is crucial to develop the best treatments of these impurities. The biofilter at its cost effective range is able to deliver effluent of very high quality, which is an obvious pro for the user.

APPENDIX:

1. Experiments:

Test done	Pre filtration	Post filtration
pH	7.1	6.4
Total Coliform	Positive	Negative
Total Dissolved solids	455 mg/L	240 mg/L
Fecal Coliform	120CFU/100mL	0 CFU/100 mL
Total hardness	73.7 mg/L	34 mg/L
E. Coli Coliform	142 CFU/ 100 ml	0 CFU/ 100mL

Table 1: Initial Test Results.

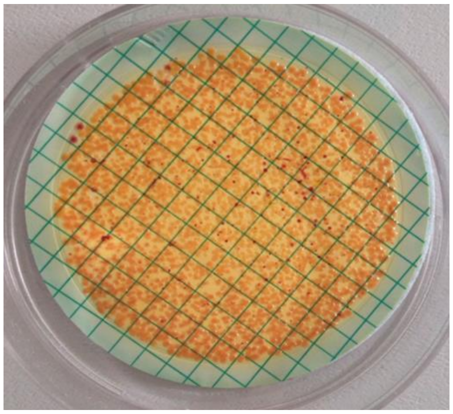

Figure 10: Total Coliform Culture.

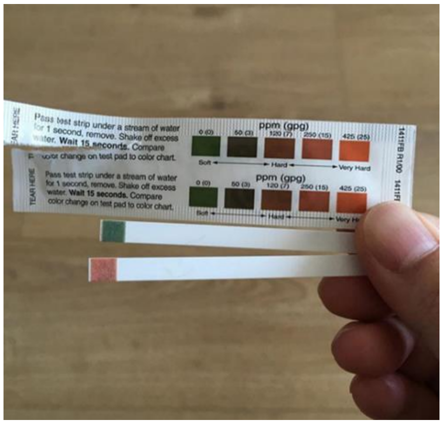

Figure 11: Total Hardness Test.

2. PVC Pipe:

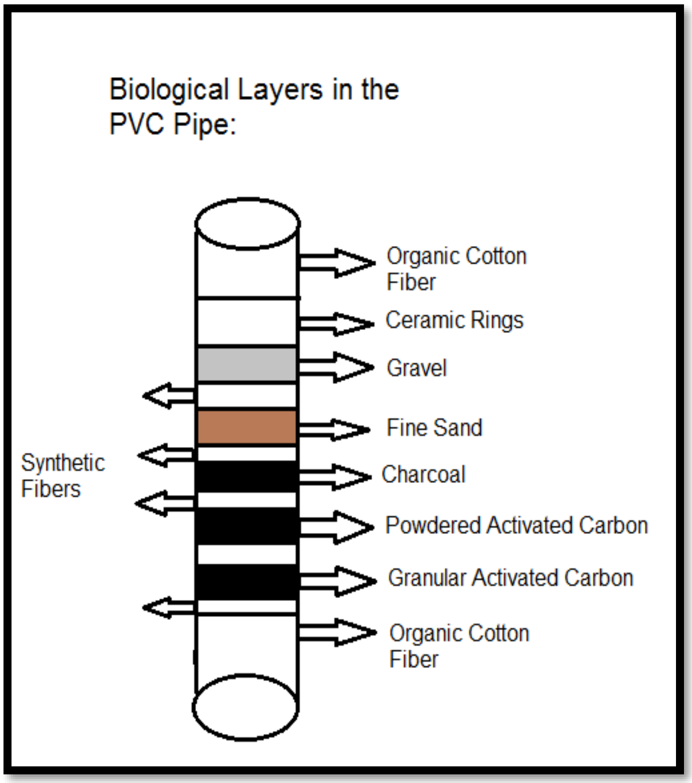

Figure 12: Biological Layers in the PVC Pipe.

Figure 13: PVC Pipe.

3. Prototype:

Before: After:

Figure 14: Prototypes.

References

A23 - Sand filtration for raw water or wastewater treatment - Wikiwater. *Wikiwater.fr*. Retrieved 30 May 2017, from http://www.wikiwater.fr/a23-sand-filtration-for-raw-water.html.

Adsorption (Activated Carbon) | SSWM. (2016). Sswm.info. Retrieved from http://www.sswm.info/content/adsorption-activated-carbon

Anon, (2017). Water | Chemistry and Environmental Engineering, from http://www.newagepublishers.com/samplechapter/002160.pdf

Basic PH Meter (300408.1 Rev. G) Operation Manual, Denver Instrument Company Denver Instrument Company, Ltd. Denver House, Sovereign Way Trafalgar Business Park, Downham Market Norfolk PE38 9SW England.

Biofiltration Filter Media Guidelines (2009), Version 3.01. Prepared by the Facility for Advancing Water Biofiltration (FAWB).

Bruni, M., &Spuhler, D. *Rapid Sand Filtration | SSWM*. *Sswm.info*. Retrieved from http://www.sswm.info/category/implementation-tools/water-purification/hardware/semi-centralised-drinking-water-treatme-14

Common Waterborne Bacteria and Cysts - Global Hydration. (2017). Global Hydration. Retrieved from http://globalhydration.com/waterborne-disease/common-waterborne-disease-bacteria-viruses-cysts/

Cuffari, B. (2016). *Materials in Water Filtration*. *AZoCleantech.com*. Retrieved from http://www.azocleantech.com/article.aspx?ArticleID=582

Filter Gravel - Water Filtration Media - Danville, California - Kleen Industrial Services. *Kleenindustrialservices.com*. Retrieved from http://www.kleenindustrialservices.com/water-filtration-media-filter-gravel.html

Filtration Efficiency. (2017). Waterworld.com. Retrieved from http://www.waterworld.com/articles/iww/print/volume-13/issue-4/features/filtration-efficiency.html

Filtration. *MARWA*. Retrieved from https://www.mrwa.com/WaterWorksMnl/Chapter%2018%20Filtration.pdf

Frers, C. (2014). *The Use of Aquatic Plants to Treat Waste Water | Fourth Corner Nurseries*. *Fourth Corner Nurseries*. Retrieved from http://fourthcornernurseries.com/the-use-of-aquatic-plants-to-treat-waste-water/

Gannon, M. (2011). *GRAVEL FOR POND FILTRATION - Full Service Aquatics*. *Fullserviceaquatics.com*. Retrieved from http://fullserviceaquatics.com/uncategorized/gravel-for-pond-filtration/

Government Lab Ministry of Health, Northern Cyprus

Guy, F. (2014). *Designing a DIY slow sand filter: what to consider | Rain water harvesting and slow sand water filters*. *Enlight-inc.com*. Retrieved from http://www.enlight-inc.com/blog/?p=2139

Hach Company, (2017). Retrieved from http://www.freedrinkingwater.com/water.../ecoli-bacteria-removal-water-page2.htm

How Backwashing Filters Work – Pure Water Products, LLC. *Purewaterproducts.com*. Retrieved from https://www.purewaterproducts.com/articles/how-backwashing-filters-work

How Often Should I Backwash My Filter? How Long?. *Dazzle*. Retrieved from https://getsatisfaction.com/dazzle/topics/how_often_should_i_backwash_my_filter_how_long

How to purify water - Boil, Chemical, Filter, UV | HowToWilderness.com ™. *Howtowilderness.com*. Retrieved from http://howtowilderness.com/water-purification/

Kamrin, Michael, Nancy Hayden, Barry Christian, Dan Bennack and Frank D'Itri. (1990). WQ 23 ``Home Water Treatment Using Activated Carbon," Cooperative Extension Service, Michigan State University.

Kearns, J. (Fall 2007). Charcoal Filtration Basics-Aqueous Solutions Drinking Water Systems.

Krehbiel, D. (2017). *Determination of Water Hardness - Odinity*. *Odinity.com*. Retrieved from http://www.odinity.com/determination-water-hardness/

Mallakin, A. and Ward, O. (1996). Degradation of BTEX compounds in liquid media and in peat biofilters, *Journal of Industrial Microbiology*, vol. 16, no. 5, pp. 309-318.

Manison, P. (2013). *Sustainable Ceramic Membranes for Wastewater Applications*. *Ceramicindustry.com*. Retrieved from http://www.ceramicindustry.com/articles/93500-sustainable-ceramic-membranes-for-wastewater-applications

Minnesota Department of Health, "Environmental Health- Minnesota Dept. of Health," *Water Treatment Using Carbon Filters: GAC Filter Information: Environmental Health: Minnesota Dept. of Health*. Retrieved from http://www.health.state.mn.us/divs/eh/hazardous/topics/gac.html.

Satterfield, Z. (2005). *Filter Backwashing* (Vol. 5, Issue 3). West Virginia University, P.O. Box 6064, Morgantown, WV 26506-6064: The National Environmental Services Center. Retrieved from http://www.nesc.wvu.edu/pdf/dw/publications/ontap/2009_tb/filter_backwash_dwfsom83.pdf

Using Plant-Based Biofilters to Purify Household Wastewater. (2012). *AMNH*. Retrieved from http://www.amnh.org/learn-teach/young-naturalist-awards/winning-essays2/2012-winning-essays/using-plant-based-biofilters-to-purify-household-wastewater/

Wastewater Treatment Protects Small Community Life (summer 1996), Health National Small Flows Clearinghouse, Pipeline, Vol. 7, No. 3.

WATER PURIFICATION USING PLANTS. HOW TO PURIFY WATER USING PLANTS. *Dew-drop.com*. Retrieved from http://www.dew-drop.com/waterpurificationusingplants.html

Which Common Water Purifying Technique is better, Boiling or Filtration? | Live Healthy (2015). *Livehealthy.aquasana.com*. Retrieved from http://livehealthy.aquasana.com/2010/08/water-purifying-technique-better-boiling-or-filtration/