DEVELOPING A WATER FILTER WHICH REDUCES SURFACTANTS IN LAUNDRY GREY WATER USING WASTE RUBBER TIRE, *Cocos nucifera* CHARCOAL AND *Moringa oleifera* SEEDS AS FILTER MEDIA

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by

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Developing a water filter which reduces surfactants in laundry grey water using waste rubber tire, *Cocos nucifera* charcoal and *Moringa oleifera* seeds as filter media

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ABSTRACT

Grey water is one of the common domestic waste water which is often disposed of without treatment. When grey water is continually disposed in the same location, surfactants may accumulate and cause deterioration of water quality and capillary rise of soil. This study aimed to determine the amount of surfactants in untreated and filtered grey water and to calculate the amount of surfactants the filter was able to filter. Waste rubber tire, *Moringa oleifera* seeds and *Cocos nucifera* charcoal were used as the filter media for the filter. The amounts of surfactants in the samples were determined using the rapid spectrophotometric method using methylene blue. There was 0.0032348 M of unfiltered grey water and 0.0009384M, 0.0002736 M, 0.0001908 M and 0 M of filtered water from first to fourth filtrations. The filter was capable of reducing at most 29 % of the surfactants present in grey water. The study confirmed that the filter media used were able to filter surfactants from laundry grey water.

Keywords: grey water, surfactants, water filter, filter media, surfactant reduction

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INTRODUCTION

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Grey water (GW) includes all the non-toilet wastewater produced by an average household including the water from kitchen sinks, washing machines, dishwashers, bathtubs, showers, and bathrooms sinks. Fifty to eighty percent of residential wastewater is GW which composes mainly of surfactants. Other components of GW are suspended solids, organic material, bacteria, hair, oil and grease, sodium, nitrates and phosphates (from detergent), and detergent residue (Gross and others 2007).

Detergents are the major source of surfactants in GW, and are the most abundant type of organic chemical in urban wastewater. Surfactants are organic molecules consisting of a hydrophilic head and a hydrophobic tail. The hydrophobic group contains a long alkyl chain of $C_{10} - C_{20}$. The hydrophilic group has an electrical charge and can form hydrogen bonds (Gross and others 2005).

The acknowledgement of non-conventional options for the reuse of wastewater around the world is unavoidable. Along with the growing of population, the demand for water increases; thus, it has become crucial that innovative and modern methods are necessary to ensure the sustainable management of water resources. The separation and reuse of wastewater (black and grey water) has increased in importance in the recent years in an effort to resolve the problem and as a result of economic and ecological considerations.

GW is commonly used in irrigating systems (Gross, Azulai and others 2005). If farmers were to use GW, expenses may be lessened rather than using fresh water to crops. It is also a big help to the environment because it reuses used water rather than consuming new water resources.

The use of GW for irrigation has been increasing lately because it is less expensive and easy to collect. But one common mistake most likely is that GW is already safe to use without further pre-treatment. However according to the study of A. Gross (2005), prolonged use of GW may change some physical properties of the soil that might be a reason of crop malnourishment and death (Shafran, Gross and others 2005). The change in properties in the soil is caused by the amount of surfactant in the GW.

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Chemical pollution of the environment by surfactants and heavy metal ions is a result of increasing industrial activity of man. Large amounts of these pollutants when penetrating into surface water reservoirs cause foaming, reduce the diffusion of the atmospheric oxygen dissolved in water and consequently lead to the death of many organisms for the deficiency of oxygen (Seifert and Domka 2003). Therefore it is recommended that waste water must be treated and is considered safe before disposing it back to the environment.

The ways of treating grey water are through using biological systems, biodegradable chemicals and water filters (Pullizi 2009). Most of these are expensive and are not widely sold in the Philippines. Finding other ways to treat grey water is recommended and important to reuse the grey water and save fresh water.

A. Statement of the Problem

This study aimed to develop a water filter to reduce the amount of surfactants from grey water.

B. Objectives of the Study

This study aimed to fulfill the following objectives:

1. to design a filter using moringa seeds, coconut shell charcoal and waste rubber tire as filter media;
2. to determine and compare the amount of anionic surfactants (moles per liter) in untreated and filtered grey water; and
3. to calculate the surfactant percent removal of the filter.

C. Hypothesis

Ninety percent of the surfactants will be filtered from the grey water.

D. Significance of the Study

Grey Water is commonly used for land irrigation usually in households. Grey Water is considered a reusable wastewater in that it has lesser quantities of toxic substances and pathogenic organisms than that of black water. Because of this, it is usually thought of as good quality water, and therefore requires minor treatment before its use. However GW release to the environment poses hazardous consequences if continually disposed in the same location which may cause accumulation of surfactants in the water. The harmful environmental effects and pollution caused by elevated levels of salinity and surfactants that is capable of changing the soil properties, damaging plants and contaminate the ground water (Shafran and others 2003).

Waste water can be reused safely for irrigation and other purposes safely after it has been treated in the filter. Fresh water can be conserved since the waste water will be used in its place. The amount of surfactants which are disposed in bodies of water will also be reduced.

E. Scope and Delimitation

The study used only three filter media, *Moringa oleifera* seeds, *Cocos nucifera* charcoal and waste rubber tire. There was only one brand of detergent used in making the grey water used in the study. The amount of surfactants was the only water parameter measured in this study. Other water qualities were not measured. The filter properties were also not measured.

F. Definition of Terms

Chloroform ($CHCl_3$) is also called trichloromethane. It is a colorless, heavy, sweet-smelling non-flammable liquid. Chloroform is a widely used extractant and solvent (Parker 1996). In this study, chloroform was mixed with the waste water to extract methylene blue activated substances from the water.

Filter is a porous article or material used for separating suspended particulate matter from liquids by passing through pores ins the filter and sieving out solids (Parker 1996). In this study, the designed filter refers to a water filter, was a capsule filter type.

Grey Water (GW) includes all the non-toilet wastewater produced by an average household including the water from kitchen sinks, washing machines, dishwashers, bathtubs, showers, and bathrooms sinks (Gross 2005). In this study, the grey water used was collected from laundry waste water.

Methylene Blue (MB) is also called methyl ionine chloride. It is composed of dark green crystal or powder. It is soluble in water, alcohol and chloroform. It is used as a textile dye, biological strain and indicator (Parker 1996). In this study, MB was used to indicate the surfactants during the separation of the chloroform and water phase.

Spectrophotometer is an instrument that measures transmission or apparent reflectance of invisible light as a function of wavelength, permitting accurate analysis of color or accurate comparison of luminous intensities of two sources or specific wavelengths (Parker 1996). In this study UV – 2100 spectrophotometer (UNICO) was used for the determination of the amount of surfactants.

Surfactants (Surface Acting Agents) are wetting agents that lower the surface tension of a liquid, allowing easier spreading, and lower the interfacial tension between two liquids or a liquid and a solid (Parker 1996). In this study, surfactants referred to as anionic surfactants, is the most abundant substances in laundry detergents.

Chapter 2

REVIEW OF RELATED LITERATURE

This chapter comprises the following topics: Grey water, Surfactants, Measuring Anionic Surfactants, Filter Design, Filter Media and Related Studies.

A. Grey Water

Grey Water includes all non-toilet wastewater from domestic origins. It compromises of about 50% to 80% of residential wastewater (Gross and others 2007). For most households grey water contains soap, shampoo, toothpaste, shaving cream, laundry detergents, hair, lint, body oils, dirt, grease, fats, chemicals and urine. The most significant pollutant of grey water is laundry detergent. It also contains bacteria, parasites and viruses washed from the body (World Health Organization - Eastern Mediterranean 2006).

Irrigation and toilet flushing are two common ways of reusing grey water. But, grey water, which is alkaline, should not be watered on acid thriving plants.

B. Surfactants

Surfactants are surface acting agents which lower the surface tension of a liquid. They are used in domestic cleaning products, personal care products, institutional cleaners and industrial cleaning processes (Human & Environment Risk Assessment 2002). Laundry detergents, which are major components of grey water, are about one-third surfactants (Connell 2005).

Surfactants in aqueous solutions tend to accumulate at the liquid/gas or solid/liquid interface, increasing the distance between the water molecules and therefore causing reduction of water surface tension. Capillary rise in the soil is caused by surfactants. Capillary rise of liquids in soils is a phenomenon that can have both beneficial and detrimental effects on the soil. It is an important mechanism by which plants can draw water from below the root zone, but it is also a mechanism contributing to the accumulation of salts in the soil. Long-term irrigation with GW rich in surfactants might cause their accumulation in the soil and may result in the formation of water repellent soils, as well as enhanced environmental pollution (Shafran and others 2005).

C. Measuring Anionic Surfactants

Improved spectrophotometric method using methylene blue was used to measure the concentration of anionic surfactants in laundry grey water (Koga and others 1999).

C.1. Calibration Curve

A calibration curve is a general method for determining the concentration of a substance in an unknown sample by comparing the unknown to a set of standard samples of known concentration. In this study, the calibration curve is needed in the determination of the amount of surfactants because it shows the relationship of the absorbance of the sample and its concentration.

C.2. Methylene Blue (MB)

MB has the property of a cationic surfactant therefore several anionic surfactants could react with it to form blue complexes that are extractable into organic solvent. Anionic surfactants form an ion-pair complexes reaction from the Methylene Blue. The ion pair complexes are extracted into an organic phase while MB is not, so this is forms the analytical basis for the application of this technique in the analysis of anionic surfactants (Nollet 2000). In this study, the methylene blue solution is made by dissolving 0.35 g of MB to 500 mL of pure water and diluted to the mark of a 1 L with pure water.

C.3. Chloroform ($CHCl_3$)

Chloroform is a colorless, sweetly scented liquid which is most well known for its historical use as an anesthetic, although it has since been abandoned due to safety concerns. Chloroform was used to extract the anionic surfactants from the water solution as stated in the study of Zhang in 2007.

D. Filter Design

A filter removes impurities from water by means of a fine physical barrier (net, screens, sand, carbon, etc.), a chemical process or a biological process. Filters cleanse water to various extents for irrigation, drinking water, aquariums and swimming pools.

In Carbon Filters the total duration of filtration time is important on the over-all effectiveness of the filters. The longer the water stays in contact with carbon, the better the result (Dontigney 2009).

D.1. Pot Filters

These are filters which are structured like a pot; they have a wide opening and a hole on the bottom side where the water will flow. These are cost effective, have long life spans and filtering elements can be easily fitted. The disadvantages are that they are fragile and difficult to maintain; recontamination may occur during maintenance and have a slow flow rate (safewater4kids [updated 2010]).

D.2. Capsule Filters

These are filters which have a capsule body frame. The filter has a small opening, an enclosed body and another opening at the bottom. The capsule filters are easy to use, portable, and capable of processing relatively large volumes of environmental water samples. However, a major disadvantage associated with the capsule filter is the cost (Kearns 2009). The design of the filter in this study, was based on capsule filters.

E. Filter Media

A filter medium is any material that, under the operating conditions of the filter is permeable to one or more components of a mixture, solution or suspension, and is impermeable to the remaining components.

E.1. Coconut Charcoal

Coconut tree (*Cocos nucifera*) which grows in the tropical climatic & is a tree falling into the palm verity. The coconut fruit is used for food purpose while the thick outer husk rich with fiber is the source of our raw materials. The coconut is a natural water filter that takes almost 9 months to filter each liter of water. The water travels through many fibers being purified where it is stored away sterile in the nut itself.

Charcoal is the dark grey residue consisting of impure carbon obtained by removing water and other volatile constituents from animal and vegetation substances. Charcoal is usually produced by slow pyrolysis, the heating of wood, sugar, bone char, or other substances in the absence of oxygen. The resulting soft, brittle, lightweight, black, porous material resembles coal and is 50% to 95% carbon with the remainder consisting of volatile chemicals and ash. Most charcoal filters use activated charcoal for more efficient results. Wood charcoals are used in the Philippines as a water purifier in wells.

Carbon, in charcoal, performs adsorption. This is a major filtration action in which there is physical attraction between the contaminant and the carbon. Carbon is also porous providing a very large surface area. As water passes through the carbon, the contaminants get caught in the pores. Another filtration action done by carbon is catalytic reduction. As the water passes through, the positively charged ions in the carbon provide an attractive force for negatively charged contaminants (Dotigney 2009).

E.2. Waste Rubber Tire

A tire is a ring-shaped covering that fits around a wheel rim to protect it and enable better vehicle performance by providing a flexible cushion that absorbs shock while keeping the wheel in close contact with the ground. The carbon black component of the tire is the factor which can help with reducing anionic surfactants. Carbon black is the same as Carbon from charcoal. It performs adsorption and it is very porous, these are properties which are good for filtration. In this study, granules of waste tire rubber were one of the filter media.

E.3. Moringa Seeds

Moringa oleifera, commonly referred to simply as "Moringa", is the most widely cultivated species of the genus Moringa, which is the only genus in the family Moringaceae. Moringa, locally known as malunggay, is grown throughout the Philippines in settled areas as a backyard vegetable and as a border plant. It could be considered to be one of the world's most useful trees, not only is it drought resistant, it also yields cooking and lighting oil, soil fertilizer, as well as highly nutritious food in the form of its pods, leaves, seeds and flowers. Its most important component is its seeds, because they can be used to purify drinking water at virtually no cost.

Mature Moringa seeds, when crushed into powder, can be used as a water-soluble extract in suspension, resulting in an effective natural clarification agent for highly turbid and untreated pathogenic surface water. As well as improving drinkability, this technique reduces water turbidity (cloudiness) making the result aesthetically as well as microbiologically more acceptable for human consumption. Moringa seeds are considered mature if the pods are cracked (Ramachandran and others 1980).

F. Related Studies

The study of Koga and others (1999) was to decrease the time and expenses used in determining anionic surfactant by using methylene blue. The results his group got was significantly close to the results of the normal way of determining anionic surfactants.

The study of Purakayastha (2002) was undertaken to evaluate the efficiency of adsorbents such as, rubber granule, charcoal, silica gel and granular activated carbon for the removal of sodium dodecyl sulfate (SDS) that is a representative member of anionic surfactant. In the batch experiments conducted at an initial concentration range of 2-6 mg/L, it was found that the rubber granules selected could remove SDS from water up to 90% .

The study of Isidro (2008) determined the purifying effects ability of malunggay (*Moringa oleifera*) seed. He stated that moringa seed acts as coagulant due to its positively charged particles attracting negatively charged particles allowing the resulting ‘flocs’ to settle at the bottom or be removed by filtration.

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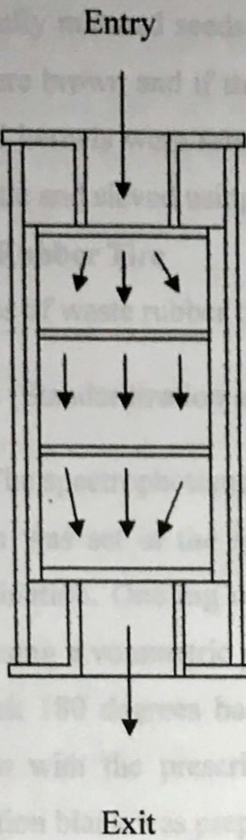

FIGURE 3: Longitudinal cross-sectional the Filter and Water Flow

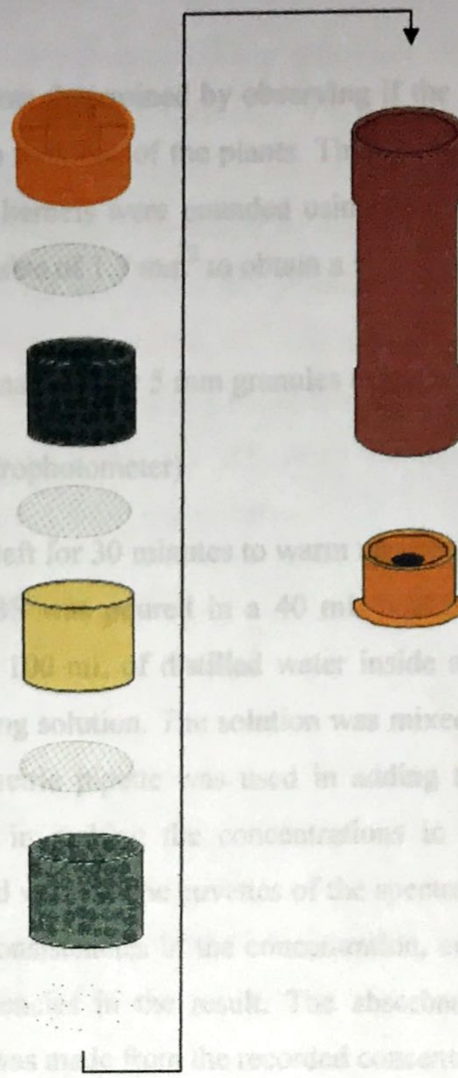

Figure 4: Exploded Isometric View of View of the Filter

The filter was composed of a case and an inner filter. The casing was made by cutting 22 cm of PVC pipe (4#20). Two reducers (5 cm in length) were attached to each end of the PVC pipe by pushing them inside. The inner filter F2 was made by three PVC pipes which have radius that is able to fit inside the case. A layer of silk screen was used to separate the filter media and to prevent them from being carried by water. From topmost to bottom, the filter media used were waste rubber tire, crushed moringa seeds, and coconut shell charcoal.

Phase 2 (Preparation of Filter Media)

Moringa Seeds

Fully matured seeds were collected. This was determined by observing if the color of the pods were brown and if there were any cracks on the pods of the plants. The shells surrounding the seed kernels were removed by hand and the kernels were pounded using laboratory mortar and pestle and sieved using a strainer with a pore size of 1.7 mm^2 to obtain a fine powder

Waste Rubber Tire

Strips of waste rubber tire were cut to approximately 5 by 5 mm granules using scissors.

Phase 3 (Standardization and Calibration of Spectrophotometer)

The spectrophotometer was turned on and left for 30 minutes to warm up. The wavelength 652 nm was set in the spectrophotometer. LABS was poured in a 40 mL beaker to prevent contamination. One mg of LABS was added to 100 mL of distilled water inside a volumetric flask, using a volumetric pipette to form a working solution. The solution was mixed by turning the flask 180 degrees back and forth. A volumetric pipette was used in adding the working solution with the prescribed amount of water in making the concentrations in Table 1. A calibration blank was prepared by adding distilled water to the cuvettes of the spectrophotometer to zero the concentration. If there would be inconsistencies in the concentration, cuvettes with the same value were used to reduce inconsistencies in the result. The absorbance of each concentration was recorded. A calibration curve was made from the recorded concentrations.

Table 1: Calibration Standards Preparation

Concentration (mg/L)	Working standard (mL)	Distilled Water (mL)
0.0	0	100
1.0	10	90
2.0	20	80
3.0	30	70
4.0	40	60
5.0	50	50

Phase 4 (Determination of the amount of Anionic Surfactants and Water Quality)

The filtered and unfiltered water samples were prepared. Fifty milliliters of each water samples was collected and then measured using graduated cylinders. The samples were then transferred to separate 125 mL separatory funnel. MB solution (5 mL) and $CHCl_3$ (5 mL) is added to each sample, MB first then $CHCl_3$. The solution was shaken by hand for 1 minute. The funnel was allowed to settle (for 1 min. or less) until the chloroform phase and water phase are distinguished. The chloroform phase was filtered into a 100 mL volumetric cylinder. The absorbance of each chloroform solution is then measured using the spectrophotometer at 652 nm. There were 7 series of filtrations done to check the efficiency of the filter. The concentration of the anionic surfactant will be solved using this equation:

$$\text{mg MBAS/L} = \frac{\text{mg apparent LABS /L x 100}}{\text{Volume of sample used (mL).}}$$

Data Analysis

The calibration curve was constructed by plotting the absorbance value of standards versus the corresponding MBAS (calculated as LABS) concentration. The amount of anionic surfactants after using the developed filter was divided with the amount of anionic surfactants found in the water sample before it was filtered to determine the percent removal of the filter. A graph of the efficiency of the filter was made using the gathered data on percent removal.

Handling and Disposal

Personal protective equipment should be worn during analysis. Chloroform is a very volatile liquid and a suspected carcinogen, handling it with caution is best. When handling chloroform, keep under a safety hood to avoid direct inhalation and to contain accidental spillage or leakage. Discard analyzed samples in a waste container after analysis.

Pour the separatory funnel solutions that contain no chloroform down a drain under a hood. Flush with copious amounts of water. Do not put chloroform solution in a plastic container since it can dissolve plastic. Draining disposal of chloroform is not advisable.

Chapter 4

RESULTS AND DISCUSSION

The study aimed to develop a filter that reduces the amount of surfactants in laundry wastewater. Only one laundry detergent was used throughout the study. The rapid spectrophotometric method using Methylene Blue was used to determine the absorbance of the filtered surfactants. The study had conducted 4 trials undergoing the same method of determining surfactants. The equation from the calibration curve was used to determine the exact amount of surfactant shown in the spectrophotometer.

A. RESULTS

Results showed that the filter was capable of filtering at most 29% of the surfactants present in grey water.

A.1. Filter Design

The filter is designed to reduce the amount of surfactants found in laundry waste water. The coconut charcoal is the lowest layer, then the moringa seeds and at the topmost is the waste rubber tire. The positions of the filter media help improve the filtering ability of the filter. The water will stay longer at the topmost because it cannot easily pass through the moringa seeds. This gives the water more time in the rubber tire layer, which absorbs more surfactant in the water. The charcoal was not chosen to be the topmost filter media because it is impure and causes the water to turn black.

The filter media used were proven capable to reduce surfactants in water. The overall structure of the filter was chosen to be as that of a capsule filter because it is easier to make, cheaper and is more portable compared to a pot filter.

Plate 1: Designed Filter

A.2. Amount of Surfactants in Grey Water

A calibration curve is needed in determining the amount of surfactants. It is a graph which shows the relationship between the concentration and absorbance of LABS in water. The graph was made using different concentrations of the working solution (10 mg of LABS in 1 L of distilled water) in distilled water.

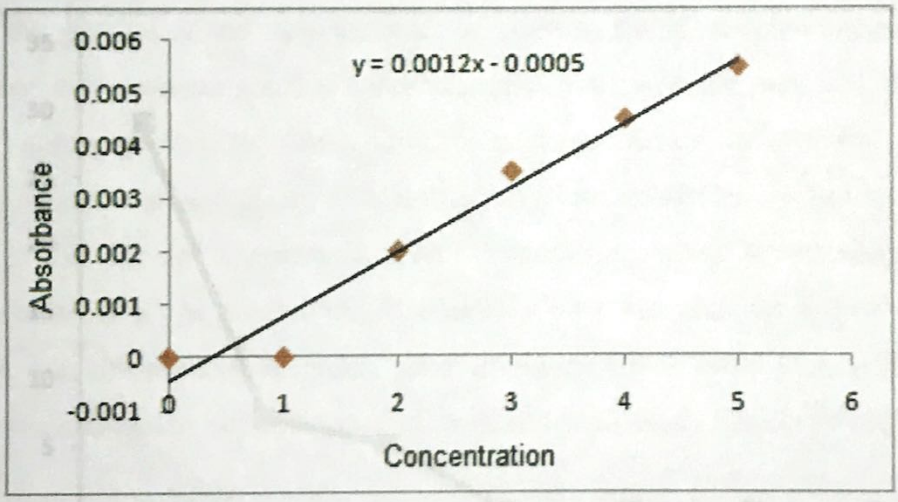

Figure 5: Graph of Calibration Curve

In the graph, it is seen that the absorbance in 0 and 1 concentration are equal. This is because the spectrophotometer used was not that accurate and did not present stable values

The amount of surfactants in water was measured using the UNICO spectrophotometer set to 652 nm wavelength. The calibration curve was used in calculating for the concentration of the surfactants in the water. There was 0.0032348 mol/L of surfactant present in laundry waste water. This will be used to solve the percentage removal of the filter.

A.4. Amount of surfactants filtered

The following are the amounts of surfactants filtered during the first, second, third and fourth to seventh filtrations respectively: 0.0009384 mol/L, 0.0002736 mol/L, 0.0001908 mol/L and 0 mol/L.

A.5. Efficiency of the filter

The filter was able to filter surfactants for three succeeding filtrations. On the fourth filtration, the spectrophotometer showed that the filter can no longer reduce the amount of surfactants in grey water. This was further proven by three more filtrations which gave the same results.

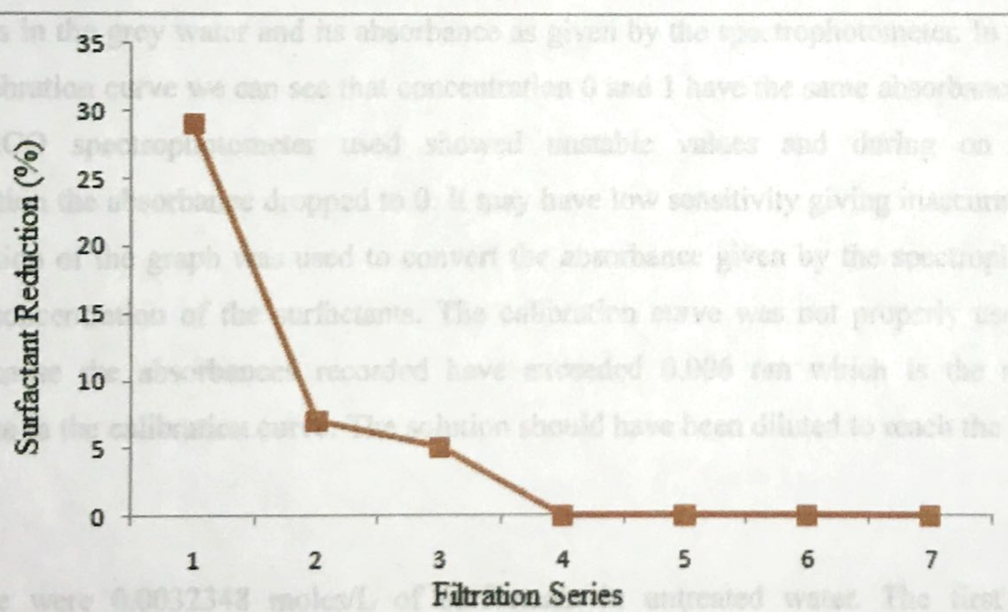

Figure 6: Filter Efficiency

A. Discussion

The filter was able to reduce 29% of the surfactants present in laundry grey water. This means that the filter media used can reduce the surfactants from water. However, in the study of Purakayastha (2002), he was able to remove up to 90% surfactants using only selected waste rubber tire and charcoal. The decrease in the percent reduction must be because of the moringa seeds. The seeds have degraded over time and this affected the effectiveness of the filter.

The filter was designed after a capsule filter. Most capsule type filters are cylindrical. The design was inspired by the common water purifier found in water dispensers. This structure was chosen because it is easier to make, affordable and more portable compared to a pot structured filter. Nowadays, water filters are made of ceramic, metals and plastic. These materials take more time to make and are expensive, that is why PVC pipe was chosen to be the body of the filter to save time and money. Reducers cover the filter at both sides in the idea of making it attachable to pipes which connect to a sink for easier water disposal.

The calibration curve shows the relation between the concentration of the anionic surfactants in the grey water and its absorbance as given by the spectrophotometer. In the graph of the calibration curve we can see that concentration 0 and 1 have the same absorbance of zero. The UNICO spectrophotometer used showed unstable values and during on the first concentration the absorbance dropped to 0. It may have low sensitivity giving inaccurate values. The equation of the graph was used to convert the absorbance given by the spectrophotometer into the concentration of the surfactants. The calibration curve was not properly used in this study because the absorbances recorded have exceeded 0.006 nm which is the maximum absorbance in the calibration curve. The solution should have been diluted to reach the 0.006 nm mark.

There were 0.0032348 moles/L of surfactants in untreated water. The first filtration (0.0009384 mol/L) shows that there was a 29% decrease in the amount of surfactant present in the grey water. As the filtration series goes on the amount of surfactants filtered is decreasing until the filter was unable to reduce surfactants anymore. The percent reduction of the filter dropped greatly on the second filtration. This is because the second and third filtrations were conducted one week after the first filtration and by that time the moringa seeds had started degrading. This was proven by the change in the color of the filtered water to brown. The fourth to seventh filtrations were conducted another week after the third and the second filtrations. The percent removal dropped to 0 because the moringa seeds had degraded making them useless in reducing surfactants. The filtration series should have been conducted on one setting to get a credible filter efficiency graph.

The filter was capable of reducing the amount of surfactants in laundry grey water. The filter media used proved to be effective in the reduction of surfactants.

Chapter 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This study aimed to develop a water filter to reduce the amount of surfactants from grey water.

It specifically aimed:

1. to design and develop a filter using *Moringa oleifera* seeds, *Cocos nucifera* charcoal and waste rubber tire as filter media;
2. to determine the amount of anionic surfactants (moles/L) in untreated and filtered grey water; and
3. to calculate the percent removal of the filter.

It was hypothesized that ninety percent of the surfactants will be filtered from the grey water.

A. Summary of Results

The filter was successfully designed consisting of *Moringa oleifera* seeds, *Cocos nucifera* charcoal and waste rubber tire. There was 0.0032348 mol/L of unfiltered grey water and 0.0009384 mol/L, 0.0002736 mol/L, 0.0001908 mol/L and 0 mol/L of filtered water from first to fourth filtrations. The filter was able to filter up to 29% of surfactants present in laundry grey water.

B. Conclusions

The filter was capable of reducing anionic surfactants present in laundry grey water. Therefore the filter media used were effective in filtering surfactants from water.

C. Recommendations

This study only used three filter media. Other researches may consider other materials to use as filter media. Future studies may also consider evaluating the surfactant removal of each filter medium or evaluating these filter media by changing their positions. Increasing the shelf life of moringa seed may also be taken into consideration. Others may research on the anti-bacterial effects of moringa seeds on waste water.

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APPENDIX A

RAW DATA

Filtration Series	Absorbance (nm)
Filtration 1	2.209 – 2.451
Filtration 2	2.872 – 2.896
Filtration 3	2.896 – 3.010
Filtration 4	3.010 – 3.214
Filtration 5	3.010 – 3.214
Filtration 6	3.010 – 3.214
Filtration 7	3.010 – 3.214
Unfiltered	3.010 – 3.214

APPENDIX B

PLATES

Plate 1: Designed Filter

Plate 2: Preparation of Filter Body

Plate 3: Crushing of Moringa Seeds

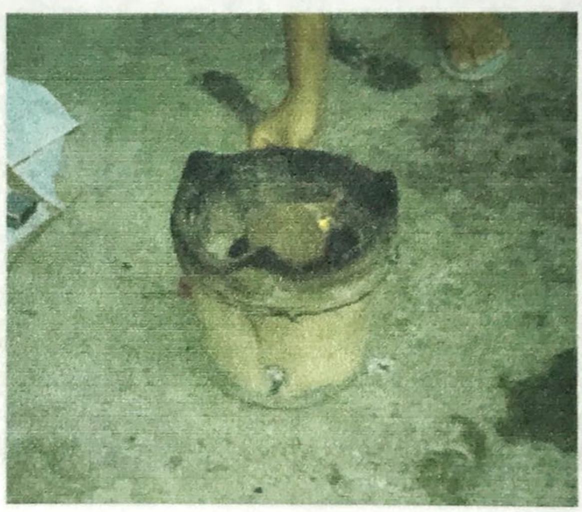

Plate 4: Making of Coconut Charcoal

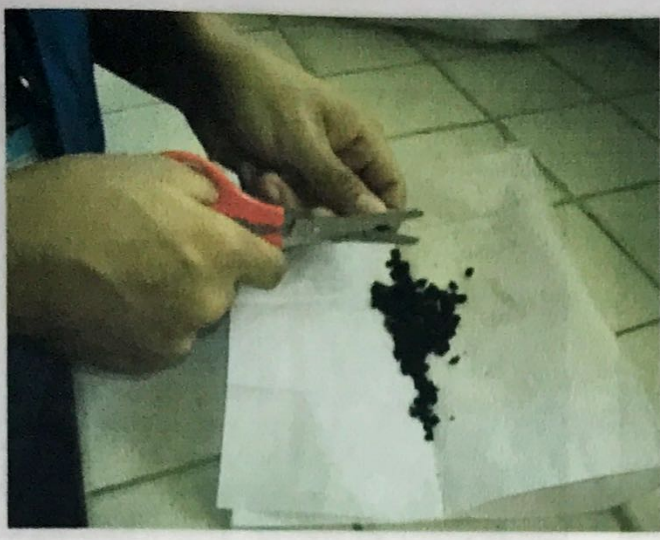

Plate 5: Cutting of Waste Rubber Tire

Plate 6: Water Filter Assembly

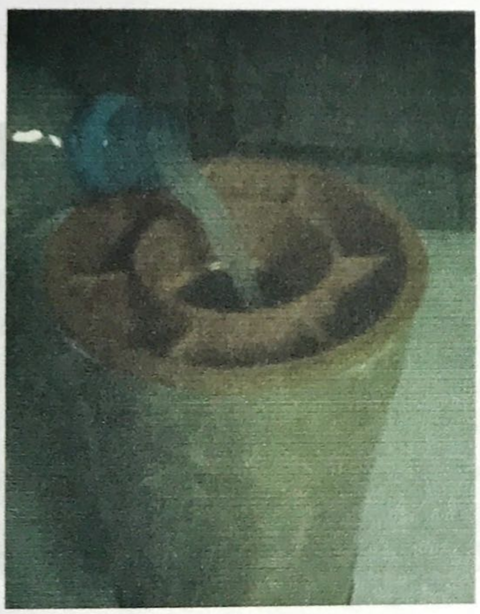

Plate 7: Pouring of Grey Water Into Filter

Plate 8: Measuring 5 mL of Methylene Blue

Plate 9: Measuring 5 mL of Chloroform

Plate 10: Mixing of Chemicals into Separatory Funnel

Plate 11: Shaking of Separatory Funnel

Plate 12: Chloroform Phase (Dark Blue)

Plate 13: Using UNICO Spectrophotometer

Plate 14: Recording Data from Spectrophotometer