

Organic Ash Soap

Engineers Without Borders Challenge 2015
Bambui, Cameroon

228.111: Global Perspectives
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This report was requested by Dr. Aruna Shekar,
Global Perspectives Paper Coordinator, on May 20,
2015 in order to present the development of an
organic soap as a method of disease and cross-
contamination prevention and for personal hygiene in
Bambui, Cameroon.



Massey University Albany
1st Year Engineering Students:



Executive Summary

This report aims to inform Engineers Without Borders of the conclusions of creative solutions to solve the personal hygiene and sanitation issues in Bambui, Cameroon.

The town of Bambui is located in the Northwest region of Cameroon; it is an English-speaking town. Hygiene and sanitation in the community are a big issue as there are no clean water supplies. Disease from cross-contamination is quickly spreading.

The cross-contamination is caused by the lack of proper personal cleaning resources and the lack of suitable drainage and toilets. Bambui has many practices that have been put in place to contain the spread of disease such as inspections and maintaining cleanliness of the streets to help prevent cross-contamination. Although they have implemented such practices many citizens are still at risk of diseases such as Leprosy and Cholera. These diseases are caused by the bacteria found in water that has been contaminated and from the lack of personal hygiene.

The objective was to provide the community with a sustainable and simple cleaning resource such as soap. The solution should provide the community with a soap that was easily made with the abundant local waste resources. Research was conducted to look into ingredients that could be used to make organic soap (such as waste wood ash, oils from nuts/vegetables/fruits/plants, fats from meat and water sources) and research into soap making was conducted.



Source:
http://www.buzzfeed.com/marietelling/11-things-you-should-know-about-camerouns-world-cup-team?mobile_app&z=1402613336

According to the resources that are found in Bambui the most practical solution is to use:

- Wood Ash - The wood ash is an excellent resource as it is abundant and can be found in essentially every home as a waste from the wood fires used to cook, it can be attained easily and will not be a resource that will run out quickly. The use of the ash will also help with the recycling of the waste.
- Oils - the oils can be naturally sources from any plants, vegetable, nuts or fruits that are always regrown all year round.
- Water from local springs.

There are only a few tools needed to make the soap: a measuring cup, stirrer and a heat source (such as a stove). The soap was made by extracting Lye from the wood ash (by mixing ash and water and filtering out the sediment, leaving the lye liquid) and mixing with the oils, and letting it set. The ingredients need to be measured out into a ratio to get the right balance. The method is easy to use and follow. An instruction guide is attached to the report to educate the citizens on the soap making technique.

The great aspect of the soap is the implementation of the soap design and its simple design and instructions. The household or community sizes may vary; despite this the soap recipe can easily be adapted to the varying number of users. The materials used for the solution are environmentally friendly, and are easily obtained for little or at no cost at all. The implementation of the soap will help the citizens of Bambui improve their personal hygiene and sanitation habits, and help reduce the risk of cross-contamination and spread of disease.

The solution is suitable for the citizens in Bambui who are suffering from inadequate sewage systems, sanitation, and polluted waters as it offers a simple, affordable and sustainable solution that cleans the bacteria and prevents cross-contamination.

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1.0 Introduction

Being an underdeveloped country, Cameroon has serious issues regarding their personal hygiene. They do not have proper toilets and sewer systems, which lead to the contamination of their water supply, which leads to disease. There is currently a committee responsible for going through the community homes and inspecting the hygiene and sanitation practices, but that is not enough to stop the spread of disease (EWB, 2015). The likelihood of cross-contamination is very high in Bambui as some households and public spaces use pits and water systems as toilets, and the water supply used to wash hands is also contaminated. The overall aim of this project is to improve personal hygiene practices, which will then lead to the reduction of diseases spreading and cross-contamination and improve health throughout the community.

The objective is to:

- Improve living conditions by removing germs and bacteria that come into contact with the skin due to unsanitary surfaces.
- Decrease the spread of disease and bacteria.
- Be sustainable, implemented with ease and maintained by members of the community.
- Aid the community of Bambui in terms of increasing hygiene and health.
- Improve quality of life and possibly even life expectancy.
- Take into consideration the local ecosystem/environment and respects cultural customs.

For the overall solution of this project is an organic ash soap has been chosen as it can be easily made with the local resources, it is sustainable, simple, cost effective and can easily be implemented into the community.

2.0 Background

Bambui is a town located in the North West region (English speaking part) of Cameroon (EWB, 2015). The population is about 50,000 people, and it has an elevation of about 1350 meters above sea level. Here the sanitation and hygiene is a big issue. Even with all the practices that the people in Cameroon have put in place, from doing inspection of the toilet and their surroundings, maintaining the cleanliness of the streets, and the sanitation committee to keep livestock and other animals away from the urban areas of Bambui. Even with these precautions put in place there is still a great risk to the people in Bambui with health and diseases. Other diseases include; Leprosy, this disease affects the skin, and the nerves that causes decolorizing and lumps. Cholera is present too this is a bacterial infection that occurs in the small intestine that is caused by drinking untreated water, this is often fatal. Soil-transmitted Helminthiasis is another disease that is common in Cameroon; this is caused by helminthes that are transmitted through excrements that is contaminated in the soil. It is nearly impossible to treat all these diseases/health issues with the resources that we are given to work with.

3.0 Problem

3.1 Issue Raised By the Brief

Outlined in the EWB challenge design brief are various issues that need addressing, as well as constraints that need to be taken into consideration while tackling the project. A serious issue regarding hygiene and sanitation within the Bambui community has arisen due to the lack of infrastructure and sanitary practices in place. Whilst there are systems in place, these systems are insufficient and require further development in areas including drainage, waste disposal, and general sanitary practices. All of these pose a major threat to the health and general well being of the community as a lack of hygiene, along with an increase in accumulated waste and stagnant water encourages the spread of disease. According to the CIA World Factbook (2014), some such diseases associated with these issues include hepatitis A and typhoid fever which are both waterborne diseases, as well as other diseases including malaria. These are just a few of many high risk diseases faced within Cameroon. The potential to be life threatening, justifies the need for an innovative solution.

3.1.1 Constraints Identified

The most noticeable constraint identified in the brief is that of the need for cost effectiveness due to the lack of funding within the community, which stems from the lower socio economic circumstances of the population's majority. Thus exemplifying this issues requirement of a simple and sustainable solution which should rely on locally sourced materials and resources. Environmental factors will be kept in mind to ensure the replenishment of any organic resources. Some interesting aspects which also need consideration are communication obstacles within Bambui and the community's knowledge base. Keeping things simple is important for an easily implementable solution. Additionally, there is also a need for community training/education programs. These aspects could be addressed through the creation of an educational

pamphlet which could communicate ideas effectively and simplify the implementation process.

3.1.2 Criteria

Throughout the development process, a range of ideas were conceptualized with only a few progressing further than a conceived idea. In order to be chosen the proposed solutions had to meet certain criteria. For example the solutions should be:

- Cost effective and affordable in households.
- Sustainable and easily implemented in the future.
- Durable and fit for purpose.
- Achievable based on the limited knowledge of the Bambui community.
- Effective and have an impact on the improvement of hygiene and sanitation in the community.
- Effective and have an impact on the local ecosystem and the lives of the people in Bambui. e.g. (social factors, traditional beliefs/customs, general day to day life).
- Easily attainable. Required materials/resources should be accessible and available.
- Simple: a simple solution is easier to implement, and can be easy to accept by the villagers.
- Innovative use of local resources and materials.

3.2 Design Areas of Most Interest

3.2.1 Water supply

Bambui continues to feel pressure on their supply and availability of water due to rapid population growth and a fluctuating climate. The result being that clean water is not easily accessible. The more immediate problem that has emerged for the community comes from their water quality and management (EWB, 2015). Sources of human contamination have dramatically increased. Another problem that has emerged in respect to

Bambui's water supply is its usage. Currently, water conservation practices are not sufficient and water wastage is a serious issue.

3.2.2 Sanitation and Hygiene

Sanitation and hygiene is a serious issue in the Bambui community. Stagnant water, stray animals and the lack of sanitary practices is increasing the spread of diseases. There are also hygiene and sanitation issue relative to waste. Therefore the spread of disease is in addition, affected by the lack of waste management and disposal within the Bambui community (EWB, 2015).

3.2.3 Food Transformation

Additional food preservation techniques are required to preserve and store food over an extended period of time without the loss of vital nutrients from the food. The current methods of smoke drying need to be addressed and improved as they result in a loss of nutrients from the food, and the smoke inhalation causes serious health risks such as breathing difficulty and lung diseases.

3.2.4 Transportation

Bambui's transportation network consists of a connection of roads, streets and farm to market roads. The current standards of public transportation are very low and the general management of the sector is considered poor and insufficient. The existing resources and transportation systems are very limited. Consequently, this system cannot accommodate for the needs and requirements of all of Bambui's people. Furthermore, many of the farmers within the Bambui region cannot afford cars or trucks. This makes the transportation of food produce difficult and limits the ability of rural farmers to sell their produce at a commercial level (EWB, 2015).

3.2.5 Chosen Design Area

Sanitation and Hygiene were chosen due to the ranking method shown below. This is what we believed had the greatest importance to the people living in Bambui, and it is what we believed that could benefit the community the most, immediately at low cost. The other aspect that

caused us to choose this specific design area was the interest that it had for all the team members. This was due to it being the one that we all believed that could have the most impact on the community, and it is the design area that we all have a knowledge in.

Table 1. Importance of Solutions

Design area specifications:	1. Water Supply	2. Sanitation / Hygiene	3. Food Transformation	4. Transportation	Allocated % to each area:
Importance / Greatest impact.	15	15	12	8	50%
Interesting	13.5	14.5	10	12	50%
<u>Totals</u>	28.5%	29.5%	22%	20%	100%

3.3 Alternative Solutions

Solutions receiving further attention and development were ultimately ruled out using a refined and simplified version of criteria. Besides the solutions' ability to meet this criteria, logical observations about design flaws and strengths assisted in the elimination of each design.

3.3.1 Ash Toothbrush

A cost effective toothbrush which could be massed produced and ultimately help to improve oral hygiene in the Bambui community. The plan was to design a simple toothbrush which could incorporate the use of ash in a toothpaste. The fibres from the ash toothpaste would assist in cleaning teeth and ultimately improve dental hygiene. However, an observation was made about there being more urgent matters regarding sanitation and hygiene which need addressing before oral hygiene.

Strengths:

- cost effective
- simplicity

Reasons for discarding Toothbrush alternative:

- lack of innovation
- The least important section of hygiene and sanitation which needs addressing.
- A toothbrush using an ash toothpaste may prevent the buildup of plaque but may not necessarily aid in the preventions of diseases such as gingivitis.

3.3.2 Hand/Surface Sanitizing Solution

The idea of creating a hand sanitizing solution was thought of to sterilize surfaces or equipment as well as a means of sanitizing hands. This would aid in the prevention and spread of diseases through contact with surfaces. On the other hand, a big drawback would be the difficulty of acquiring the materials required to produce an anti-bacterial agent.

Strengths:

- Sustainability
- Simplicity
- Effectiveness of stopping the spread of disease.

Reason for discarding Hand/Surface sanitizing solution:

- Costs of creating a solution and packaging it would be unreasonable.
- accessibility to resources required in the production process.

3.3.3 Composting toilet

The Composting toilet was possibly the most flawed and least developed out of all the alternatives. The idea of the composting toilet was to design a wooden toilet which would use waste to produce a composting fertilizer for fertilizing crops. The simply designed toilet was to be made from locally sourced wood. However this would contribute to deforestation and would have an increased expenditure due to the labour and equipment used to mill the wood and construct the design.

Strengths:

- An innovative design.
- Sustainable solution.
- Beneficial impact on waste management and sanitation.

Reasons for discarding the Composting toilet:

- high cost.
- need of carpentry skills to produce the solution. Increasing the difficulty of implementation.
- damages to the environment through deforestation.

3.3.4 Overhanging Shower

This design consists of a shower design made from recycled materials (e.g. plastic bottles) which would be hung from a height and used as a portable shower. The design would incorporate a soap dispenser and would use gravity to dispense a steady flow of water. Although this design was promising, the need for small components in the shower head to control flow, and the process of ensuring it to be watertight would be very complex.

Strengths:

- innovative
- cost effective and portable

Reasons for discarding Overhanging Shower alternative:

- Sustainability would be hindered by the use of small mechanical components. This could lead to constant need for maintenance.
- Availability of parts.
- Functionality would decrease with limitations of the container supplying water.

3.3.5 Organic Soap – Selected Concept

This design was eventually chosen to be the final solution for the Hygiene and Sanitation issue. The organic soap consists of oils extracted from organic waste and lye extracted from a mixture of water and ash leftovers. This solution holds the ability to improve hygiene and sanitation, by reducing the spread of disease by killing bacteria but unlike the hand sanitizing solution, the ingredients are easily acquired with little to no cost.

Reasons for the selections of the Organic Soap:

- Recycles organic waste material to produce a simple but effective solution.
- Cost effective with the potential of providing economic benefit in the form of income.
- Good impact on the issue of hygiene and sanitation.
- Easily implementable and sustainable into the future.
- Simplicity combined with innovation. The soap can easily be made in small homes for individual families, or can be made in large quantities for business purposes - selling to the community.
- Resources required are easily accessible and obtainable.
- Little impact on the environment as the ingredients of the soap does not contain any harsh chemicals that could harm people or the fauna. The soap also uses abundant natural resources which will not affect the growth of new flora.

Final Criteria/Decision making process:

Table 2. Criteria-based Selection Process

Design specifications:	1. Composting Toilet	2. Hanging Shower	3. Organic Soap	4. Hand/Surface sanitizing solution	5. Ash Toothbrush	Allocated % to each area:
Brief	4.5	3.5	5	5	2	20%
Innovation	6	5	4.5	3.5	1	20%
simplicity	2	4.5	4.5	3	6	20%
Low cost	2	4	5	3.5	5.5	20%
sustainability	4.5	5	6	2.5	2	20%
<u>Totals</u>	19%	19%	25%	17.5%	16.5%	100%

1 point = 1%

Points range: 1 to 6

Designs

1. Composting toilet: waste from toilet can easily be recycled as compost for use on crops.
2. Hanging shower: A simple/compact shower design, which can be moved and is hung from e.g. a tree.
3. Organic soap: An organic soap easily produced using locally sourced materials, making for a sustainable design.
4. Hand/Surface sanitizer: A sanitizer solution, which can be used to disinfect surfaces.
5. Ash Toothbrush: A simple toothbrush design, which uses the fibers from ash to clean teeth.

3.4 Ethics

Ethics are an essential part of the project and processes encountered throughout this project. Ethics play an essential role in balancing and fulfilling the group's obligation to both our clients and the intended user of our solution. It is imperative that we uphold our ethical obligations to the clients without misleading them in any way.

3.4.1 Obligations to the Bambui Community of Cameroon

- Ensuring our solution benefits the whole community and not one sole beneficiary.
- Creating a product that will improve the quality of life and well being of the user.
- Taking steps to minimize potential risks and health hazards during the implementation of the solution and its use.
- Using provided resources efficiently to provide information of integrity and create a viable solution.
- Creating a sustainable solution which does not degrade the surrounding ecosystem or attack the user's beliefs and customs.

3.4.2 Obligations to Massey University

- Do not plagiarize, fabricate, or falsify information.
- Do not misrepresent the competence and experience of your team.
- Do not jeopardize the integrity of Massey University's reputation.

3.4.3 Obligations to (EWB) Engineers Without Borders.

- Follow all rules and regulations accordingly.
- Do not plagiarize or falsify information.
- Obligation to fulfill your requirements and produce a sustainable and affordable solution which addresses one or more of the issues identified in the brief.

3.5 Design implications

3.5.1 Social and Cultural

Our solution doesn't hinder the cultural beliefs, it respects the morals, it doesn't cause harm or damage to anything, or anyone. It has no negative effects on the community or environment. Even though it will take some time to make this soap, it will have a beneficial impact on the community and the hygiene issue in Bambui. This could even bring the community closer together. This could be achieved by separating the tasks that are needed into different homes. For example, one home could make the lye water, and another could get the oil. Then after these have been done, they could pass it all on to another house hold, and they would make the soap from the ingredients from the other households.

3.5.2 Environment

The benefit for the environment is that this soap has only got organically derived ingredients meaning that it is good for the environment. However there is a negative effect when obtaining the ash. To access the wood ash, wood has to be burnt. This can be found in most communities when cooking with fire stoves. Although easily obtained continuously burning wood releases many harmful gases and particles that can affect your lungs and heart (Health Effects of Wood Smoke, 2015). Due to there only being organically derived materials it means that there are no harmful chemicals that can be leaked into the environment. However due to the conditions of their waste water treatment, it is very likely that chemicals from the communities waste will be leaked into the environment through the water line.

3.5.3 Economic

This solution is very economical. The key ingredients are derived from easily accessible materials. The ash is free, and it is re-using a by-product from Bambui community's day to day life. The only other ingredient needed that may cost money is the oil, but if need be the

community can source oil from natural sources such as coconuts, nuts and other vegetation. As the soap is very simple and easy to make, the people of Bambui have the ability to produce the soap themselves in smaller quantities at little or no cost. The community also has the opportunity to create a new job/position for one of the citizens to be the creator of the soap who can then sell to others in the community. This is economically beneficial as it creates an income for the citizens.

3.5.4 Sustainability

For this soap to be sustainable, it has to meet the needs of today, without compromising the needs of the future. Our soap is sustainable because its only raw materials are organically derived from locally sourced ingredients. It is taking the communities waste materials and combining it with an oil/fat to produce this soap. The equipment that is needed to make this soap can be reused many times. The only piece of extra equipment that is needed is for measuring the quantity. This can be done with an old plastic drink bottle. The other pieces of equipment can be found in the community. The raw materials are needed are ash and oil. The ash is found in the citizens fire stoves, and the oil can be extracted from coconuts, nuts and other vegetation.

3.5.5 Communication

The level of skill that the people of Bambui have in speaking English, or ability to read could have a negative impact on the implementation of the solution. Because of this, we will have another method of communication, pictures. These can either be photographs or it can be done from drawings. This is beneficial because all ages and levels of English or other languages spoken should be able to interpret the pictures and understand that they are trying to portray.

4.0 Chosen Design: Organic Soap

4.1 Why We Have Chosen Organic Soap

This was the most preferred solution because we believe that it is the most beneficial to the community. This is because there are many diseases and other health issues that can be treated with some of the most basic methods. Some of these are Leprosy, Podoconiosis, Cholera, and helminthiasis.

We chose this product to develop due to the raw materials that are needed to make this organic soap. It is from some of the most basic materials that they have available to them. This is from potassium hydroxide, and an oil/fat. This potassium hydroxide can be derived from one of the most openly available materials, such as ash. This ash can be processed to leave a solution of potassium hydroxide. From here it can be reacted with the oil/fat to make the soap. This is starting off with a by-product from the day to day life of the people in the community, and from this by-product we can use it to produce a soap that is needed for the community. This is starting off with a waste material and using it to produce this organic soap.

Two of the group members have a developing understanding for what is occurring in this chemical reaction, these two members have knowledge in chemistry and are developing their skills by taking a chemistry paper to become chemical engineers. The other group members are studying to become Mechatronics engineers, this is beneficial to the group because this can help develop a method for the community to develop this soap.

Even though this design was not specifically stated in the project designs, the brief stated that other ideas would be accepted too. We believe that the soap concept met the criteria because it addressed the issue of improving personal hygiene and reducing diseases spreading

in the community. Even with all the precautions in place to stop the spread of disease, there is still a great risk to the people living in Bambui. We believed that if we could make a hygienic and affordable solution for the community, they would use this product more often. With it being developed from easily accessible materials with an easy method of production with it being very affordable, we believe that they will use it without the feeling of wasting their resources on something that is very difficult to see the effects of. Because of these hygiene issues that can have a big effect on the health of the people in the community, we believed that if everyone kept up their own personal hygiene that it would help reduce the spread of diseases. They do not need to buy expensive soaps.

4.1.1 Is this the best for the community?

We believe that this soap will be an addition to the precautions already in place for hygiene. It can easily combat the hygiene issue and it can reduce the spread of disease from person to person.

4.1.2 What are the strengths of this soap?

The strength of this soap is that all the raw materials needed, can be derived from ingredients that are easily accessible in most homes in the community. Not only are they easily accessible, they are from waste products that would have otherwise been wasted. Because of this it causes the overall cost of production of this soap to be at a minimum. This soap is basically free for them to make and use in their community. It does not require any special equipment or skills to make the soap. As the soap is being derived from organic materials and waste products it will have a very minimal impact on the environment. We have only used raw materials and have not added any harsh chemicals. This soap will have the same cleansing properties as regular soaps on the market today. This is low cost for them because the key ingredients are derived from wood ash which is a by-product of

their day to day life, their method of cooking using wood. The oil that they can use to make this soap can easily be derived from coconuts. With all these key ingredients being sourced easily, there is essentially no cost to this process at all. Or they can also buy this oil as only small quantities are required.

4.2 The making of the soap

This soap is made from a basic chemical reaction, between a strong alkali/base and an acid. In this case it is an oil acid.

4.2.1 How does the soap work?

How it works is like a normal soap, when the soap is in water it will cause the soap molecules to join together and form tiny balls, which are much too small to see called micelle - an electrically charged group of molecules (Whatischemistry.unina.it, 2015). The hydrophobic (not compatible with water) ends of the molecule form together and align together. Whilst the polar part of the molecule interacts with the water molecule. Due to the hydrophobic environment in the centre of the micelle, it will cause any grease or oil molecules to go inside because they are attracted, this is because the end of the soap molecule is lipophilic whilst the other end is hydrophilic, when it appears that the oil or grease is dissolved, and when it is rinsed under water. The hydrophilic/polar part of the molecule is attracted to the water and when the water runs off the hand/body it will "pull" the dissolved oil/grease with it because of the attraction with the flow of water (Kam, R, 2014).

$$(200 \times 10^{-3}) / 915 = 2.18 \times 10^{-4} \text{m}^3$$

0.218 litres

Water

60 grams

0.06 litres

NaOH

Density = mass/volume

Volume of Sodium Hydroxide = mass/density

$$(30 \times 10^{-3}) / 2130 = 1.408 \times 10^{-5}$$

0.01408 litres

This ratio can be simplified;

Oil: Water: NaOH

$$22:6:1.5 = 15:4:1$$

Results: The mixture was too runny, we concluded that there was too much oil for the mixture to set.

****Experiment Two:****

Aim: To correct the consistency of the soap mixture by adjusting the amount of oil and water.

Method:

$$n = m/M_r$$

$$n = 22.5 / 39.997 = 0.56 \text{mol}$$

$$n = cV$$

$$0.56 / (30 \times 10^{-3}) = 18.75 \text{mol/L}$$

Volume of oil = mass/density

$$(30 \times 10^{-3}) / 915 = 3.279 \times 10^{-5} \text{m}^3$$

0.03279 litres

Water

30 grams

0.03 litres

NaOH

Density = mass/volume

Volume of Sodium Hydroxide=mass/density

$(22.5 \times 10^{-3}) / 2130 = 1.056 \times 10^{-5}$

0.01056 litres

This ratio can be simplified;

Oil: Water: NaOH

3.2:3:1

Results: The adjustment of the ingredients was correct and we got a soap mixture with the right consistency to set.

These equations are based on sodium hydroxide (NaOH), this is due to the accessibility of the ash that they community of Cameroon have available to them. In Cameroon they have access to Potassium Hydroxide (KOH), for ease for us to develop this soap we used NaOH. The potassium and the sodium will both act as spectator ions and therefore will not affect the reaction at all.

4.2.3 How Was The Soap Made?

Soap is made of a basic chemical reaction called Saponification between a strong base, generally sodium hydroxide, and it is reacted with a fat or oil. To make this soap we used ingredients that are available to people living in Bambui. Since we don't have access to all the same resources we had to make a few modifications to the way we made it here. In Bambui they will need one or two more steps.

The first thing that they will need will be lye. We used the easily accessible sodium hydroxide. The people in Cameroon, may not have access to this, but instead they can use another ingredients that can be derived directly from wood ash. The key ingredient that is derived from this is potassium hydroxide; this is the same component as we used the sodium hydroxide for, a strong base. People in Bambui can obtain this chemical by using wood ash, and mixing it with water, to make a saturated solution. They will then need to filter this solution. This can be easily done by using an old plastic drink bottle or container filled with stones/gravel.

When the solution has been passed through this, what will be left will be a solution of aqueous potassium hydroxide. From here it will need to be evaporated out, simply done by putting it in a pot and leaving it on the stove, this could be left overnight on the stove when the fire is burning out. When this is done all that will be left will be a powder of potassium hydroxide.

Oil will be needed too. Coconut oil will be easily accessible for the community in Cameroon. They will need to extract the oil from the coconut. This is done by a few easy steps, the first is to get the meat from a mature brown coconut and cut it up into fine pieces, till it is shredded. Next, what is needed it to put a cloth over a jar/a collection bowl and pour the coconut onto the cloth and squeeze the milk into the jar. This process may need to be repeated a few times. Leave this to set, this will be at least 24 hours. What will happen here is that the curd and the oil will separate, what is needed to be done here is to scoop out the curd and what will be left will be pure virgin coconut oil. Not only can this oil be used to make this soap, it can also be used in cooking.

These are all the raw materials that are needed to make the soap. From here it is a ratio addition of each of these key ingredients. Since it is a ratio addition, they can use the same measuring device for the whole process. This measuring device can be any size depending on

what options they have available to them. This could be a pot or an old plastic drink bottle of any size. They will need to add the ratio of Oil: Water: NaOH=3.2:3:1. This is essentially 3:3:1 with a little more oil added. From here, the required amounts of the Potassium Hydroxide and water are hand mixed, and once the potassium hydroxide is fully dissolved, it is best to wait until the temperature has decreased to close to room temperature. Here the oil was mixed in for about 15 minutes until it starts to trace (become thick). If there is any fragrance available, that can be added here too. After this, the mixture was placed in a small container and left to set for a couple of days.

5.0 Implementation

It is important for our group to undertake consultation with local communities through the EWB representatives. This is because we want to make our product as useful as possible for the people of Bambui. Consultation can be performed for future variations of the basic soap kit in many ways, such as; Polls, Survey research, One-on-One interviews. Each method has its own advantages and disadvantages. For our operation the most effective ways are Survey research and Polls, for Survey research the advantages are as follow:

- You could get feedback from a large and diverse group of people
- Can be produced by large numbers at low cost
- It gives you good large quantitative data.

And the disadvantages are as follows:

- No one may have time to complete the survey
- May not be accessible to people who have limited literacy
- The analysis of the data takes a large amount of time.

For Polls the advantages could be:

- Permits a quantitative assessment of community opinion
- Responses are relatively easy to collate
- It is a relatively quick and cost effective way to sample a large number of people on a variety of topics.

There are also a few disadvantages which could be:

- Assumes a level of knowledge/opinion that may not exist
- Does not generally provide information regarding the reasons underlying certain opinions.

For our soap we do not need a lot of time to make it, as it only requires mixing two ingredients together, and letting it rest for two days. We have prepared a **booklet** with ingredients to make the soap, and also how to mix the soap. For example you will need to mix water with ash and drain the water, later add some coconut oil to the water and mix, keep it at room temperature for a few days. This is an initial example - the plan is to make it in both French and English language with simple pictures (See appendix for step by step visual preparation).

Soap-making is quite easy, and does not need much resources, skills or labour. As the North Western region of Cameroon is known to have coconuts they could extract the oil from coconuts there. As for the Potassium Hydroxide, it could be extracted from the burnt wood that they cook with as it produces ash. To make the soap, little labour is required as it can take approximately ten minutes of mixing the ingredients, then they will have to let it rest so they can use it.

Education is important world-wide, and it is necessary for Cameroon to know the advantages of using soap, so we will be making pamphlets to describe the advantages and how to use soap properly. This is important because in recent studies it shows that cleaning with soap every so often can prevent diseases and flus from expanding to other people. The diseases such as Cholera, Typhoid fever and Hepatitis A are caused by bacteria and so the use of soap can prevent them, as soap generally helps kill these bacteria.

In order to introduce the organic soap into the community of Bambui, we will provide:

- a. Soap 'starter kits' with the EWB logo to be given out to villagers by the EWB team there. This hygiene kit contains the ingredients in the right proportion for them to easily make their first soap at home.
- b. We suggest that they can use coconut shells as an organic mould for soaps.
- c. We also suggest that a small-scale business/shop can be set up by a group of villagers or a keen individual to make and sell these in large quantities locally.

The cost of making soap will be very low so everyone in Bambui can have access to making it. The ash is freely available, but the oil may not be as easy to access. The cost of oil is between \$1 USD - \$8 USD per kilogram (Alibaba.com, 2015). However if the people of Bambui cannot afford expensive oils, there are ways in which they can obtain oil from things such as coconuts, nuts and other vegetation that are lower cost alternatives.

Table 3: Cost of Making Soap - One bar vs. 100+ bars (Alibaba.com, 2015) (Numbeo.com, 2015)

	One Bar	More than 100 bars
Coconut Oil	\$0.03 (30 MI)	\$1 (One Liter)
Water	\$.0175 (25 MI)	\$0.70 (One Liter)
Ash	\$0	\$0

6.0 Conclusions

For this report we have the following conclusions from the research we have done:

2. Bambui, Cameroon has very poor personal hygiene and sanitation standards. This prevents the community from having a safe and clean water supply which can cause disease and sickness such as leprosy and cholera.

3. The aim of this project was to create a solution to the hygiene issue found in Bambui, Cameroon. The objective was to create an organic soap to improve hygiene and reduce any further spread of disease and improve health within the community.
4. The constraints identified for this project are the need for cost effectiveness (due to the lack of funding in the community), the solution must be simple and sustainable and materials should be sourced locally and any resource costs must be kept to a minimum.
5. Organic soap was chosen as the solution as it met the EWB criteria provided by the brief.
6. If the solution were to be implemented in Bambui, Cameroon it would reduce the spread of disease and improve personal hygiene within the community. The solution requires minimal work and could be executable in the any community within Cameroon similar to Bambui.
7. In order to introduce the organic soap into the community of Bambui, we will provide:
 - a. Soap 'starter kits' with the EWB logo to be given out to villagers by the EWB team there. This hygiene kit contains the ingredients in the right proportion for them to easily make their first soap at home.
 - b. We suggest that they can use coconut shells as an organic mould for soaps.
 - c. We also suggest that a small-scale business/shop can be set up by a group of villagers or a keen individual to make and sell these in large quantities locally.

7.0 Recommendations

As a result of this report, Eleven Incorporated recommends that the following action should be taken:

- Before the soap is to be implemented, it is recommended that further testing be done to check the long term usage. Further testing is also recommended to ensure the soaps ability to effectively remove bacteria from surfaces. Unfortunately this extensive testing was not possible due to time constraints. We however, are carrying out the initial testing and the results can be presented soon.
- Before the implementation of this solution, it is suggested that 'Hygiene starter kits' be distributed by EWB representatives and village leaders and presented to the community with the intention of getting locals interested in the concept.
- It is recommended that educational workshops be set up in order to teach locals how to create a sustainable organic soap. These workshops will provide community members with the knowledge base needed to construct a soap which can improve hygiene and sanitation in the community significantly.
- The distribution of educational pamphlets within the community is also highly recommended. These pamphlets should stress the importance of proper hygiene and sanitation practices as well as the possible health benefits involved. Furthermore, these brochures should outline basic hygiene methods and instructions on how to correctly wash your hands. The need for verbal communications can be reduced by creating a pamphlet consisting of mainly images depicting step by step instructions (See example in appendix).
- It is suggested that necessary equipment and safety equipment be acquired before attempting to undertake large-scale soap-making processes.

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Organic Ash Soap

Instruction Pamphlet

Quantity: 2 bars of soap

Materials Needed:

- 2x Measuring Cups
- Small Square of Cloth (to fit over measuring cup)
- Stove and Pan
- Stirrer
- Bucket

Ingredients Needed:

- 30 mL Oil
- 1/2 bucket of Waste Wood Ash and 1/2 bucket of Water to get 20 mL Lye Water
- Scent (Optional)





Figure 3
Step 1:
Measure out the oil, in a measuring cup.



Figure 4
Step 2:
Mix Wood Ash and Water in a Bucket.



Figure 5
Step 3:
Filter out the Lye Water from the soot using a cup with a cloth covering.



Figure 6
Step 4:
You should start to see the liquid gathering in the cup and soot left in the cloth.



Figure 7
Step 5:
Your Lye water should look like this, if not filter more.



Figure 8
Step 6:
Heat up a pan and add Lye Water.



Figure 9
Step 7:
Allow Lye water to heat up but do not let it boil.



Figure 10
Step 8:
Add the warm Lye water to the oil and mix.



Figure 11
Step 9:
Once oil and lye water has been mix, add scent if desired.



Figure 12
Step 10:
Pour mixture into a mold of your choice after cooling slightly.



Figure 13
Step 11:
Let the mixture set for a couple days give or take (depending on size of mold).



Figure 14
Step 12:
Your Organic Soap is now complete and ready to use.

12.0 Glossary

- Cholera – an acute intestinal disease
- Helminthiasis – a disease caused by worm infestation
- Hydrophobic – afraid of water. Not compatible with water
- KOH – Potassium Hydroxide
- Leprosy – a tropical skin and nerve disease
- Micelle – electrically charged group of molecules
- NaOH – Sodium Hydroxide
- Podoconiosis – a disease of the lymph vessels that is caused by chronic exposure to irritant soils.

13.0 Personal Reflections

Ayumi Slegers:

Initially starting out in this paper I thought that would be an interesting project to get involved in. Although I did not realize how much work was to be done, I still thoroughly enjoyed the project. For this project my key role was the team leader. I helped organize all the team meetings and allocated tasks to each of the other team members. I also helped look over everyone's work when they need help. I believe we all had an equal part in this project, and all did a great job to make our solution a success. Initially at the beginning of this project we did not work as cohesively as a team as we did not know each other too well but very soon we began to work very well with each other to get tasks finished on time and up to scratch. We did run into a few issues along the way when it came to researching and the prototype but we worked together to come up with a solution and fix the problem.

Darryn Wells:

As members of team Eleven Incorporated we all had equally important roles. My main role in the group was based around project research and prototyping of the organic soap. This meant I was involved in all research areas of the project including background and design research as well as the production process of the soap. My key role in the production of our organic soap was to source ingredients and techniques required for soap making, and to carry out the actual process of soap making to produce an organic soap that was effective and user friendly. This meant I had to learn techniques for the extraction of lye from wood ash and skills involved in the creation of the organic soap. As it was my job to produce a viable prototype, I was faced with the challenge of creating a successful soap recipe and after many failed attempts; I was able to form a recipe, which gave us the desired result. As a team, we contributed an equal amount of effort and were all involved in specific tasks including concept design and development. We were all given roles and our team leader allocated specific tasks that needed to be carried

out. All of which I believe were carried out to the best of our abilities which ultimately saw our concept and prototype being a success.

Yaser Tamimi:

For our project I was mostly helping one of the other team members with the ingredients, and how it works. We worked on all the chemistry of making the soap. Before we started our project we had to identify the issue and do some more research on it, so I discovered the problem, and did some research on the background of Cameroon. For the report my main objective was to get reliable and realistic cost of making the soap in Cameroon along with the cost I had completed the implementation section. For the final report referencing was also required and so I completed some APA referencing for the group.

Taite Shepherd:

Everyone in the group was to do an equal amount of work for this project, for the research we split up all the work that needed to be done equally between all group members. As I had finished my research, I worked on the extra stuff that we needed to do for the report. For the initial creation and testing of our soap I worked along side another team member and worked on the chemistry side of things. As well as this I began to work on the design implications of the solution. For this section I had extra help from the other members to assist with sections that I got stuck on. All in all I believe that every member of the group had an equal amount of work and helped each other when in need.