2019 GENEVA CHALLENGE

RUWAFIKI

RURAL WATER FILTRATION KIT

Improving global health through safe drinking water

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ABSTRACT

Water is vital for human health and well-being and it is required for achieving sustainable development. However, water can cause devastating effects as a carrier of pathogens that transmit diseases to a large population. Water-borne diseases continue to be a global health challenge and are most prevalent in developing countries especially in rural areas. Water-borne diseases are caused by the consumption of contaminated water containing pathogens like viruses, bacteria, parasites, and protozoa and in some instances, the water may contain heavy metals like lead, zinc and mercury that can cause neurological illnesses.

Our project, Rural Water Filtration Kit (RUWAFIKI)is the development of a household water treatment kit comprising of; crushed moringa seeds; saw dust and; filter papers. The kit also consists of other accessories including a funnel, stirring stick, latex gloves, and a user manual (in Luganda language) with visual instructions on how to use the kit. A proposed design of the kit has been made containing all accessories and dimensions. Our proposal has explored the detail conditions of Makondo Parish in Uganda where we are going to apply our solution first as the area faces a lot of challenges of water-borne diseases. RUWAFIKI is an innovative solution that will enable households in Makondo to filter collected water so as to remove pathogens, improve odor and color of the water. This will result in a reduction of the burden of waterborne diseases in the area. The kit is portable, easy to use, and very affordable. The project will be implemented in Makondo in coorporation with various local and international partners. Various performance tools and indicators will be used to monitor and evaluate the performance of the project in Makondo. RUWAFIKI directly supports the identified targets of the following Sustainable Development Goals (SDGs): No poverty; Good Health and Well-being and; Clean Water.

RUWAFIKI TEAM MEMBERS

Claydon Mumba Kanyunge is an African Union Scholar from Zambia and currently pursuing a Master of Science in Water Policy at Pan African University Institute of Water and Energy Sciences, Algeria. Claydon studied Biology and Chemistry during his undergraduate at the University of Zambia, Zambia. He has worked as a youth Climate Change ambassador at unite4climate Zambia for 3 months. In 2016, he supervised 30 students in water treatment projects as part of a regional science fair. Claydon has interests in climate change adaption, public health, water treatment, renewable energy, and sustainability.

Francess Gbolare Awunor is an African Union Scholar from Nigeria and currently pursuing a Master of Science in Water Policy at Pan African University Institute of Water and Energy Sciences, Algeria. Francess studied Law during her undergraduate at the University of Ibadan, Nigeria. She has worked as an Environmental Lawyer and carried out various research in maritime pollution, water policy and laws for the past 3 years of her career. She is currently undergoing her internship at the ECOWAS Water Resource Coordination Centre, with activities for coordinating west African water resources. Francess has interests in Water Policy and governance, Ocean conservation and Environmental law and human rights.

Margaret Sima Kironde is an African Union Scholar from Tanzania and currently pursuing a Master of Science in Water Policy at Pan African University Institute of Water and Energy Sciences, Algeria. Margaret has Bachelor of Environmental Science and Management from Ardhi University, Tanzania. She worked as a Program Coordinator at Young Women Christian Association of Tanzania for 3 years where she ensured that women and girls rights and care for environment are promoted and sustained. Margaret has interests in promoting and contributing to SDGs through advocating for good policies and proper intervention that can contribute to water resource management in the face of climate change.

Oludare Sunday Durodola is an African Union Scholar from Nigeria and currently pursuing a Master of Science in Water Engineering at Pan African University Institute of Water and Energy Sciences, Algeria. Oludare studied Agricultural and Environmental Engineering during his undergraduate at the Ladoke Akintola University of Technology, Nigeria. He worked as a Teaching Assistant for 1 year at Federal University Dutsinma, Nigeria where he taught some engineering course. He is a member of the Sustainable Development Solutions Network- Youth (SDSN-Youth). Oludare has interests in youth and leadership development, WASH and climate change adaptation.

Victo Nabunya is an African Union Scholar from Uganda and currently pursuing a Master of Science in Water Engineering at Pan African University Institute of Water and Energy Sciences, Algeria. Victo studied Agricultural Mechanization and Irrigation Engineering during her undergraduate at Busitema University, Uganda. She has worked as a volunteer in gender studies and agriculture for 1 year, with focus on increasing women participation in agriculture and the use improved irrigation technologies. Victo has interests in rural community and humanitarian works, Irrigation technologies, WASH, climate change mitigation and gender studies.

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1. INTRODUCTION

Access to clean and safe water to each human being is a basic need and human right. One of Africa's challenge that adversely impacts public health is lack of access to clean safe water supply to urban and rural areas, where in rural areas the situation is dismal. About 20 percentage of rural people in Sub- Saharan Africa rely on surface waters such as rivers, ponds, lakes for drinking and cooking (WHO, 2006). While the source can be readily available it is highly contaminated. Lack of clean safe water affects many with major impact being on children under age five. Contaminated water has been the leading cause of water-borne diseases such as diarrhea, cholera, typhoid and death in Africa. In Africa, statistics from WASH (2016) more than 315,000 children die every year from diarrheal diseases caused by unsafe water and poor sanitation. According to WHO (2018) globally, deaths from diarrhea caused by unclean drinking water are estimated at 502,000 each year, most of them of children under 5 years.

According to Baumann (2005) approximately 35% of all rural water supply systems in Sub-Saharan Africa are not working properly. While two studies conducted by Sutton (2005) and Hazelton (2000) in Sub-Saharan region showed operational failure of 30%-60% in rural water projects, furthermore the study conducted in Tanzania (2009) indicated that one-quarter of new water points become non-functional within two years of installation. The cause of failures and non - functionality being miscellaneous and include a number of factors from natural, technical, social, cultural and financial factors.

Uganda just like many African countries' access to safe water in most of rural areas remains a challenge. Although the government of Uganda decentralized rural water supplies, empowering local government authorities financially to organize the service and involving private sectors by signing contracts, most of the contracts are weak and water facilities are underperforming. A study conducted in Makondo Parish in Uganda by Marci et al (2013) showed that over 50% of water pumps have remained idle and useless to communities due to lack of proper maintenance.

Nearly 90 percent of Uganda's 35 million people live in small towns and rural areas, and roughly two thirds of them lack access to clean and safe water. Poor sanitation worsens the problem, waterborne diseases and infant mortality are widespread (IFC, 2016). Accessing of contaminated and unsafe water is such a heavy burden for the Uganda's community. Drinking and using contaminated water is a major leading cause of waterborne diseases and death across Uganda with 4,500 children dying every year due to having no other option but to drink this unsafe water ("Uganda's water crisis", 2018).

Our solution is an innovative idea on domestic water treatment on-site so as to address water quality issues in Makondo Parish, Lwengo District in rural Uganda by introducing ***Rural Water Filtration Kit (RUWAFIKI)***. The kit comprises of Moringa seeds which will be used as coagulant and is widely available, filter paper and activated carbon. The kit will enable households to filter water they have fetched from surface or ground water sources on site to remove color, odor and pathogens such as bacteria, viruses and protozoa that cause water borne diseases. The kit is user friendly and affordable enabling households who can't afford household connection in which water comes from treatment plants to treat the unsafe water on their areas.

1.2 Case study overview

The Parish is situated in rural Lwengo District that was carved out of the former Masaka District and is located approximately 194 km from Kampala, the nation's capital city. Makondo Parish has 1726 households with an estimated population of 8193 inhabitants, many of whom derive their livelihoods from crop and livestock farming typical of rural communities in most African countries.

The landscape in Makondo has typical savannah characteristics dominated by shrubs that are interspaced with grasses. Furthermore, the parish has several hummocks dissected by streams, rivers and swamps, including Katonga and Kanana rivers that drain into Lake Victoria to the east. Seasonal surface runoff from rainfall is the major recharge, although most streams are dry for much of the year. Makondo Parish is situated between the savannah tropical climate and the semi-arid climate with temperatures ranging from 26 °C to 29 °C. The Parish also benefits from two periods of rainy seasons (March–May and September–November) and two dry spells (January–February and June–August), with an annual average rainfall amount of 950 mm per annum. However, due to climate variability and change, the Parish experiences changes and fluctuations in climatic conditions that are reflected in longer periods of droughts and erratic rainfall.

The rural site selection was based on the sources of domestic water supply. A study carried out in the same location, published in 2013 recorded that 35% of the surveyed households used unimproved sources such as ponds, open or hand-dug wells, and unprotected springs as their primary sources of water. Another reason is based on health and water survey conducted where it shows that 76% experienced malaria, 42% had at least one family member who suffered from stomach aches, while the incidence of diarrhoea is also notable (37% of households) (Marci et al, 2013). Figure 1.1 is a picture of the pond used by household in the study area.

Figure 1.1: An open pond used by household in Makondo Parish. (Daniel et al, 2018)

1.3 Justification of the project

Water is considered a right to all for social and economic existence of humanity (Agnew and Woodhouse 2011), and thus depriving humans from their right to water threatens life and undermines human dignity (UNDP 2006). In Uganda, national safe water coverage is estimated at 66% with 42% coverage in rural areas (DWD 2011a), this leaves a bigger percentage of the rural population with no access to safe water. In Makondo, a rural area in Uganda with 17 villages a survey was carried out and indicated that 41% of households used water from unprotected sources like open ponds and rivers while 27.6% of households used water from shallow wells which are also highly susceptible to risk of contamination, 42% had at least one family member who suffered from stomach aches, while the incidence of diarrhoea is also notable (37% of households). This exposes the people of Makondo rural area to high risk of waterborne diseases which eventually lead to death. The number of children under five dying from water borne diseases in Uganda is over 4500 annually and this is attributed to consumption of dirty water. (Uganda water crisis, 2018)

The number of available options for water treatment are quite expensive for rural standards due to their low incomes. The aim of this project therefore is to design a low-cost water filtration kit from locally available materials and to provide a sustainable solution to the problem of unsafe water for the rural people in Uganda. The rural filtration kit can be used to treat water from rain, springs and shallow wells.

The reason for the selection of the use of these materials to make the RUWAFIKI is that materials are locally available, environmentally friendly and processes of making not tedious. This makes it highly feasible to develop with the help of the scientists from PAUWES and the help of the women in the rural locations. The implementation of the RUWAFIKI will help to provide a source of employment for the rural women thus improving on their lives. The intention of involving the rural women in the development of the water filtration kit is to provide a sustainability to the project as they can continue making the kits even when the kit life is expired and thus promote a continued health of families, particularly children under five.

The uniqueness of this kit is that it emulates the drinking water treatment process which involves coagulation, filtration and disinfection. The coagulation and disinfection process will be accomplished by ground moringa seeds and the filtration process by activated carbon and filter paper. The two-stage process ensures complete treatment of water to about 99% pathogen removal. The RUWAFIKI will also include health awareness messages that will always remind the users about the importance of taking safe drinking water.

With successful implementation of this project; the global SDGs 3: to promote healthy lives and promote wellbeing for all at all ages will be achieved. Also, SDG's 6 and 1 will also be achieved. This will enable to reduce the mortality rate of children under five and thus improving the health of all citizens. A healthy nation means a better development for the country. More details on the SDG's are shown in logical framework.

2. LITERATURE REVIEW

2.1 Water and Health Overview

Around 1.1 billion people worldwide do not have access to improved water supply sources, where as 2.4 billion people do not have access to any type of improved sanitation facilities. According to WHO (2014), about 2 million people die every year due to diarrheal-related diseases most of whom are children less than 5years of age. The most affected are people of the developing countries living in extreme condition of poverty, normally peri-urban dwellers or rural inhabitants.

According to a WHO report, in the developing countries, four-fifth of all the illnesses are caused by water-borne diseases with diarrhoea leading to dehydration being the leading cause of childhood death (WHO, 2014). The WHO and UNICEF joint monitoring report of 2014 indicates that an estimated 246.7 million people worldwide are infected with schistosomiasis and out of these, 20 million suffer severe consequences of the infection while 120 million suffer neither symptom. An estimated 80% of the transmission takes place in Africa south of the Sahara. 4,000 children die each day as a result of diseases caused by ingestion of filthy water. Additionally, four out of every 10 people in the world, particularly those in Africa and Asia, do not have clean water to drink. Lakes and streams which people use for drinking water, bathing and defecating are sources of disease, as is water left by natural disasters.

2.2. Contribution to the Sustainable Development Goals (SDGs)

Sustainable Development Goal (SDG) 6 focuses on clean water and sanitation for all and aims to achieve universal and equitable access to safe and affordable drinking water for all by 2030. It also aims to ensure there is access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations. Furthermore, another target for SDG 6 is to improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally (UNDP, 2015).

2.3. Water and Sanitation

A report published in the medical journal, the Lancet, (2005) concluded that poor water sanitation and lack of safe drinking water take a greater human toll than war, terrorism and weapons of mass destruction combined.

Among the main problems which are responsible for this situation were;

a) Lack of priority given to the sector (poor policy formulation and implementation);
b) Lack of financial resources;
c) Lack of water supply and sanitation services;

d) Poor hygiene behaviours and inadequate sanitation in public places including hospitals, health centres and schools providing access to sufficient quantities of safe water.
e) Lack of water treatment devices in communities and households.

The provision of facilities for sanitary disposal of excreta and introducing sound hygiene behaviours, are of capital importance to reduce the burden of disease caused by these risk factors.

More so, the lack of trained personnel to carryout health education on its prevention is another problem. This is because communities lack educators to educate them on the dangers of waterborne diseases there by influencing the health status of the people (Strausbaugh, 1997). Besides, another problem faced in the developing countries is that of lack of water project schemes; since most communities do not have water projects, they turn to use water from doubtful sources there by increasing the rate of water borne diseases in Africa. (Gerba et al, 2010).

2.5. Waterborne Diseases

Waterborne diseases can be classified into three types, bacterial, viral and parasitic diseases:

2.5.1. Bacterial diseases

Untreated drinking water and faecal contamination of water is the major cause of diarrhoea. *Campylobacter jejuni* spread diarrhoea 4% to 15% worldwide. Fever, abdominal pain, nausea, headache are major symptoms of diarrhoea. Good hygienic practices and use of antibiotics can prevent this disease. Disease cholera is caused by the contaminated water. *Vibrio Cholerae* is responsible for this disease. The symptoms of this disease are watery diarrhoea, nausea, vomiting and watery diarrhoea leads to dehydration and renal failure. Anti- microbial treatment is used to get rid of this disease (Jackson et al, 2001).

2.5.2. Viral diseases

A common example of a viral waterborne disease is Hepatitis. Hepatitis is a viral disease caused by contaminated water and infects the liver. Jaundice, loss of appetite, fatigue, discomfort and high fever are symptoms of hepatitis. If it persists for a long time it may be fatal and results in death. Vaccine is available for hepatitis and by adopting good hygienic practice; one can get rid of this disease (Sasikaran et al, 2012).

2.5.3. Parasitic diseases

Cryptosporidiosis is a common parasitic disease caused by the *cryptosporidium parvum*. It is worldwide disease and symptoms are diarrhoea, loose or watery bowls, stomach cramps and upset stomach. *Cryptosporidium* is resistant to disinfection and affects immune system and it is the cause of diarrhoea and vomiting in humans. Disinfecting water can easily remove the parasite and prevent illness (Mahmud et al, 2014).

2.6. Waterborne Disease Transmission

Poor environmental sanitation and water quality play a significant role in spreading infectious diseases. For instance, faecal material can reach the mouth from the hands or on contaminated food leading to transmission of pathogens. In general, contaminated food and water is the single most common way in which people become infected. The Figure 2.1 below shows the faecal-oral routes of diseases transmission.

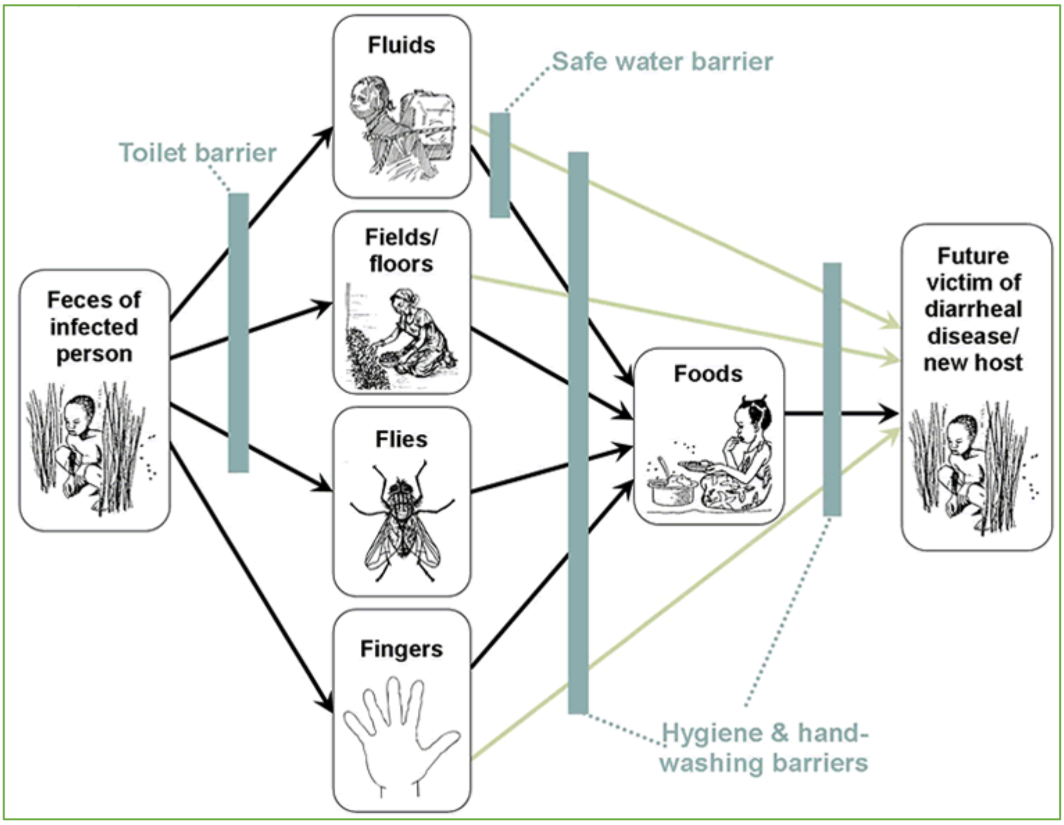


Figure 2.1: Feacal-oral route of disease transmission (Source: Jackson et al, 2001)

Safe drinking water is one of the most important indicators of food absorption. Many water-borne infections spread due to use of unsafe drinking water. Thus, it needs to be remembered that the augmentation of water supply alone does not ensure good health, proper handling of water and prevention of contaminations are equally important.

2.7. Water Treatment Methods

Strausbaugh (1997) describes some conventional water treatment methods available in rural areas of developing countries. Some conventional water treatment methods include boiling, filtering, sedimentation techniques, the use of chemicals and the use of storing water in clay pots.

A study conducted by Patricia (2007) showed that about 33% of households in rural areas of Africa did not purify their water. The study also indicated that 25% of household boiled their water, 17% of households used chemicals to purify their water and about 15% practiced sedimentation methods.

Despite the use of the conventional methods of water treatment methods, difficulties in preventing water borne diseases are often encountered by many community members in rural areas. This is usually due to lack of health education, lack of finances, and lack of time and absence of water projects to construct water supply systems in the communities (Lattimore, 2002).

2.8. Water treatment materials

2.8.1. Moringa Seeds Moringa Oleifera (M. Oleifera)

Moringa Oleifera (M. Oleifera) is a natural coagulant that is sustainable, cheap and safe alternative for water purification. The purpose of adding coagulants to waters in purification stages is to increase the flocculation in the water (Qasim et al. 2000). The removal of turbidity in water treatment is essential because naturally suspended particles are transport vehicles for undesirable organic and inorganic contaminants, taste, odour and colour-imparting compounds and pathogenic organisms (Raghuwanshi et al. 2002).

Figure 2.2 Two women collecting Moringa oleifera leaves from Moringa trees. source: nation.co.ke

Moringa oleifera coagulant is safe and very effective in removing impurities. Additionally, *Moringa oleifera* has being reported to have antimicrobial properties in water (Amagloh and Benang 2009). It also has been reported as having the ability to remove metals from water (Nand, Maata, Koshy & Sotheeswaran 2012).

The use of Moringa has an added advantage over the chemical treatment of water because it is biological and has been reported as edible. According to Muyibi and Evison (1995), hardness removal efficiency of *Moringa oleifera* was found to increase with increased dosage. Using natural coagulant such as the seeds from the *Moringa oleifera* tree instead of aluminium sulphate might provide advantages, such as lower costs of water production, less sludge production and the ready availability of reagents. The seeds from *Moringa oleifera* have been proven to be one of the most effective primary coagulants for water treatment, especially in rural communities in comparison with other plants material used over the years (Doer, 2005; Onwuliri and Dawang 2006).

"Moringa Oleifera (M. Oleifera) is a natural coagulant that is sustainable, cheap and safe alternative for water purification."

Moringa oleifera is an environmentally friendly natural coagulant most suitable for the treatment of water containing undesirable heavy metal concentrations. Based on the experimental test results, it can be concluded that *Moringa oleifera* is an effective natural coagulant which can be used in improving the physicochemical characteristics of water in terms of pH, turbidity, total dissolved solids, suspended solids, alkalinity and conductivity (Doer, 2005).

2.8.2. Filter papers

The filter medium of a filter paper is a porous (or at the very least semipermeable) barrier placed across the flow of a suspension to hold back some or all of the suspended materials. If this barrier were to be very thin compared with the diameter of the smallest particle to be filtered (and perforated with even sized holes), then all the filtration would take place on the upstream surface of the medium (Aikhomu et al., 2000).

Filtration is an ancient and widely used technology that removes particles and at least some microbes from water. Microbes and other colloidal particles can be physically removed from water by various processes one of which includes the use of filter papers. Bacteria are somewhat larger than viruses (about 0.5 to 3 micrometers) but too small to be readily removed by plain sedimentation or settling. Protozoan parasites are the next largest in size (most are about 3 to 30 micrometers). Protozoan removal efficiency by filtration varies with parasite size and the effective pore size of the filter medium. Helminths are multicellular animals that are readily removable by settling and various filtration processes (Imtiaz A., 2013).

2.8.3. Activated carbon from Sawdust

Activated carbon is one of the most important microporous adsorbents due to its tremendous adsorptive capacity, an affinity for variety of dissolved organics and ability to be custom-tailored to suit specific application (Ismadji et al., 2005). Active carbon is unique and versatile adsorbents, and they are used extensively for a removal of undesirable odour, colour, taste, and other organic and inorganic impurities (Bansal and Goyal 2005). It is most effective in removing organic contaminants and other particles from water. The major uses of activated carbon are in waste water treatment, water purification, gas purification, desulphurization, removal of dye in water and mercury removal (Lam and Zakaria, 2008).

Sawdust has been studied as a water treatment material for the removal of anions (e.g. nitrate, vanadate), but sawdust has to be activated/modified by adding cationic groups and so far, modified sawdust has proven to be an excellent material for the removal of anions from water. (Leivika T 2014). Research also indicate that sawdust a waste material from the timber industry can be used to prepare activated carbon that can be used as an adsorbent for pesticides.

Steam activation is a type of activating carbon in which the concept of water-shift reaction with water vapour (steam) as carrier is utilised, in order to enhance the porosity of the carbon matrix making them very valuable activated carbon. According to Kakoi et al (2015), the temperature of 750°C with a soaking period of 60 minutes and an activation period of 30 minutes with steam was found to produce an adsorbent material with a high surface area hence large adsorption capacity. The removal percentage of pesticides by both sawdust activated carbon was observed to be over 95% at equilibrium conditions indicating that the sawdust activated carbon could make a good adsorbent (Kakoi et al, 2015).

2.9. Problem Landscape

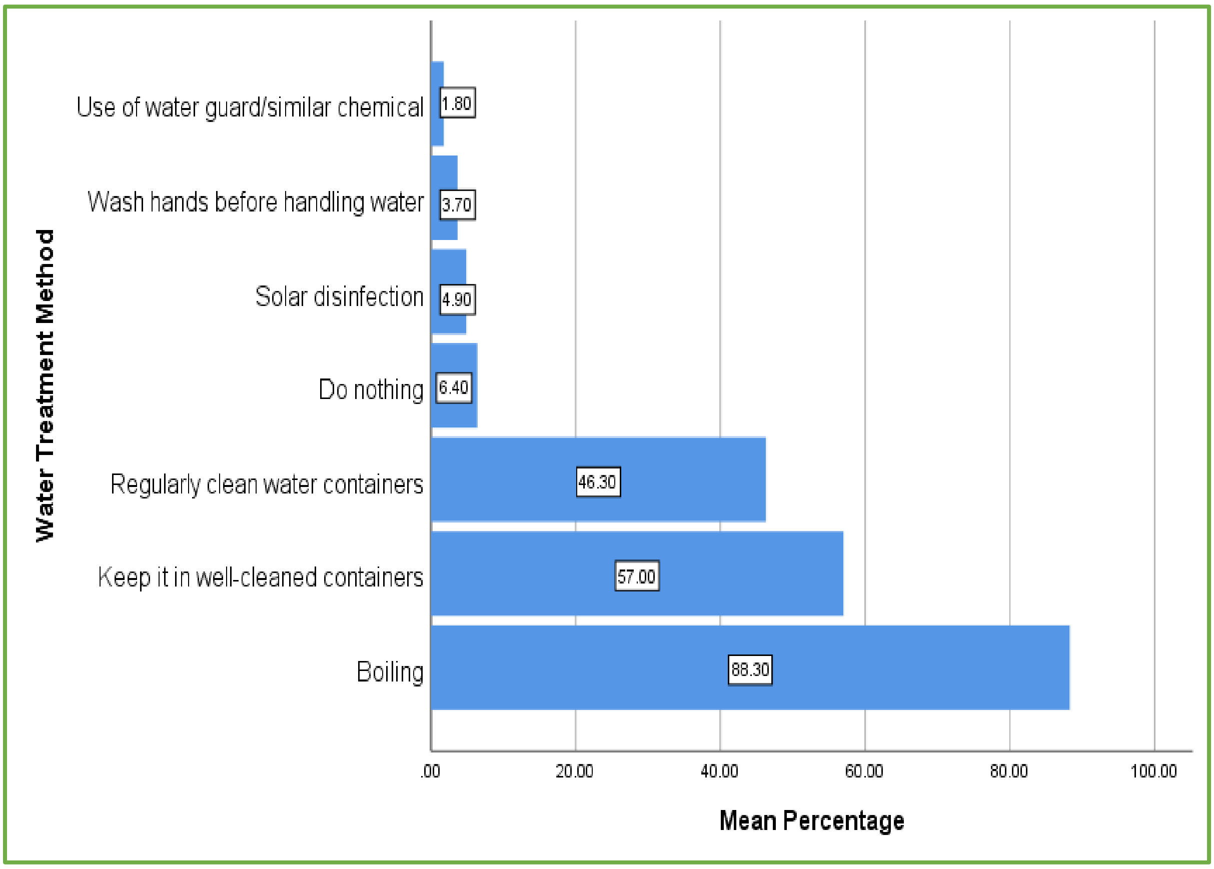
Waterborne diseases have been reported to be among the major public health problems in Uganda and thus prompted the use of moringa by some locals. Increases in cases related to waterborne diseases is mostly associated with poor hygiene and environmental sanitation as well as poor supply of safe water (Macri, et al, 2013). In Uganda, most of the rural populations obtain their water supplies from unprotected water, underground water, streams, spring wells, ponds and lakes. The water obtain from these sources is unsafe and needs treatment, the use of moringa has been a traditional method of treating water to improve its quality. Uganda as a tropical and developing country is frequently subjected to waterborne disease outbreaks in many regions. Rural areas are the most affected regions and many people in these areas tend to use traditional methods to treat their water (DWD, 2011a).

The pilot study area will be in Makondo Parish located in Lwengo district in Uganda. The area has a population of approximately 10, 000 and has 17 villages which include: Makondo, Kiguluka, Kiganjo, Misaana, Kijjajasi, Kayunga, Wajjinja, Luyiiyi Kaate, Kyamukama, Luyiiyi Protazio, Kibuye, Kiteredde, Micunda, Kabuyoga, Kitabaazi, Kanyogoga, and Kiyumbakimu (Uganda Bureau of Statistics, 2014 census report). The area is prone to waterborne diseases and this can be partly explained by its vast source of (shared) water which include ponds, streams, springs, shallow wells, and boreholes which are a source of contamination (Macri, et al, 2013).

A survey conducted by Macri, et al (2013) found that 88% of respondents in the study area mentioned that their main strategy for ensuring that the water they use in the household is safe is to boil it in order to prevent any waterborne diseases. A considerable number of respondents also indicated that they ensure that water is kept in well-cleaned containers (57%) and that they clean these containers regularly (46%). The Figure 2.2 below illustrates the methods that households in the study area use to prevent waterborne diseases.

"Unsafe water kills more people than disasters and conflicts"

Figure 2.3: Water treatment methods used by households in Makondo (Source Macri et .al, 2013)



The survey went on further to investigate some of the waterborne diseases experienced by households in the area. The results showed that about 76% experienced malaria, 42% have had at least one family member who suffered from stomach aches, while the incidence of diarrhoea was noticeable (Macri, et al, 2013). Other waterborne diseases experienced by households in the study area from the survey are shown in the Figure 2.4 below. Figure 2.5 also describes the terrible situation of unsafe water in Africa.

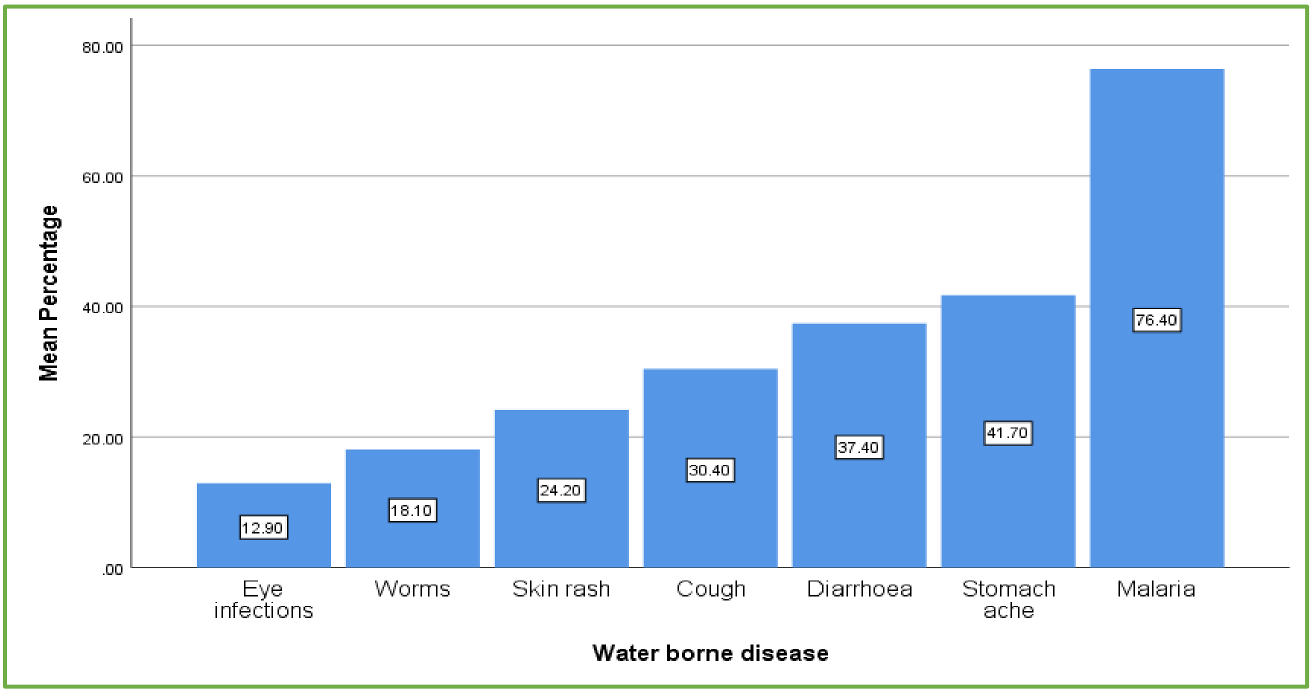


Figure 2.4: Waterborne diseases experienced by households in Makondo. (Source: Macri, et .al 2013)

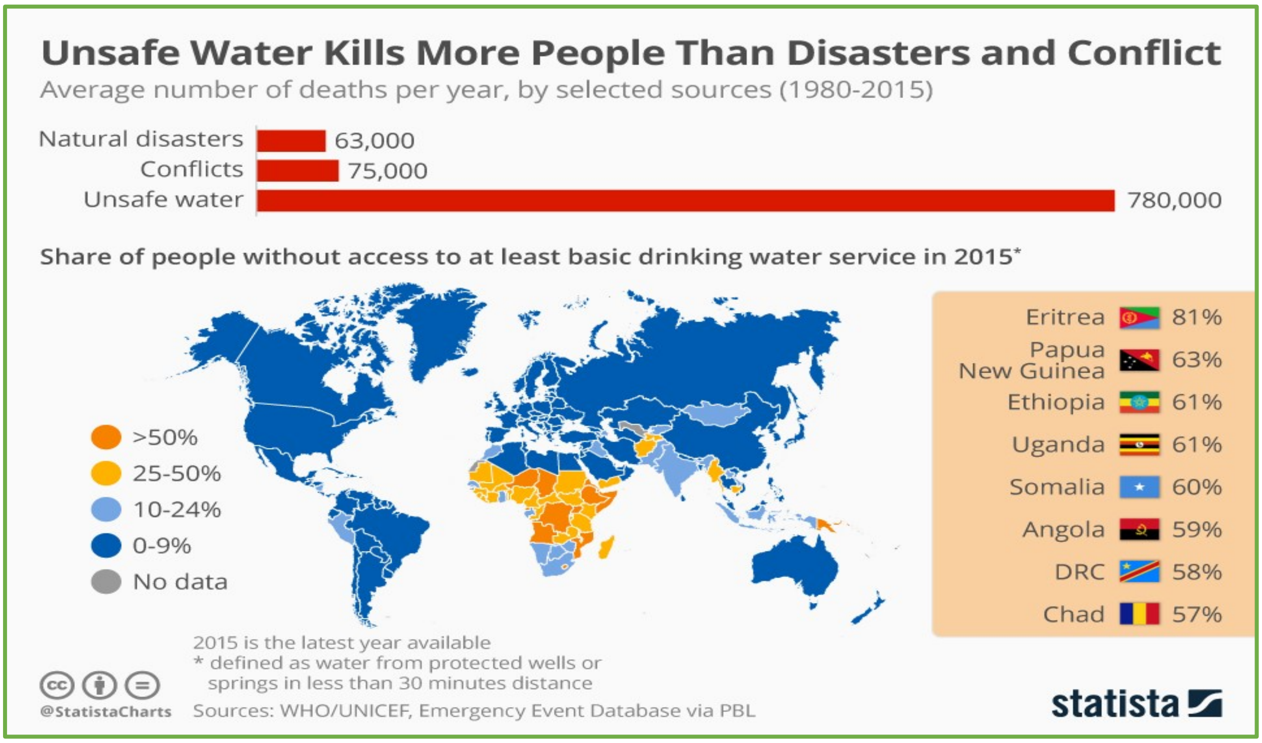


Figure 2.5: Average number of deaths per year from unsafe water (Source: Statista, 2016)

3. RUWAFIKI SOLUTION

3.1 Insights into RUWAFIKI (Rural Water Filtration Kit)

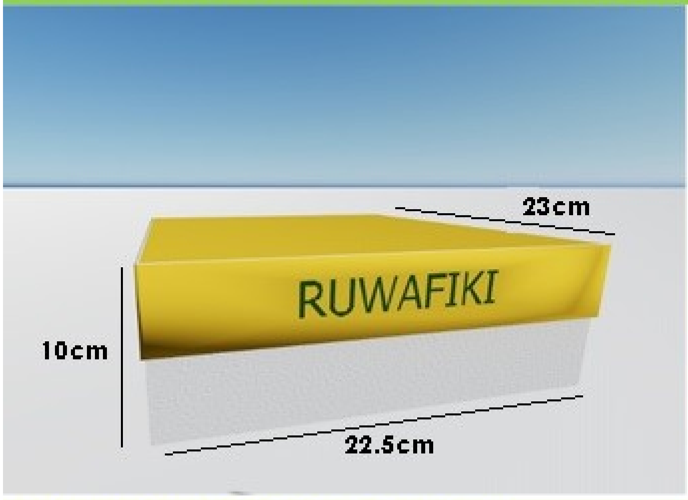
The project RUWAFIKI is coined out as an acronym from the Phrase; **Ru**ral **Wa**ter **Fi**ltration **Ki**t. This project develops a Water filtration Kit that is made adaptable to the immediate needs for clean and portable water in rural areas where water distribution channels of the government are yet to cover or poorly managed. The case study area for initiating this idea is a town in Uganda called Makondo parish (details of the study has been provided under Problem Landscape).

RUWAFIKI is a kit that seeks to aid households within these rural communities in carrying out about three stages of water purification for the removal of harmful substances and other micro particles from the water being collected within the community. Special filtration materials that are sustainable and highly natural, with very minimal environmental effects, are being harnessed in the creation of this rural water filtration kit. Some of which includes; *Moringa Oleifera* seeds to act as coagulant, filter papers and activated carbon from saw dust for adsorption of odour, colour and taste impurities, which would be discussed in details in each of the components. The kit contains an instruction manual which is made very easy and less complicated in the local and English language as well as indicative pictures to aid the user.

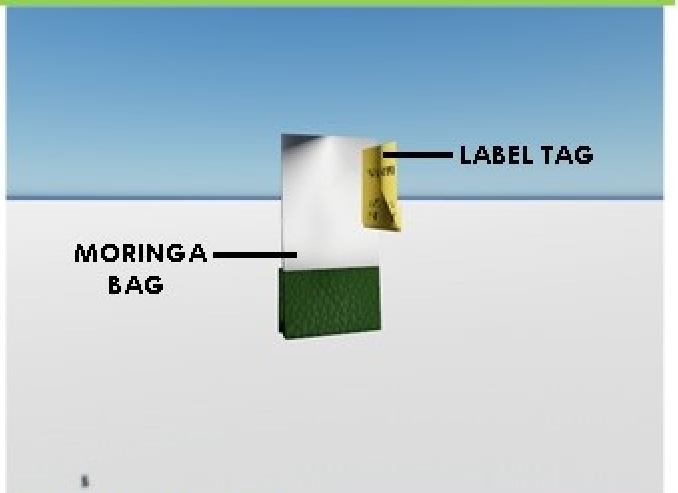
Below is an overview figurative chart presentation of the contents of RUWAFIKI Kit.

3.2. KIT DESIGN AND FEATURES

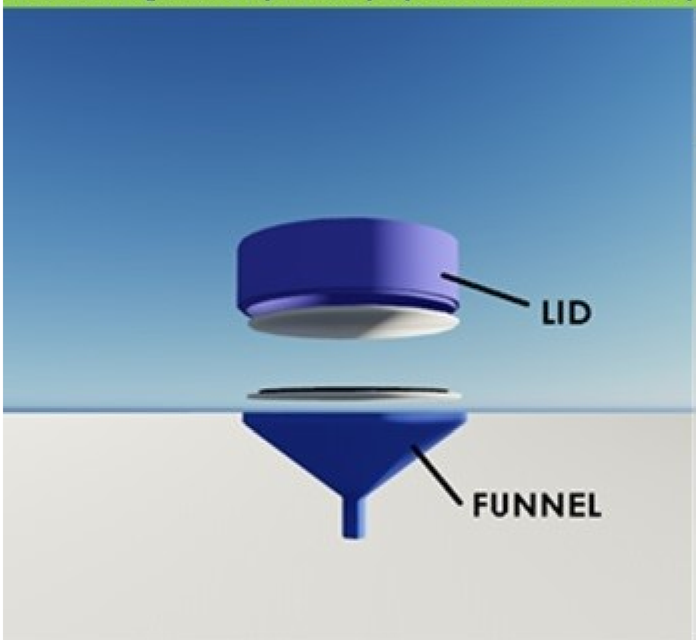
EXTERIOR VIEW (dimensions: 22.5cm x 23cm x 10cm)

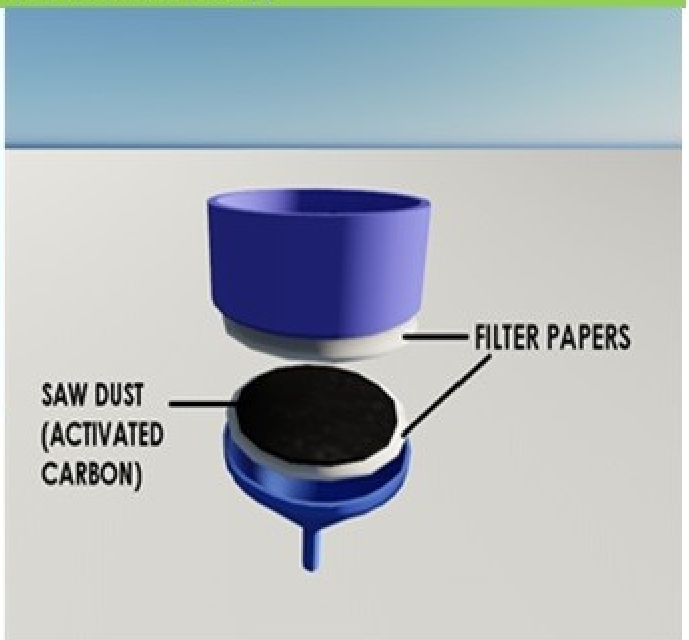


MORINGA BAGS (with Label tags)

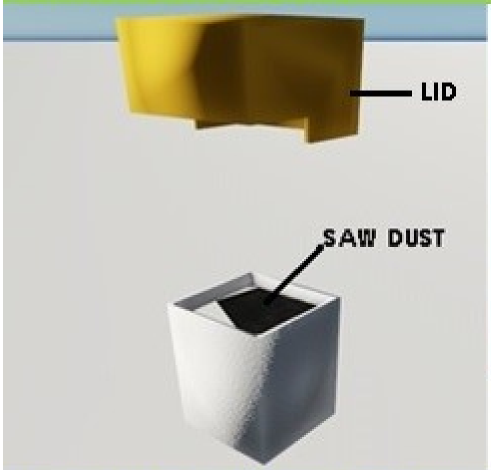


FUNNEL [with lid, filter papers and saw dust (activated carbon)]

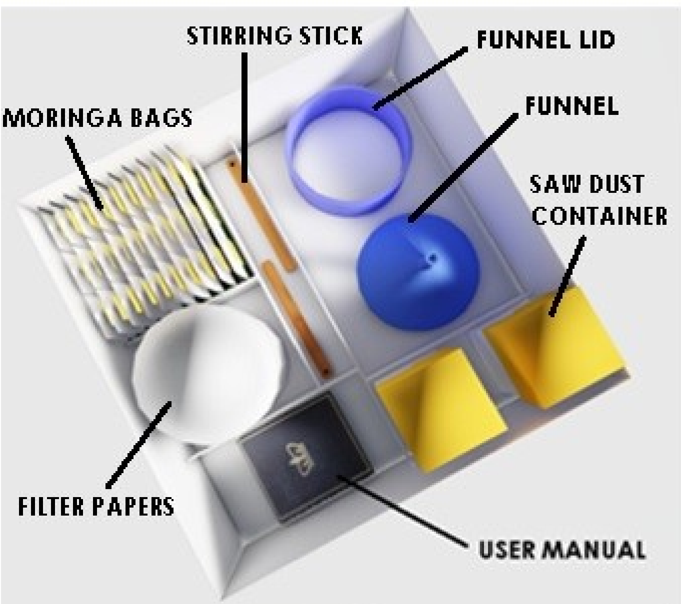


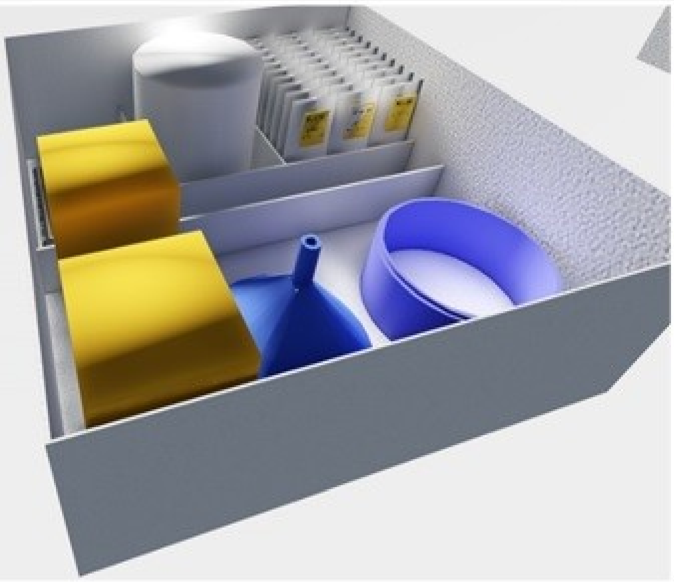


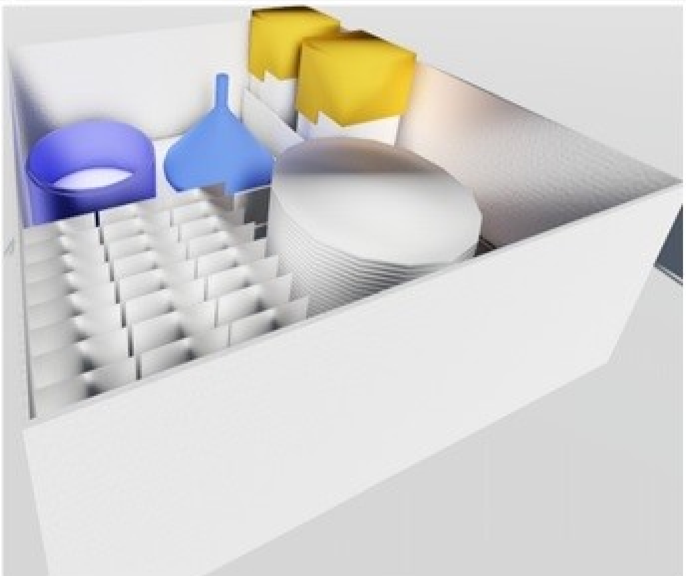
SAW DUST CONTAINER | STIRRING STICK | LATEX GLOVES



INTERIOR VIEW (WITH ALL ACCESSORIES incl. User Manual)







3.3 Details of the Water Filtration Materials in RUWAFIKI

The components of the RUWAFIKI which are aimed at the purification of the water include:
1. Moringa Seeds *Moringa Oleifera (M. Oleifera)*: *M. Oleifera* seeds to be used in the RUWAFIKI project shall be selected, husked, dried, ground and sifted until a fine powder is obtained. The seeds will be obtained from the case study area since it is readily available. Then the oil in the fine seed powder will be extracted by mixing the seed powder in ethanol. The oil has high market value, can be used for hair and skin.

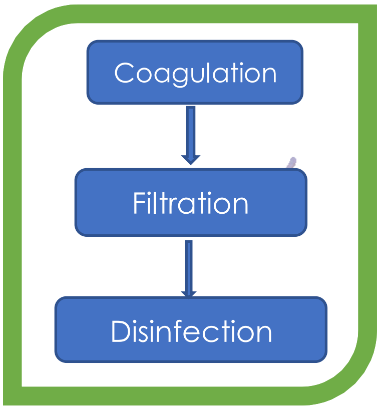
2. Filter papers: The RUWAFIKI project will be making use of paper filters have pore sizes smaller than the diameters of many viruses and bacteria, so removal of these microbes is higher than regular filtration, to efficiently remove parasites (one to several micrometres pore size), bacteria (0.1-1 micrometre pore size) and viruses (0.01 to 0.001 micrometre pore size or ultrafilters). The Filter paper method is not in itself sufficient for making water safe for drinking, therefore, other water treatment processes are incorporated by the RUWAFIKI process to make for the effective control a wider range of waterborne or water-associated microbial pathogens in household drinking water.

3. Activated carbon from Sawdust: RUWAFIKI project will make use of activated carbon in granular form which will be used to remove organic matter in water that could not be removed by filter paper. It uses physical adsorption process to hold molecules on its surface. In time to keep the activated carbon active activation step will be done to increase the surface area. Activation will be done through pyrolysis where the activated carbon will be heated, decomposed and converted to carbonized material in the absence of air.

3.4 RUWAFIKI Step-By-Step Process for Water Filtration

Stage 1: Coagulation

This is the beginning of the process for the treatment of the water collected by the households. Instructions in the user guide manual has to be followed strictly to achieve maximum result. First, the water fetched from poor water sources should be left to settle between 45 - 60 minutes, then upon settlement of particles, the water should be transferred into a clean bucket with lid.



Now, user would take out one of the Moringa bags and pour out the content into the bucket of water. The water treated should be stirred rapidly for at least 1 minute and then slowly for 5-10 minutes. The treated water will be left to settle for at least 1-2 hours. After the particles and contaminates have settled to the bottom, the clean water should be carefully poured off in another clean bucket to allow a second stage which is Filtration.

Stage 2: Filtration

Upon the completion of Stage 1, the water is then being transferred to another clean bucket in order to eliminate the visible coagulated particles settlements at the bottom of the bucket. The kit contains refill filter papers and also refill activated carbon that will now be arranged into the RUWAFIKI filter funnel which is very easy to handle and less complex.

The funnel contains an opening in the middle which can be flipped, where the user will first insert a layer of filter paper, then add some activated carbon granules on top of the layer of filter paper, then put another layer of filtration paper and close the funnel refill tank.

The water will be poured, filtered and collected in a receiver vessel. The particles are removed and collected on the filter media as the water is poured into the vessel. Filter paper and activated carbon granules will retain micro-organisms, including bacteria and viruses, by straining them out based on size exclusion, settling them within the depth of the filter matrix and by adsorbing them to the activated carbon surface. Therefore, removal is dependent on the size, shape and surface chemistry of the particle relative to the effective pore size, depth and surface physical-chemical properties of the filter medium.

Stage 3: Disinfection

This is the final stage of treatment of the water. Disinfection is necessary to ensure water is safe and ready for drinking. The filtered water in a vessel may still contain some microbes which were not trapped in filter paper and activated carbon. Hence boiling is a cheap and affordable means of disinfection for rural people to ensure good health of the community from the water they consume.

4. PROJECT IMPLEMENTATION

4.1 Logical Framework

The goal, objectives, expected results and outputs for implementation of this project are explicitly explained in the Table 4. 1 below with indication of the SDG's that are attained through its implementation.

Table 4.1: Logical Framework for RUWAFIKI

Item	Outcome	Performance Indicator	Source	SDGs goals contributed to
GOAL	To contribute to improved health of rural families particularly for children under 5			**Goal 3.** Ensure healthy lives and promote well-being for all at all ages
SPECIFIC OBJECTIVES	1. Reduce the consumption of untreated water	Number of users of the rural filtration kit increases by 20% annually, with target of 100% coverage in 4 years.	Survey reports	**Goal 6.** ensure availability and sustainable management of water and sanitation for all
	2. Improve health of citizens	Reduced cases of water borne diseases caused by consumption of unsafe water by 20% by end of 2020	Survey reports Ministry of health Hospitals	**Goal 3.** Ensure healthy lives and promote well-being for all at all ages
RESULTS	1. Reduced cases of diarrhoea	Diarrhoeal cases reduce by 40% by end of 2020 compared to levels in 2018	Ministry of health Hospitals	**Goal 3.** Ensure healthy lives and promote well-being for all at all ages
	2. Reduced mortality rates of children under 5 years	Mortality rates reduce by 15% by end of 2020	Hospitals	**Goal 3.** Ensure healthy lives and promote well-being for all at all ages
OUTPUT	1. Fully designed filtration kit	Supply filtration kits to over 1726 households	Survey reports	**Goal 6.** ensure availability and sustainable management of water and sanitation for all
	2. Trainings on how to use filtration kit and how to improve health at home	Improved behavioral change	Survey reports	**Goal 3.** Ensure healthy lives and promote well-being for all at all ages **Goal 1.** End of poverty of all forms

	through use of the filtration kit			
	3. Awareness campaigns on use of filtration kit conducted	Improved behavioral change	Survey reports	**Goal 3.** Ensure healthy lives and promote well-being for all at all ages

4.2 Stakeholder Analysis

The Table 4.2 below explicitly discusses the various stakeholders involved in the successful implementation of the project, the roles they play and their interests. All the stakeholders need to be actively involved to realize the success of the project.

Table 4.2: Stakeholder Analysis for RUWAFIKI

Stakeholder name	Role in project	What is important to stakeholders
Beneficiaries (Local communities, women)	• To adopt new technology	• Safe drinking water • Improved health • Improved standards of living
Government (Ministry of health)	• To aid in project implementation, and promote the use of the kit in other parts of the country including some urban areas with poor water quality • To offer financial support	• Improved community health and sanitation • Achieve SDG 6,3 and 1 
Retailers	• To aid in distribution of kits	• Improved incomes • Better standards of living
Researchers/Scientists (Pan African University)	• To perform laboratory tests for project. • Research on how to improve the project, Monitoring and Evaluation •	• Obtain satisfactory laboratory results • Positive research results • Improved incomes
Donors (NGOs) E.g. Water Aid WHO	• To offer financial support • To assist in making the project more available in other communities • To help develop capacity building programmes on how to use the product.	• Achieve SDG 6,3 and 1 • Improve community health and sanitation 

5. PROJECT IMPLEMENTATION STRATEGY

The project implementation phases will span a period of 10 months starting from April 2019 to January 2020 and are detailed below in the Figure 5.1 below.

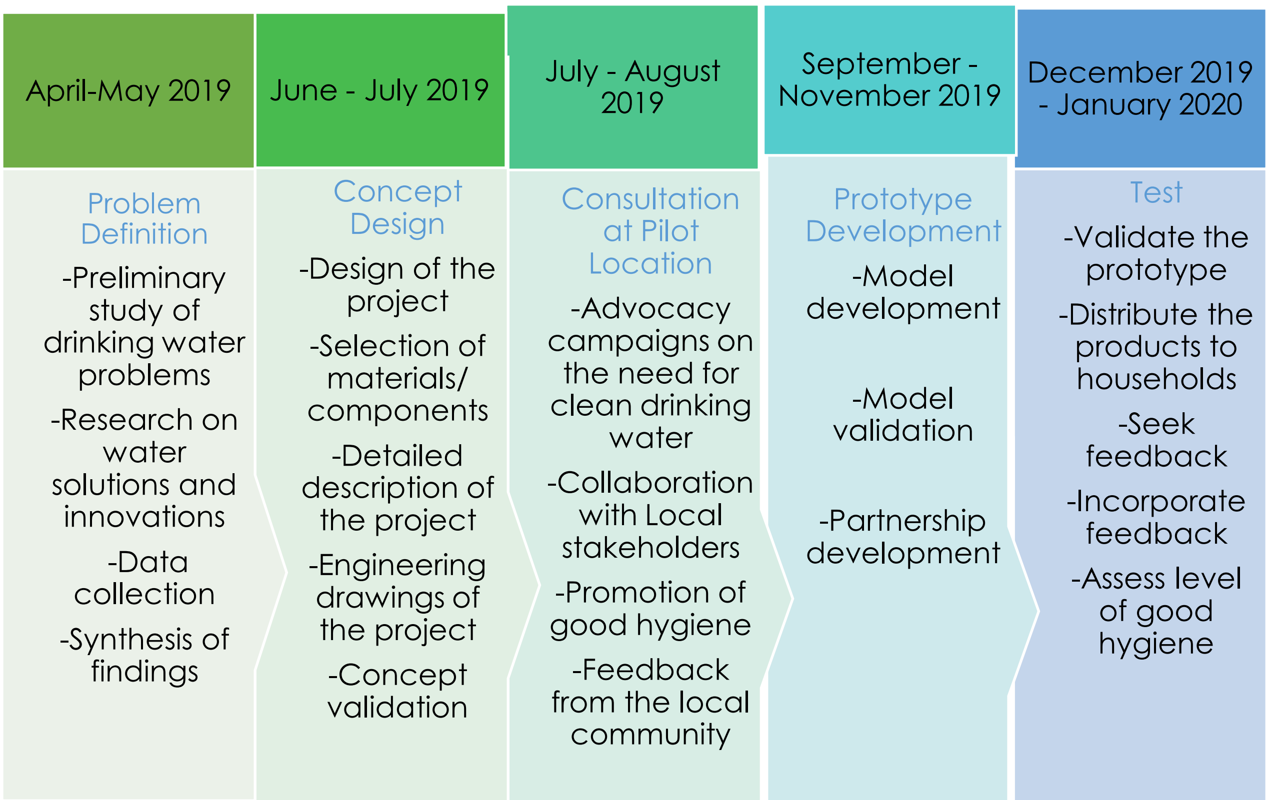


Figure 5.1: The Project Implementation Strategy

5.1 Project Design and Implementation Process

Presently, the project is at the consultation stage. The aim of this stage is to validate the concept design with the appropriate stakeholders involved in the Water and Sanitation and Hygiene (WASH) sector. Also, the objective of this stage is to collaborate with main stakeholders to organize campaigns on good hygiene. This will enhance usability of the product for the target population. The list of partners is described in Figure 5.2.

The next steps of the project are:

- Partnership Establishment: The team will comprehensively and actively involve stakeholders in the planning, execution and sustenance of the project. The team will form four (4) types of partnership:

(1) Government agencies such as the Uganda Ministry of Water Resources and Uganda Ministry of Health to provide standards and regulations;

(2) Local organizations, especially NGOs as partner project execution and facilitation. The team will reach out to groups that adopt community-driven and participatory approaches;

(3) International organizations dedicated to improving access to clean drinking water for community members. These organizations will work as project execution, facilitation, and financing and for professional expertise and

(4) Pan African University for research support; foundations, private companies and other organizations for project financing.

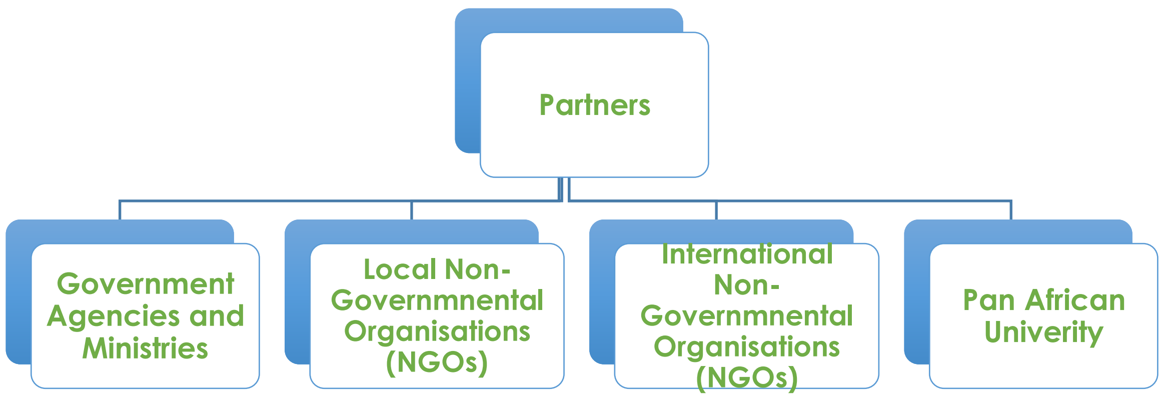


Figure 5.2: The Project Partners for RUWAFIKI

● Prototype Development: The aim of this phase is to develop an effective product design. The team will partner and utilize the vast experience of researchers including water and sanitation professionals at the Pan African University in order to develop a prototype that will effectively and efficiently filter drinking water for the populace in the pilot location. The prototypes will also be used in presentations to Ugandan government ministries, NGOs, community groups and households. The focus will be on individuals to ensure cordial public relations, and market penetrations mechanisms including word of mouth (verbal communication).

● Prototype Validation, Testing, and Scale-up. After the prototype has been developed, it will be tested in the pilot location. Thereafter, it will be validated and scaled up to other locations/countries in Sub-Saharan Africa. The various feedback received from the prototype testing and newly gained insights will be incorporated in the design to roll out a sustainable model. Then, the level of good hygiene and spread of water borne diseases in the location will be assessed through medical checkups and surveys.

● Operation and Maintenance. Project performance and key indicators will be reported based on the project monitoring and evaluation framework. The key indicators include the reduction in the outbreak of water borne diseases and Improvement in the level of good health because of the project.

5.2 Project Timeline

The project is expected to be implemented in three phases: design, development, and operation. In addition, the project development phase is further divided into two stages: prototype development and partnership formation. The detailed project timeline is given in Annex 1.

5.3 Project Finance

5.3.1 Estimated cost of each filtration kit

The estimated cost for each filtration kit is 5 USD, which is readily affordable in Uganda's rural setting specifically in Makondo parish.

5.3.2 Projections of potential sources of income and expenses

The potential/expected sources of income are;

1. GIZ sponsorship
2. African Union sponsorship
3. Private companies' sponsorship
4. Ministry of Health and Environment, Uganda
5. Pan African University Scientists

Table 5.1: The Projected Expenses of the Project

No	Expenses/cost	Amount (USD)
1.	Development of water treatment kit	1,200.00
2.	Seeds and activated carbon preparation	1,000.00
3.	Building the first three prototypes	3,000.00
4.	Marketing and launching campaigns in Uganda	2,800.00
5.	Distribution of RUWAFIKI to the communities.	1,500.00
6.	Public health advocacy campaigns	2,300.00
7.	Data gathering	1,500.00
8.	Mobility of team members	3,000.00
9.	Miscellaneous	800.00
10.	**Total**	**17,100.00**

5.3.3 Cost- benefit analysis of the project

Our focus is to reduce waterborne diseases and mortality rates in Makondo Parish, which is caused by poor water quality as a result of contamination. The water treatment kit will have tremendous benefits on ensuring that the water is safe for drinking and other purposes, reducing outbreak of diseases as a result of poor water quality, reducing mortality rates among children under 5 years. The project will cause a behavioral change among community members and lead to improvement of better hygiene practices. The project will create employment for some women as the kit materials are locally available and can be assembled onsite and be sold at low price.

5.4 Monitoring and Evaluation

The importance of both monitoring and evaluation the progress of the project is to provide information to inform decisions, improve outcomes and achieve objectives. *Monitoring* is an ongoing process by which stakeholders obtain regular feedback on progress made towards achieving objectives. *Evaluation* is an objective appraisal of either completed or ongoing activities to determine the extent to which they are achieving the stated objectives.

The aim of collecting Monitoring and Evaluation (M&E) data and disseminating M&E results is to achieve the main benefit of the water treatment kit: *improved health*. The value of M&E will be realized only to the extent that results are utilized to inform future programmes, policies and investments. The progressive accumulation of M&E data from water treatment kit project will provide an important knowledge resource for guiding implementation and scaling up. This, in turn, will result in decreased incidence of disease and healthier lives for all those who consistently and correctly use the kit.

The project will make use of performance indicators to monitor its impacts. The inputs, processes, outputs, outcomes and impacts of development interventions will be observed in a timeframe. Cost-benefit and cost-effectiveness analysis will be another way of monitoring. The Table 5.2 below shows various performance indicators that will be used to monitor project impacts.

> ***"The project will make use of performance indicators to evaluate and monitor its impacts"***

Table 5.2: Performance Monitoring and Evaluation of the Project

Performance Indicators	Data Collection Methods/Sources	Frequency & Schedule	Person/s Responsible	Information Use
Water Quality	• Laboratory tests • Water quality analysis	Once every month	Water quality analysts	1. Assess water quality. 2. Assess project impact. 3. Impact evaluation to justify intervention to, donors, health ministry, etc.
Project Impacts	1. In field monitoring by program team with community partners. 2. Field surveys 3. Project progress reports	Ongoing monitoring during duration of program.	Field monitoring: program team	1. Monitor risks for informed implementation and achievement of the project objective/s. 2. Accountability to donors and public
Community response	In-depth interviews	Once every month	Field monitoring program team	Increase project productivity.
Public and donor resource use	Public and donor's expenditure tracking surveys	Ongoing monitoring during duration of program.	Program accountant	Diagnose service-delivery problems and improve accountability.
Health data	Formal surveys in district health centres	Once every month	Field monitoring: program team	1. Assess impact of project on waterborne disease occurrence. 2. Monitor waterborne diseases cases.

In rigorous home water treatment systems (HWTS) M&E programmes, the *outputs* and *outcomes* of HWTS programmes are measured. *Outputs* are the more immediate consequences of inputs and relate to tangible consequences of project activities. Output indicators include the number of treatment kits distributed and/or sold, the number of community project outreach meetings held or and the number of community health workers trained. *Outcomes* describe the intermediate effects of outputs.

Treatment kit outcomes include indicators of physical evidence of kit use, such as a filter, improved drinking-water quality, as measured by microbial indicators. *Impacts* are the long-term consequences of delivering outputs. The Figure 5.3 below is an illustration of the project's inputs, outputs, outcomes and impacts.

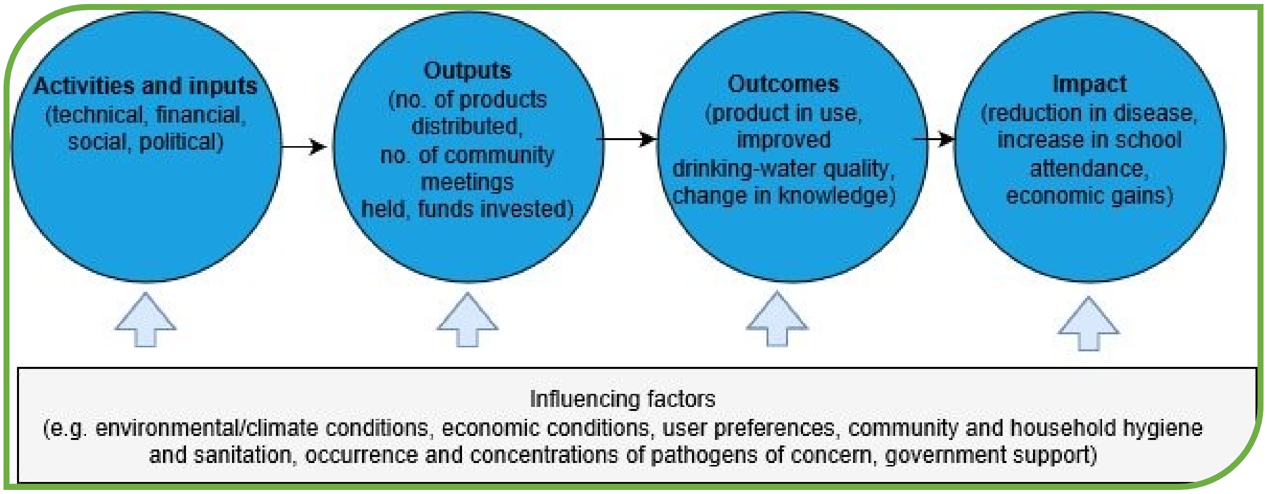


Figure 5.3: The Project's Inputs, Outputs, Outcomes and Impacts.

6. EXPECTED OUTCOMES OF THE PROJECT

6.1 Short-Term Outcomes

As earlier indicated that the people of Makondo Parish consumed water from unprotected wells puts them at risk of contracting waterborne diseases, these diseases have led to increased cases of diarrhoea and infant deaths as a result of consumption of water from the un protected wells. It was evident that 42% had at least one family member who suffered from stomach aches, while the incidence of diarrhoea is also notable (37% of households) (Marci et al, 2013).

Rural communities are mostly not aware of the dangers resulting from consumption of unsafe water. Thus, the RUWAFIKI project team in its implementation includes education and awareness to communities on the dangers of unsafe water and trainings on how to treat water at home with natural extracts. Empowering families particularly women who are the care takers of the home is of utmost importance in promoting children health and education. An educated woman is more empowered to provide good health conditions for her child.

Design and testing of the RUWAFIKI, which will involve model development and validation. Samples of the RUWAFIKI will be developed and testing in the study area, improvements will be made accordingly to make it up to standard for filtration of water. Validation then will be done and full production of kits for the entire community will be produced will help of the women and youth who will help in collection of the raw materials for making the kit.

6.2 Long-Term Outcomes

Reducing the risks from consuming water from unprotected wells is the long-term goal, to promote healthy families. Reduced cases of diarrhoea thus reducing on the money spent on medical treatment. As a result of families treating cases of diarrhoeal diseases, they are deprived of money which would be allocated on other areas like providing food.

Complete RUWAFIKI's being used in the community of Makondo Parish to treat water from the unprotected wells and water from rivers to standards recommended safe for use. It is expected to reduce the number of infant deaths resulting from consumption of unsafe water. Infants are most likely affected by diarrhoea perhaps due to their weak immune system. Thus, by providing safe drinking water to families will eliminate the risk of death.

After implementation of RUWAFIKI in Makondo parish, this technology shall be extended as well to other rural communities in Uganda and other countries as well with the end goal of ensuring clean and safe water availed to communities. In alignment with the SDG goals, clean water and sanitation as is in SDG 6 is a priority to achieve good health, therefore project RUWAFIKI if implemented will help promote SDG 6.

6.3 Limitation/Risk Analysis

Every project is always associated with likely risks that are capable of threatening the achievement of the project's objectives. Therefore, it is necessary to identify likely risks to any project before the implementation of the project and provide necessary mitigation measures in order to ensure smooth implementation process.

Consequently, for this project, below in Table 6.1 is the list of the five (5) risks that we will likely face during the development and implementation of the project as well the mitigation measures that will be adopted.

Table 6.1: Risks and Mitigation Measures

Risks	Mitigation measures
Lack of Government's interest: Government's water and health ministries will be one of the key partners of the project especially as regarding the policies on drinking water standards and water related diseases. Therefore, their interest and support are crucial for project success.	Network adequately with the Ministers of Water and Health. The team will better understand government concerns and needs and incorporate them in project design. Continuous engagements with technocrats in the government.
Insufficient Project funding: The project needs funding for operational expenses before the project becomes financially self-sustained and prototype development.	The team will explore several funding strategies and pitch the idea to a variety of potential funders such as student competitions, NGOs, government agencies, and foundations with deep interest in water and health sectors.
Competition: The number of groups, NGOs and private organizations working on improving the access to clean drinking water is increasing.	The project team has done a comprehensive search and did not find any idea related or similar the team's idea and this is one of the reasons that make the product unique.

Low acceptability: It is expected that since the idea is innovative and new, the local community might have challenges in accepting the product.	Campaigns, sensitization sessions and promotional activities will be done regularly to demonstrate the usage and benefits of the kit to the community members. Regular feedback will be conducted in order to incorporate the feedbacks into the design of the product.
Project Feasibility After the project is designed and operational, the operation expenses are not expected to be significant. However, the project would be revenue-generating to be self-sufficient. The product is expected to be socially, economically and environmentally sustainable.	The team members will leverage on local contacts and resources to ensure that the project fits into rural context and is implementable on the ground since the idea is for rural communities. A progression plan would be developed to ensure that the project will improve, and expand to serve its beneficiaries even beyond the pilot location. Financially, the project will become sustainable after project launching since the clients will pay for the kits to cover operating costs.
Low Community Participation: This project is community based and massive community participation would contribute greatly to the success of the project.	The project would provide job opportunities for people especially women who would be involved in seed and activated carbon preparations.

7. CONCLUSION

Access to clean and safe water is considered a basic human need and right. Waterborne diseases are the leading cause of death worldwide and mostly important Uganda's community with diarrheal being the leading disease. Lack of access to clean and safe water in rural Uganda has exposed the people of Makondo rural area to high risk of waterborne diseases which has eventually led to death, especially of children under five. Water treatment options are quite expensive for rural community due to low level of income.

RUWAFIKI team presents the RUWAFIKI an innovative low-cost water treatment kit made up from locally available materials and aids to provide sustainable solution to the problem of unsafe water for rural people in Uganda. The kit will enable households to filter water they have fetched from surface or groundwater sources to make it authentic enough to drink. The kit is user friendly and affordable enabling households who can't afford household connection in which water comes from treatment plants to treat the unsafe water on their areas.

Although RUWAFIKI is designed for Makondo Parish (rural Uganda) to address public health issues caused by drinking unsafe water, it has the potential to be replicated across the globe that face similar challenges. This innovation will promote global health and well-being as well as the attainment of the Sustainable Development Goals (SDGs).

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Rural Water Filtration Kit

Rural Uganda Case Study- Makondo Parish, Lwengo District										
ACTIVITY	ACTUAL DURATION (Months)							PERIOD		
				2019						2020
1.0 Project Design	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY
1.1: Preliminary studies on water and health related problems										
1.2: Research on water solutions and innovations										
1.3: Data collection										
1.4: Synthesis of findings										
1.5: Project concept design										
1.6: Geneva challenge proposal										
2.0 Prototype Development										
2.1: Design of the project										
2.2: Selection of materials/components of the project										
2.3: Detailed description of the idea										
2.4: Concept validation										
2.5: Prototype completion										
3.0 Partnership Establishment										
3.1: Establish partnership with the Ugandan's Ministries of Water and Health										
3.2: Establish partnership with NGOs in water sectors										
3.3: Establish partnership with Research institutes, foundations and other groups										
3.4: Establish partnership with the local community										
3.5: Fund raising										
4.0 Project Operation										
4.1: Validate the prototype										
4.2: Launching the project										
4.3: Distribution of the products to households										
4.3: Initial feedback from households										
4.4: Incorporate feedback for improvement										
4.5: Continuous monitoring and evaluation										
4.6: Scaling up to other locations/countries										