To Recycle grey water from household baths and laundry, for use in gardens

Name of finalist 1:

Name of finalist 2:

Name of finalist 3:

Main category: Stem

Sub-category: Environmental studies

Country:

Supervisor/teacher name:

Contents

TOPIC

To design a simple "Do-it-yourself" filtration system to recycle grey water at home for re-use in the garden.

ABSTRACT

Recent water restrictions and reports from the news that the dams supplying water to our area will turn into mud if we have no rain by December, alerted me to the severity of the current drought. This frightened me and I thought that I should do something to help the situation. I wanted to do something cheap and simple, yet effective to get many people to use it. I therefore decided to devise a household DIY grey water filtration system for this project. The filter will save water and the incentive to use the filter is to save money by reduced water consumption.

We use water to clean but how do we clean water when its slightly mixed with relatively harmless contaminants that we use. How do we avoid having to throw "clean" water down the drain?

I decided to build a water filter with things that you can find around the house, and that will be cheap. Recycling grey water is not new. There are many filters available on the market which, but they are not practical. This is due to availability, price and ease of use in integrating it in the household. This project is aimed overcoming these challenges

Grey water from the shower was passed through a series of filters made up of muslin cloth, gravel, pool sand and crushed charcoal.

During testing, I started off with a single muslin filter, and added progressive layers and checked water quality at each stage. The grey water became much clearer to the naked eye as the grey water passed through each extra filtering medium.

From the research and results, it is recommended that households adopt this system as they will be able to save drinking water by 25-50%.

INTRODUCTION

When I was told that I had to do a research project for school, there were just so many choices. We are very "green" at home; we, in our daily routine recycle paper, plastic, glass and cans so my project had to be around saving one of earth's precious resources.

Water is an extremely valuable, scarce natural resource in Africa, being the 30th driest country in the world. News reports that the dams supplying water to our areas would turn to mud if we have no rain by December, concerned me.

This led me to base my project on how we, as a nation can try to conserve water at home.

Following hours of internet research, I came across a very interesting website, www.greendiary.com. From this I got the idea to build a simple 'DIY', (Do-it-yourself) system to recycle grey water in the home, for use in the garden.

Reusing wastewater can significantly reduce the amount of water used in a household.

In our homes two types of wastewaters are generated: grey water and black water.

Greywater is wastewater from non-toilet plumbing fixtures such as showers, basins, and taps. **Black water** is water that has been mixed with waste from the toilet.

At present, most homes use potable (drinkable) water for almost everything in the house and garden. In this project, I shall look at building a filtration system for recycling grey water to be used for irrigation purposes in the garden.

The end goal is for all households to implement such a system, leading to vast amounts of fresh water being saved.

BACKGROUND INFORMATION

Water scarcity is a global challenge, this is no exception for Africa. As mentioned earlier, Africa is ranked as the 30th driest country in the world.

Water availability affects the development of the entire country; it affects the economic, social, and environmental well-being of Africa over the next decade. We are sure to experience water shortages similar to the electricity load shedding we had last year as the demand for water increases.

The annual rainfall level in Africa is around 50% lower than the world average; we encounter unevenly distributed rainfall across the country. The east and west coast, as well as the inland have highly variable climates, where droughts and floods are common. Climate changes due to global warming also affect rainfall patterns.

In addition to this, the low rainfall level for the last five years, has us in the middle of a severe drought, reported as the worst in 34 years. In 2015, Government declared five out of the nine provinces as disaster zones. Our province, Kwa-Zulu Natal has been hit the hardest.

From all of this, we can see the urgency of finding ways to save water immediately. How can we make a difference? We can start by recycling water in our homes every day.

Water recycling refers to the re-use of treated wastewater for beneficial purposes such as agricultural and landscape irrigation, industrial processes, and toilet flushing. Recycled water for irrigation requires less treatment than recycled water for drinking water.

In our homes, there are two types of wastewaters generated: grey water and black water.

Blackwater is water that has been mixed with waste from the toilet. This water has a high organic loading (nitrogen) and contains harmful germs; it requires biological or chemical treatment and disinfection before reuse. This is not in the scope of this project.

Grey water is water from the bathroom and washing machine. The organic loading is much lower, so it can be recycled for re-use. The definition according to Greywateraction.org, "Greywater is gently used water from your bathroom sinks, showers, tubs, and washing machines. It is not water that has come into contact with faeces, either from the toilet or from washing diapers. Greywater may contain traces of dirt, food, grease, hair, and certain household cleaning products",

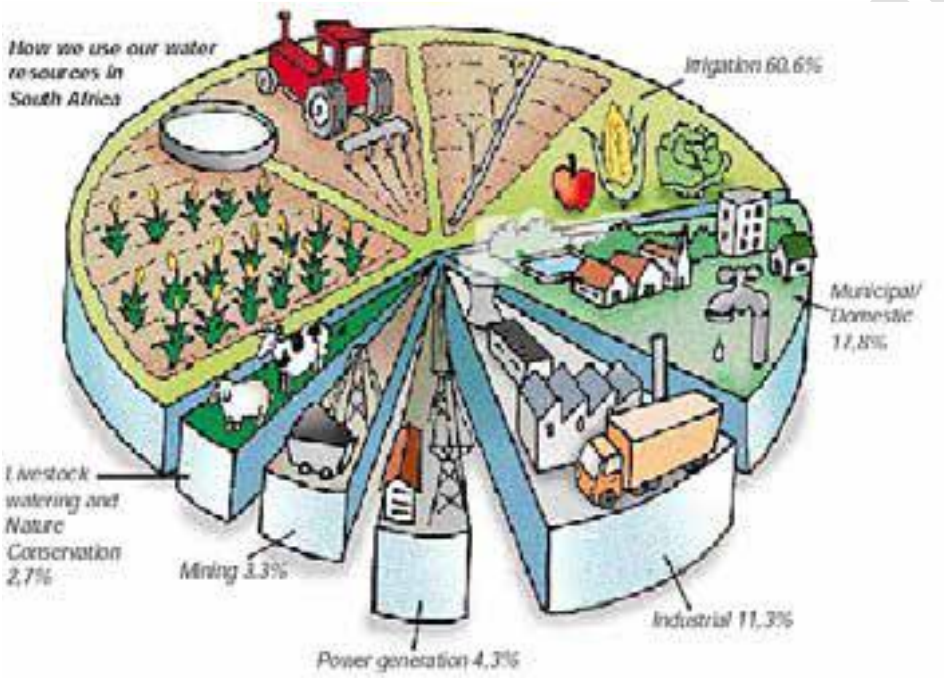
In this experiment, water from kitchens and dishwashers were excluded from grey water as they contain oil, grease, and food particles which has the potential for contamination by pathogens. Therefore, they will fall into the black water category.

Grey water can be safely used to water plants.

Strategic Overview of the water sector in Africa 2013

www.dwa.gov.za

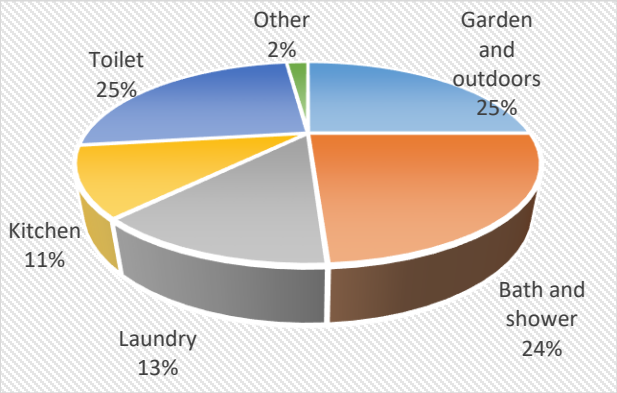
This shows how water is used in Africa. 27% of the total water is used for domestic purposes.



https://www.dwa.gov.za/io/Docs/CMA/CMA%20GB%20Training%20Manuals/gbtrainingmanualchapter1.pdf

Water usage in an urban home

Based on water usage studies done by the Municipality in 2009, the pie chart below shows the typical water use for a middle income, 4-person home with a garden.



http://www.urban.gov.za/City_Services/development_planning_management/environmental_planning_climate_protection/Publications/Documents/GG_Water_Guide.pdf

From this chart the laundry, bath and shower water use 37% of the total water.

25% of the total water is used outdoors and in gardens. If we recycle this water and use it in the garden, then we would easily be able to reduce water usage in the home by at least 25%.

Not only a water saving, but a rand saving as well!

PROBLEM

Water is necessary for preserving life and civilisation on Earth. There is a world-wide shortage of water. In addition, Africa is classed as a "water-stressed" country. We need to investigate ways to conserve water.

If we look at total water usage in Africa, 20% is utilised for domestic purposes. Presently, most homes use potable (drinkable) water for practically everything in the house and garden. There is opportunity to recycle wastewater for re-use; thereby reducing household water consumption. This can reduce domestic potable water use by 25-50%.

AIM

The aim of this project was to develop a simple DIY filtration system to encourage the average household to recycle grey water for use in the garden.

HYPOTHESIS

Grey water from the bath, shower and washing machines can be cleaned using a simple filtration system and reused in the garden. In an average household, recycling grey water would reduce its total water usage by 25-50%.

VARIABLES

The method chosen to 'clean' the grey water influenced the quality of the recycled water. With each additional filter, more and more impurities were removed resulting in the water getting cleaner at each stage.

The **dependent variable** was 'clean' water suitable for use in gardens. The qualities that were tested were odour and appearance.

Independent variables included the set up and method used to clean the water. In this project, a gravity feed, filtration system was tested. The efficiency of this system depended on the type of filtration media selected, the number of filters and the quantities of media used.

These filtration variables were tested: -

- Muslin cloth
- Muslin cloth + gravel
- Muslin cloth + gravel + sand
- Muslin cloth + gravel + sand + coal

METHODOLOGY

Materials used

- Tap water (used as the control)
- Grey water (made using 1 litre water mixed with 2ml of the following, shower gel, shampoo, and liquid laundry detergent)
- White muslin cloth cut into squares (6 x 6cm)
- Gravel used in fish tanks
- Pool Filter Sand (average particle size of 0.6 – 1.5mm)
- Charcoal (charcoal crushed down to below 0.5mm in size)
- Large, clear glass jug
- 2L clear plastic cool drink bottles cut around 1/3rd from the top and inverted (settling tank)
- Clear tumblers (surge tank)
- Mild bleach solution
- Black cable ties
- Scissors

Procedure

Step 1

- The best method that would work in the average home was selected.
- This had to be practical and easy to implement.
- A gravity feed filtration system was chosen, as no expensive plumbing changes, and pumps would be required.

Step 2

- From the wide range of products available to filter water, the most suitable materials were assessed in terms of efficiency, cost, and availability.
- A four step multi-media filtration process using muslin cloth, gravel, sand, and coal respectively was selected as the ideal system to clean the grey water.
- The muslin cloth was bought from a fabric shop, the gravel was that used in a fish tank, the sand was pool sand and crushed household braai charcoal was used.

Step 3

- Grey water from bath, sinks, showers, and the washing machine was replicated.
- This was prepared by adding 2mL each of shower gel, shampoo, and liquid laundry detergent to 1.5 litre of tap water.

Step 4

- The 'settling tank' was the cut top of the clear cool drink bottle.
- The 'tank' had to be large enough to capture all the grey water, be water-proof and durable, ideally a hard plastic.
- In a practical situation, the tank must have an opening at the top for periodic cleaning and maintenance.
- In this tank, oils, and grease particles from the grey water float to the top and sediments settle at the bottom.

Step 5

- The multi-media filtration system was set up.
- As this was a gravity fed system, the materials went into the 'tank' in reverse order; that is the last filtration medium went in first.
- A piece of the white muslin was placed at the bottom of the 'tank'.
- This served as a lining to make the cleaning that is required easier.
- A filtration bed for the bottom of the settling tank was assembled as follows: -

Crushed Charcoal

  - The bottom filter layer consisted of charcoal.
  - Store bought coal was crushed using a hammer into coarse particles, under 5mm in size.
  - The particles were washed in water first to remove the fine black dust particles.
  - This was followed by a mild bleach wash to rinse off any dirt or residue and left to dry for 3 hours in the sun.
  - Ideally, a carbon activated filter is the best to remove impurities from water.
  - As this is costly, an improvised filter was made using crushed charcoal.
  - A 2 cm layer of the crushed charcoal was used for the last filtration stage.
  - A piece of muslin cloth was used to separate the next layer.

Sand

- The next filtration layer consisted of pool grade filter sand (0.6 – 1.5mm grain size)
- The sand was cleaned with the mild bleach solution to rinse off any dirt or residue and left to dry for 3 hours in the sun.
- The layer was 3-4cm thick.
- A much thicker layer of sand was needed for the fine filtration, the deeper the layer of sand, the better the filtration.
- A piece of muslin cloth was used to separate the next layer.

Gravel

- Gravel, generally used in fish tanks formed the next layer.
- Prior to use, the gravel was washed in a mild bleach solution to rinse off any dirt or residue. It was then left to dry in the sun for 3 hours.
- A thin layer of gravel was needed, 1-2 cm layer was used.
- Water that passes through the gravel is coarsely filtered.
- A piece of muslin cloth was used to separate the next layer.

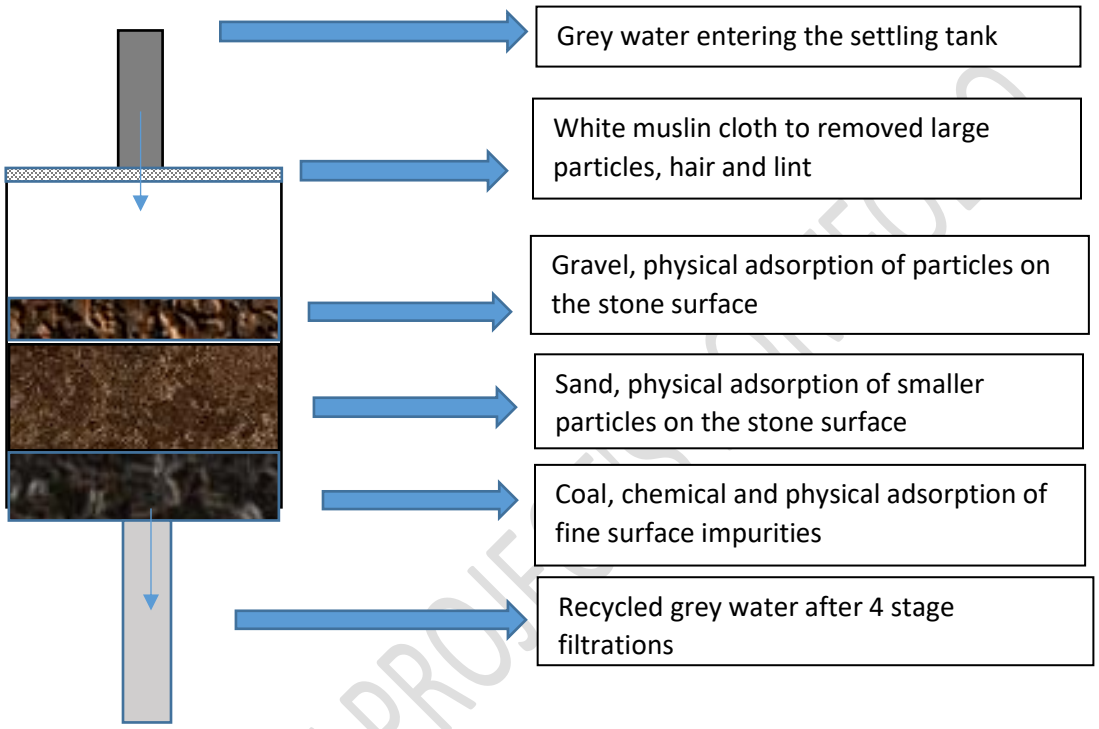
White muslin cloth

- In this study, the white muslin cloth served 2 purposes.
- The cloth was used at the entrance of the settling tank to serve as a coarse mesh filter to trap large particles such as lint and hair.
- This is the first step in the filtration process, it also prevents clogging in the filters by removing the bigger particles first.

Step 6

- The bottle top was suspended over the tumbler.
- 250mL of grey water was poured over the filter system
- This was left to filter through to the surge tank for 10 minutes.
- The water collected in the 'surge tank' was tested.

A simple diagram to show the filtration system that I designed



This diagram is drawn by finalist.

Step 6

- A second exercise was carried out to see the effect of the different filtering material on the recycled water.
- The following filters were prepared in the cut cool drink tops and suspended over the clear tumblers: -
    - Muslin cloth
    - Muslin cloth + gravel
    - Muslin cloth + gravel + sand
    - Muslin cloth + gravel + sand + coal
- 250 mL of unfiltered grey water was poured into the clear tumbler.
- 250 mL of tap water, used as the control was also filled in a clear tumbler.
- 250 mL of recycled water was passed through each stage and kept aside in the clear glasses.

- After 10 minutes, all 6 samples were assessed.
- The black cable ties were inserted into each glass to check clarity.

RESULTS / OBSERVATIONS

- This was a qualitative study based on cleaning grey water.
- Water quality was assessed after each filtration stage.
- The results tested were odour and appearance in terms of colour and clarity
- Normal tap water was used as the control.

	COLOUR	CLARITY * 1 = BEST 6 = WORST	ODOUR
TAP WATER (CONTROL)	**Clear**	**1**	**No odour**
GREY WATER BEFORE FILTERING	Milky to grey colour	5	Mild soap smell detected
FIRST FILTRATION MUSLIN CLOTH	Milky to grey colour	5	Mild soap smell remains
SECOND FILTRATION COARSE GRAVEL	Milky to grey colour, but a little lighter	4	Mild soap smell remains
THIRD FILTRATION SAND	Milky to grey colour, but lighter	4	Slight soap smell
FOURTH FILTRATION CRUSHED COAL	Milky to grey colour, but lightest in colour	3	Slight soap smell

* Visibility of the black cable tie

ANALYSIS OF RESULTS

An analysis was carried out after each filtration stage. I observed that after each step, the water quality improved, measured by appearance and odour. After the 4-step multi-media filtration, the water was much clearer. There was a small drop in odour as well.

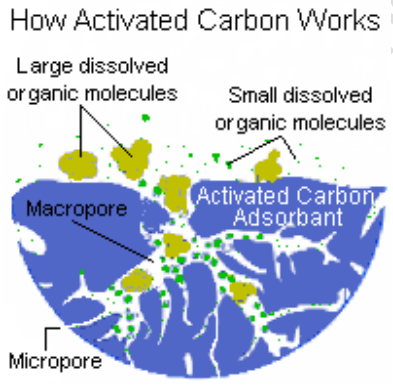
The first stage filtration using the muslin cloth was a **simple separation** of the large solid particles from the water. This was removed early to prevent clogging of the following filters.

As the water flowed through the porous structure of the various filters, impurities were removed by either absorption or adsorption.

The second stage with the sand gravel and the third stage with the fine sand (0.6 – 1.5mm), worked on the principle of **physical adsorption**. They acted as **surface filters**; the pollutant particles were trapped on the permeable sand surface. These filters removed bacteria and other small particles. Sand filters do not remove heavy metals or chemicals.

The final stage filtration with the crushed charcoal (carbon) worked as a **depth filter** working on the principle of **physical adsorption** and **chemical adsorption**. The physical absorption drew the particles to the core where it was chemically adsorbed within the porous body of the coal. The carbon removed odour, and most contaminants and impurities.

Commercial filters use activated charcoal. "Activated charcoal is charcoal that has been treated with oxygen to open up millions of tiny pores between the carbon atoms", according to Encyclopaedia Britannica.



http://www.tigg.com/what-is-activated-carbon.html

In this project, water was filtered for re-use in gardens and not for consumption; therefore, there was no need for an expensive activated coal filter. For our use, the crushed charcoal gave us sufficient cleanliness in the water.

The main reason for adding the coal filter was to get the water to as safe a level as possible in the simple filtration process. Most impurities are removed resulting in a lower organic loading in the water, hence a safer product.

DISCUSSION OF RESULTS

Recycling grey water is not new, Japan, parts of America and Australia have been doing it for years.

Current recycling systems are expensive and difficult to install, so they are not used often. An easy to use, affordable system would appeal to homeowners, as water-saving equals money saving.

The main advantages of recycling grey water are: -

- a reduction in the need for fresh water and a money saving
- a reduction in the amount of wastewater entering sewers
- a constant supply of water for the garden, even during droughts or water restrictions

The presence of disease-causing pathogens is a disadvantage to using grey water. But this is minimised if the water is used within 24-48hours.

Grey water can also benefit plants, some nutrients such as phosphorous and nitrogen provide food for the plants and can make them grow better.

After the 4-step filtration, water in the surge tank can be further disinfected to remove the bacteria. Two common chemicals used are chlorine and iodine. Chlorine found in bleach is cheap and readily available compared to iodine.

Chlorine is not environmentally friendly and not good for plants, so it would not work for our system. However, chlorine can be used to treat water for toilet flushing, in the event of water cuts or restrictions.

ERRORS AND LIMITATION GAPS

The main limitation was that we did not have the equipment to do quantitative testing of the water. For this exercise, the qualitative results were fine, but it would have been interesting to see the changes in chemical and biological activity before and after filtration.

Assessing colour and odour are subjective tests. With the results being quite similar, some of the test checks got confusing.

The aim of this exercise was to achieve a 25 to 50% water saving. This range cannot be narrowed as water usage differs significantly in households. Key factors are the location, either rural or urban; the size of the house and household, whether the house has a garden or not, and the size of the garden.

Whilst doing this experiment, I observed that it is difficult to separate the different media used in the filter. For this reason, I used the muslin cloth between the different layers. This made separation easier, this is necessary when the filters must be removed for cleaning.

The periodic maintenance and cleaning do pose disadvantages in a practical situation. The settling tank would have to be cleaned to avoid a build-up of sediment. The different filter media must be removed, washed, and disinfected with bleach.

Another practical disadvantage is the presence of traces of pathogens, which could be harmful. For this reason, it is recommended to release the water close to the ground or directly in the ground, and not sprayed. It is also advisable to not keep the water for longer than 24 -48 hours, as there is a strong chance of microbial activity.

Another constraint is the bath products and cleaning detergents that are used. Where possible, natural, biodegradable cleaning chemicals are recommended. Soaps, shampoos, and detergents should contain low or no sodium products. Chlorine bleach cannot be used as it is toxic to garden plants.

After doing this project, I have a better understanding of world-wide and African water shortage. With an increasing population, the demand for water is going to grow. Recycling grey water is a good way to conserve drinking water.

CONCLUSION

This project demonstrated how a simple "DIY" filtration system could be set up using readily available materials (cloth, sand, and charcoal), to successfully clean grey water for use in gardens.

The exercise aimed to reduce the daily water need in households by 25-50%. Almost 40% of household water is used for bathing and laundry. If households adopt this system of recycling grey water, then water usage per home would decrease by up to 50%, thereby saving precious drinking water, and money.

FUTURE RESEARCH

25% of domestic water is used in toilets. Future research could look at disinfecting the recycled grey water for use in the toilets.

I could also look at using activated coal to purify the water to a level that can be used in swimming pools.

I could also investigate by discussion with various professionals, the effect on the water table, the flora and fauna downstream, if my filter had to be adopted in households.

Quite importantly, I will be keen to research developing an easy-to-use kit that can be manufactured for sale to homeowners.

ACKNOWLEDGEMENTS

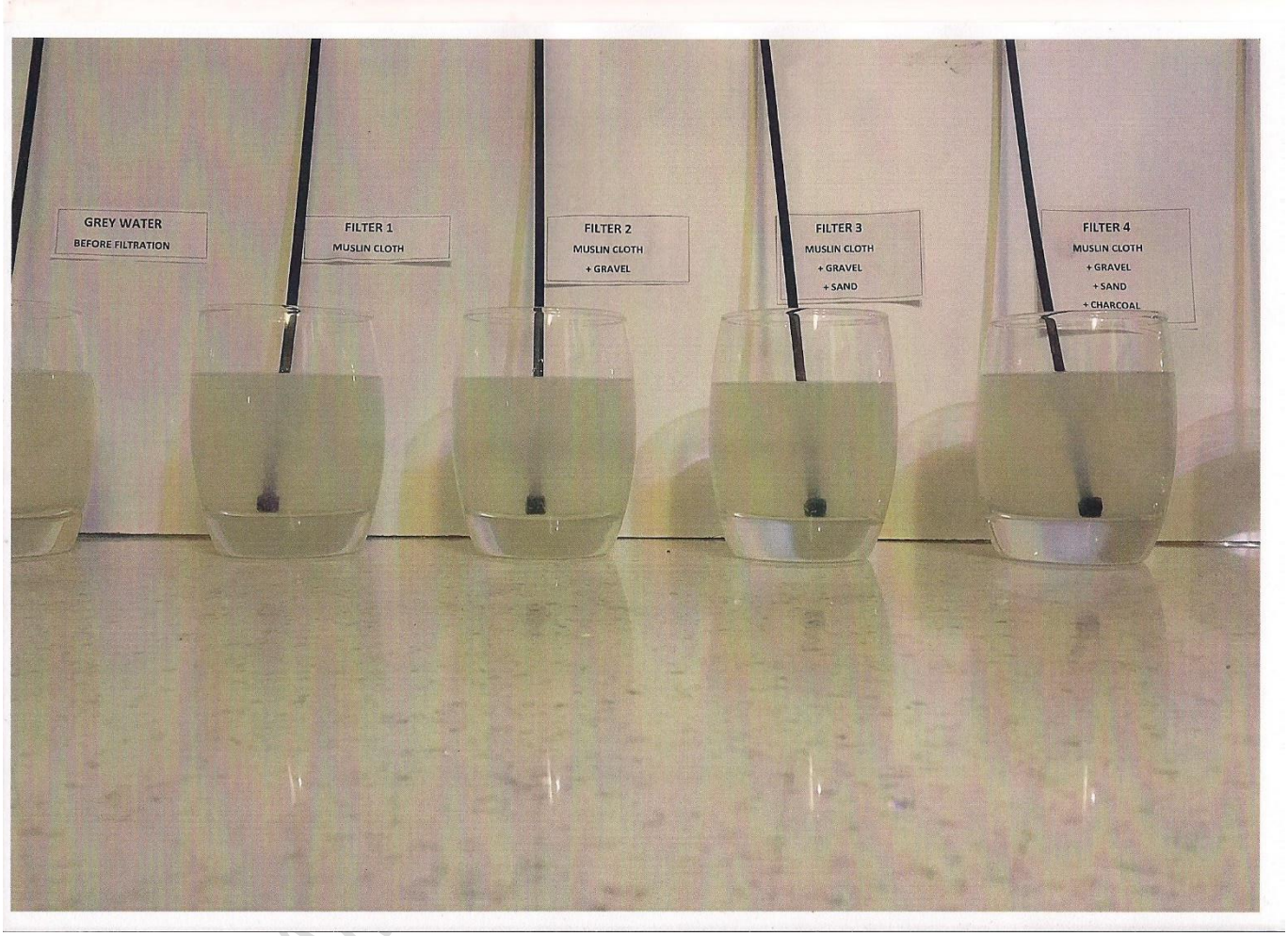
I express my sincere gratitude to my mother, [mother's name], for her invaluable assistance, financial support, and unwavering patience throughout the duration of this project.

A special thanks to my father, [father's name], whose dedicated efforts were instrumental in constructing the home for demonstration purposes.

I extend appreciation to my teacher, [teacher's name], whose wealth of laboratory experience guided me through the project. I am grateful for the access to the laboratory, as well as for proofreading and correcting my report.

PHOTOGRAPHS AND DIAGRAMS

Grey Water after filtration



This photo is taken by finalist's father.

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