Further investigations on recycled firebricks and methods used in firebricks manufacturing.

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Polytechnic of Namibia

School of Natural Resources and Tourism

Department of Nature conservation

Student name: Daniel I Shagama

Student number: 200728326

Station: NaDEET

Mentor: Mrs. Viktoria Keding

Tutor: Mr. Willie Adank

Contact details: **Email: dniinekela0@gmail.com**

Mobile phone: 0813044585

Table of contents

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1. Introduction

This report covers a research project conducted at Namib Desert Environmental Education Trust (NaDEET), "Further investigations regarding recyclable materials and methods used in firebricks manufacturing". The Namib Desert Environmental Education Trust (NaDEET) is located 500km southeast of Windhoek and 100km south of Sesriem Sossusvlei and situated on the farm Die Duine within NamibRand Nature Reserve in the Namib Desert. The mission of NaDEET is to protect the natural environment of Namibia by educating its citizens to practice a sustainable lifestyle. The environmental centre is offering a variety of programmes for primary and secondary school learners and community groups, as well as, for educators and tertiary level students (Viktoria Keding, personal communication, July 08, 2010).

Due to gaps in a previous study on firebricks, the NaDEET management requested that a follow-up study should be done on firebricks because; the NaDEET management would like to know more about firebricks to promote them countrywide. Therefore this research aims to investigate the most suitable waste components to be used to produce most efficient firebricks and to improve methods used in firebrick manufacturing. This would contribute to sustainable living by re-using the waste paper and waste water generated at NaDEET Centre and Base. The long term goal is to promote a healthier environment while conserving flora and consequently the fauna that depends on it.

Trees in Namibia are removed for various reasons including firewood, building materials and to clear crop fields. With the increased demand for firewood and timber, more and more trees are being removed at a faster rate than they are being replaced, if at all (World Bank Group, 2009). With the current increase of deforestation in Namibia, the following environmental consequences are on the increase too, such as soil erosion, biodiversity loss and desertification. In Namibia, fire is the main source of heat for cooking in rural and poor urban situations. As the population increases, the demand for firewood is also increasing, thus leading to economic, environmental and health problems due to

deforestation. Namibia need to promote recycling projects through Environmental Education to reduce any form of pollution and mitigate climate change for example to use old newspapers and waste paper to make firebricks to substitute firewood (Carty, 2009). In addition, Namibia need to find different alternative sources of power, which are more environmentally friendly, causes less pollution and promote sustainable living.

Rubbish especially newspapers, office papers, plastics, tins and glass are mostly seen scattered along road sides. These are materials that can be recycled and re-used. Materials such as office paper, cardboard boxes, newspapers, food wrapping materials and egg cartons can be recycled to make firebricks, which can be a partial answer to deforestation and waste management.

Two criteria used to determine the ideal firebrick are which one brought a litre of water to the highest temperature and which one can boil water in the shortest time.

Review of previous study

At the end of the previous study which was done by Ruusa Gottlieb (2010), the NaDEET management became aware that there were some uncertainties regarding the methods used in various tests concerning the firebricks. Factors such as wind could have an effect on the burning and the heat produced by firebricks, as the burning experiment was done with a self or home-made fuel efficient stove. The stove was made out of a 20 litre paint drum, with 8 wires at the bottom to hold burning materials, two wires at the top opening to hold the pot and also made with one big open space on a side of the drum for putting in fuel.

Depending on the wind conditions, the results would therefore be different. The materials used for firebricks were not weighed and the starting water temperature was not constant. All of these factors lead to a gap in the information and made the results unreliable. In addition the study compared different amounts of materials but the method was not flawless. Therefore the NaDEET management requested a further investigation on the firebricks manufacturing.

Figure1: Home-made fuel efficient stove, used in the previous study.

The title of the previous study was: **Testing ways to produce the most efficient firebrick out of waste paper at NaDEET, as a sound alternative to firewood cooking.**

Below are objectives of the previous study on firebricks:

1. To adapt the present recipe of making firebricks by: testing different types of waste paper, different combinations of these materials and different amounts of compression.

2. To compare the efficiency of the different firebricks by testing how long each firebrick took to boil a litre of water and for how long each brick remained burning.

3. To teach Namibians, i.e. the school children and communities that visited NaDEET, the new improved way of making firebricks and to make them aware that these firebricks are an efficient alternative to firewood for cooking food.

This study concluded that half compressed firebricks made out of newspaper, egg cartons, food wrapping materials and saw dust made the best firebricks.

1.3. Objectives

1.3.1. The specific project objectives were:

As discussed above, the previous study on firebricks has raised additional questions and requested some re-testing. This follow up study will improve the results and correct mistakes made in the previous study by reducing variables within the research methods.

- To re-test the rate of burning of the various firebricks by using a "Vesto-stove" and by starting with the same water temperature for each test.
- To make a more financially viable low cost firebrick press that will also improve the burning process of firebricks and address the best compression method.
- To investigate, if it is possible to reduce the amount of water used for firebrick manufacturing.
- To investigate the possibility of preparing recycled materials for firebricks, without shredding, in order to save time and labour.

1.3.2. My personal objectives were to:

- gain knowledge and experience in firebricks.
- have a broader understanding on using different types of fuel efficient stoves.
- improve my computer skills.
- work independently
- enhance my communication skills and to create a good relationship with people.

2. Materials and methods

2.1. Materials used in the project were:

- Old newspapers
- Food wrapping materials
- Cereal boxes
- Saw dust
- Office paper
- Egg cartons
- Confidential kitchen balance
- Buckets
- 2 Kettles
- Thermometer
- Timer (watch)
- Generator
- Drill
- Grader
- Metal bar
- 2kg Tin
- Firebrick Press (Old and new one)
- Drying rack
- Pen and a Pencil
- Measuring jar
- Fuel-efficient stove (2×Vesto-stove)
- Shredder

2.2. Methods

2.2.1. To retest the rate of burning of the various firebricks by using a "Vesto-stove" and by starting with the same water temperature for each test to determine the best firebrick.

a) <u>Gathering of materials and manufacturing of firebricks</u>

Materials required to make firebricks were gathered from NaDEET Centre and Base, Tok-tokkie Trails, Wolwedans Lodge, African Marketing and different offices in Windhoek. Materials collected were: Newspapers, Office papers, Egg cartons, Food wrapping materials and Sawdust. Sawdust ~~is the dust~~ from pinewood during sawing of wood. Most of sawdust comes from companies which work with wood especially cutting and sanding off wood. Sawdust was from Wolwedans, because they do most wood work.

The newspapers were shredded with a shredder while office paper, egg cartons and food wrapping materials were wrapped with hands, because they are hard to be shredded with

a shredder. With these materials, 30 firebricks were made from different materials: 10 firebricks made from newspapers, egg cartons, food wrapping materials and saw dust which was the best firebrick for previous study (Ruusa's best firebrick). 10 firebricks made from Ruusa's best firebrick plus office paper and then 10 firebricks made from Ruusa's best firebrick plus office papers but no sawdust. All these firebricks were made with NaDEET firebrick press. Each material added to a firebrick was weighed 50g, by means of using a kitchen balance and a bowl for putting in materials. Bowl used was first weighed to determine its weight and then later paper were put in the bowl and put on the balance. The weight of the bowl was then subtracted from the total weight (Bowl and Papers) to get the actual weight of the different paper materials. Once all firebricks were made, they were dried on the firebricks drying rake exposed to the sun for 8 days. Sometime firebricks dried more than 8 days, because of the weather which could be cloudy.

b) Experiment

After firebricks dried, the efficiency of these 30 firebricks was tested in a Vesto-stove, whereby one litre of water in kettle was used to test firebricks. Two Vesto-stoves and two kettles were used for the experiment, to make sure that one Vesto-stove and the other kettle cool down. The water used for experiment was left in a fridge set to 10 °C overnight, to make sure that the water temperature remains constant and same for all efficient tests (Willie Adank, personal communication, August 12, 2010). During the burning or efficient testing of firebricks, the water temperature was recorded in every 30 seconds by using a thermometer for 20 minutes, to determine which firebrick will boil water at the highest temperature and in short time.

During the experiment, firebricks were broke into 3 pieces to ensure that firebricks can be fitted well in the vesto-stove, because the bricks are big. All these were done to determine the best materials to make best firebricks (Andreas Keding, personal communication, July 27, 2010). This experiment was also used in objective 2, 3 and 4. In this objective a total of 30 firebricks were made and tested.

Figure 2: Efficiency testing of firebricks using a vesto-stove

2.2. To make a more financially viable low cost firebrick press that will also improve the burning process of firebricks and address the best compression method.

Two financially viable low cost firebrick presses which can make holes in firebricks during the compression were made. One press made out of a 2kg tin with 2 metal rods projecting to make holes in the firebrick and one was welded, made with 6 small metal rods to make 6 holes in firebricks.

Once the two firebrick presses were completed, were used to make 20 firebricks from best firebrick materials obtained from objective 3.1 which composed of Newspaper, Saw dust, Egg cartons, office paper and food wrapping materials (all materials). 10 firebricks were made with a welded firebrick press and the other 10 firebricks were made with Tin press. Each material added in firebrick was ~~weighed~~ 50g; with a kitchen balance, exactly the same as the firebricks manufacturing in objective 3.1.

The compression issues were not able to be addressed, because firebricks presses were not made with a stopper, in order to keep the compression constant for all firebricks. The firebricks were dried for 8 days and sometimes were even dried for more days due to the

weather condition. Some days are cloudy and this made it difficult for the firebricks to dry completely within 8 days. All the firebricks were tested in Vesto-stoves, exactly the same as experiment above in objective 3.1. In addition the volumes of metal rods for making holes in the brick, during compression were calculated and this was done for all two presses (welded press and Tin press). These was done to determine the amount of air circulate in the firebrick made from each press. In this objective a total of 20 firebricks were made and tested.

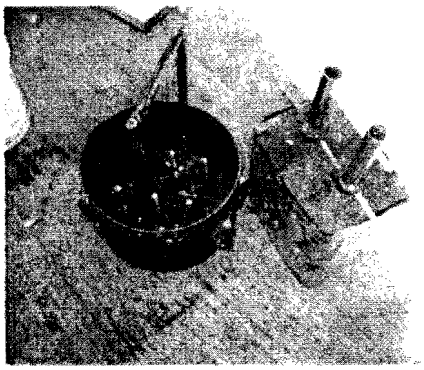
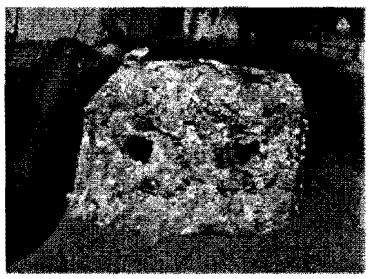


Figure 3: Two types of firebricks press, welded and tin press

(a) 

(b) 

Figure 4: (a) A firebrick made with a Tin press (b) A firebrick made with welded press

2.3. To investigate, if it is possible to reduce the amount of water used for firebrick manufacturing.

Different water variables were collected at NaDEET Base and Centre; (a) water from the kitchen, (b) laundry water, (c) water previously used in firebricks and (d) normal tap water (Willie Adank, personal communication, August 12, 2010). Kitchen water was collected from the fat trap at NaDEET Base and NaDEET Centre. The collected water variables were then used to make 40 firebricks. The best result from objective 3.1 which

was all materials brick composed of newspaper, office paper, egg cartons, sawdust and food wrapping materials; and best result from objective 3.2 which was Tin firebrick press, were used to make 40 firebricks with these different water variables collected. With each water variable, 10 firebricks were made and dried for 8 days. To keep the same quantity of materials in each brick, each material was weighed 50g. All Bricks were tested in Vesto-stove, similar to experiment used in objective 3.1.

2.4. To investigate the possibility of preparing recycled materials for firebricks, without shredding, in order to save time and labour.

All papers used in the best firebrick; newspaper, office paper, egg cartons and food wrapping materials, were weighed without wrapped before soaked. Each type of paper was weighed 50g, before added into a firebrick. These papers were soaked in the best water obtained in objective 3.3. Papers are soaked without wrapped to see if unwrapped papers can also produce effective firebricks and because wrapping of paper is time consuming and lots of labour on firebricks. Papers were soaked for different periods of time to determine the best time for soaking paper. Some papers were soaked for 6 hours, some soaked for 12 hours, some soaked for 1 day, and some soaked for 2 days.16 firebricks were made: 4 firebricks from paper soaked for 6 hours, 4 firebricks with paper soaked for 12 hours, 4 firebricks from papers soaked 1 day and 4 firebricks made from paper soaked for 2 days. After soaked, paper was mashed for 5 minutes, before being put in the tin firebrick press. (Victoria Keding, personal communication, August 15, 2010). The firebricks were then dried and tested. The efficiency of these 10 firebricks was tested in a Vesto-stove and the best days of soaking unwrapped paper were determined. The same experiment from objective 3.1 was used to test the efficiency of these firebricks.

3. Results

3.1. To retest the rate of burning of the various firebricks by using a "Vesto-stove" and by starting with the same water temperature for each test.

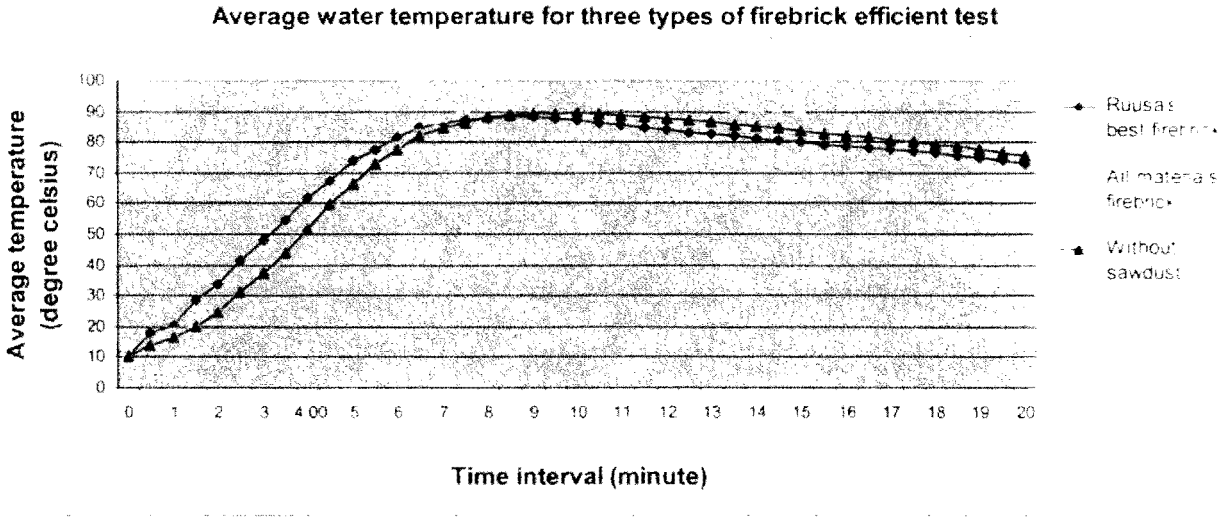


Figure 4: Average water temperature recorded in every 30 seconds over 20 minutes for three types firebricks (Ruusa's best brick, all materials brick and without sawdust)

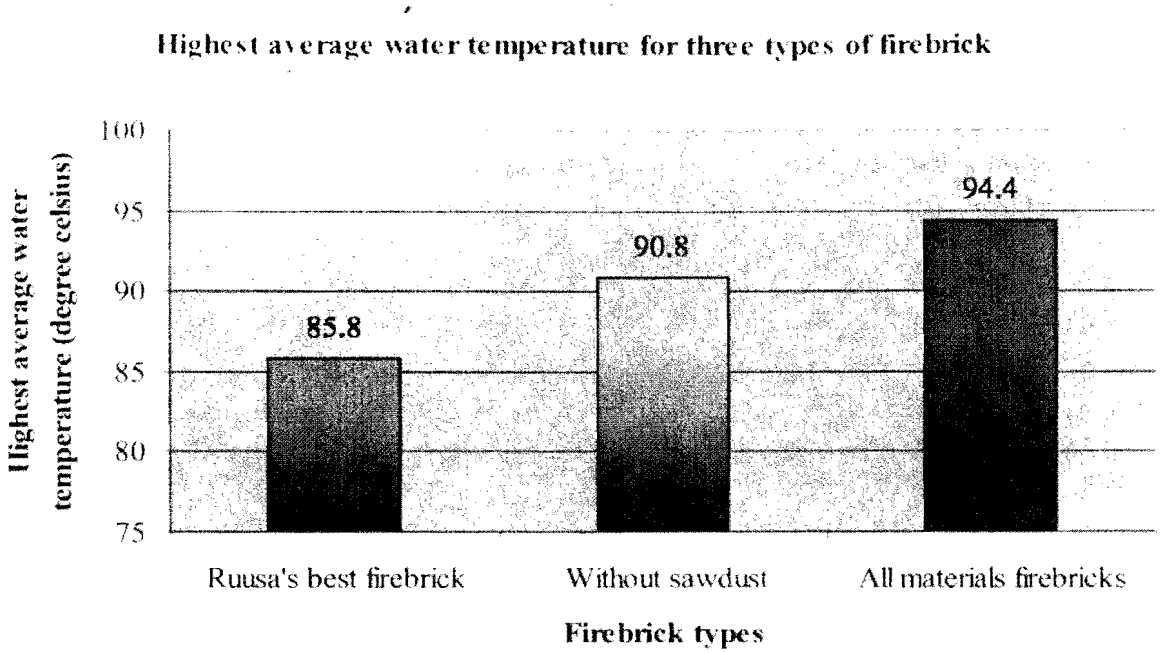


Figure 5: Highest average water temperature obtained in three tests (Ruusa's best brick, without sawdust and all materials brick).

The composition of paper materials in each types of firebrick:

- Ruusa's best firebrick: newspaper, egg cartons, food wrapping materials and saw dust.
- All materials firebrick: Ruusa's best firebrick plus office paper.
- Without/no sawdust: newspaper, egg cartons, food wrapping materials and office paper with no saw dust.

NB: The best firebrick of this study was not the same with for the previous study.

3.2. To make a more financially viable low cost firebrick press that will also improve the burning process of firebricks and address the best compression method.

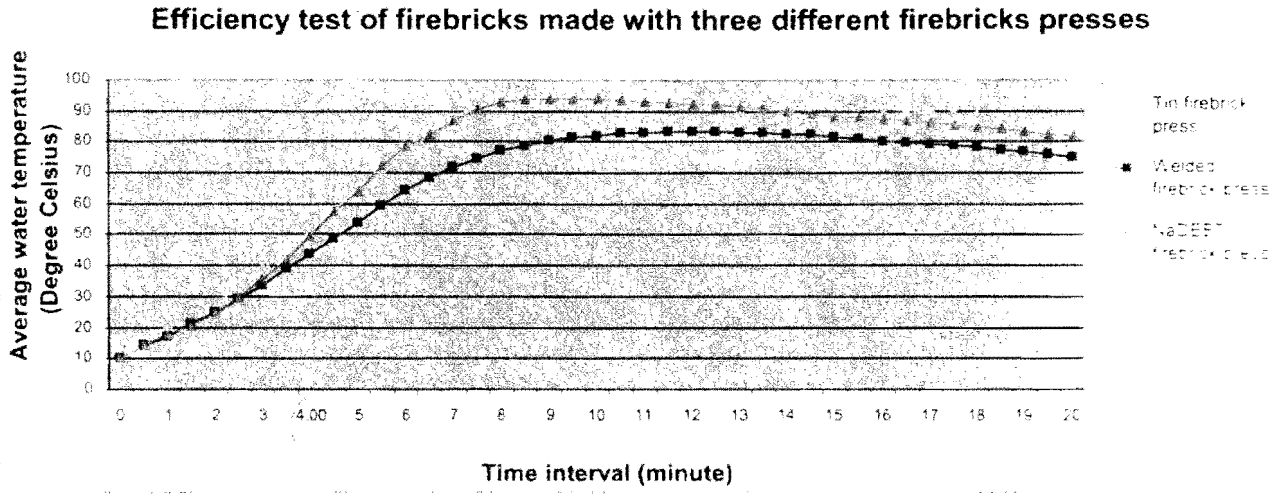


Figure 6: Average water temperature recorded in every 30 seconds over 20 minutes for three types firebrick presses (Tin firebrick press, Welded firebrick press and NaDEET firebrick press).

Tin firebricks press was the best, even though its average water temperature was almost similar ~~with~~ that ~~one for~~ NaDEET press especially in 8 to 10 minutes. Welded was the last ~~one with least average water temperature~~.

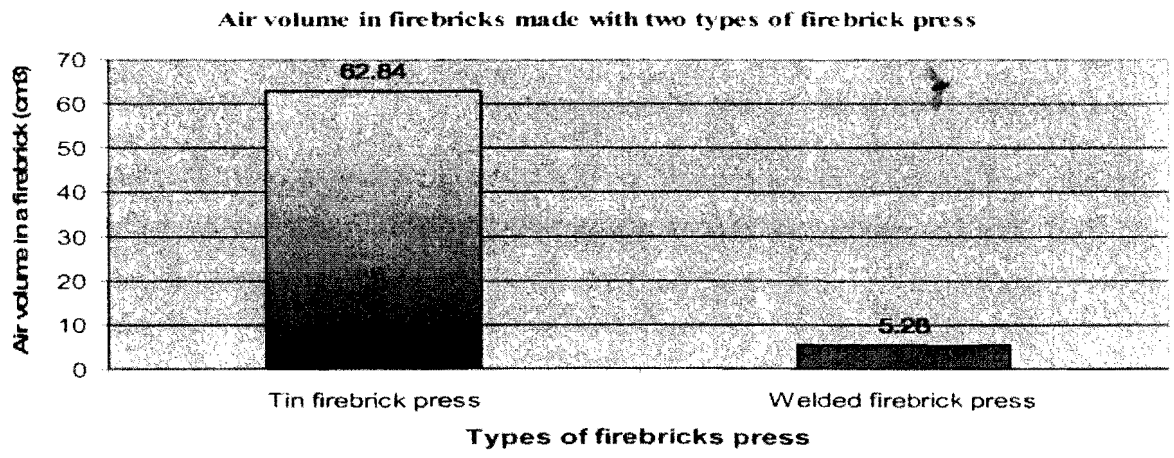


Figure 7: The comparison of air volume in firebricks made with tin press and welded press.

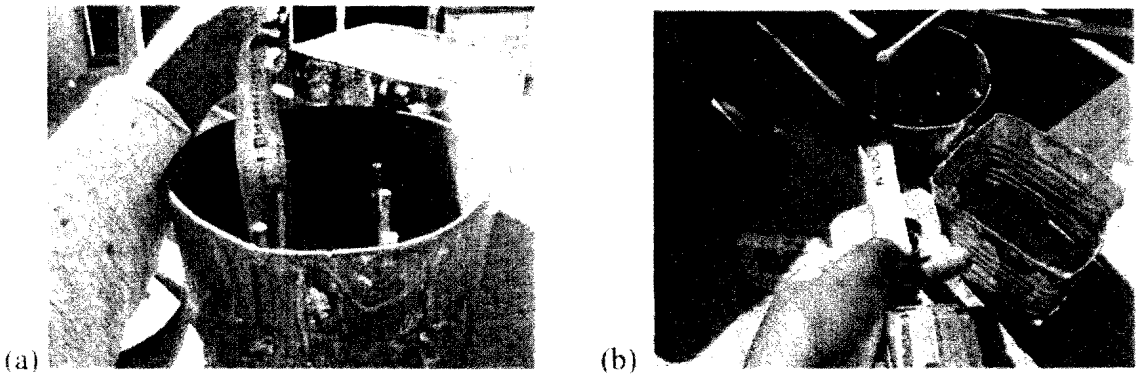


Figure 8: Daniel measuring the height and diameter of metal rods of (a) welded press (b) tin press to determine the air volume carried by holes made with metal rods in firebricks.

3.3. To investigate, if it is possible to reduce the amount of water used for firebrick manufacturing.

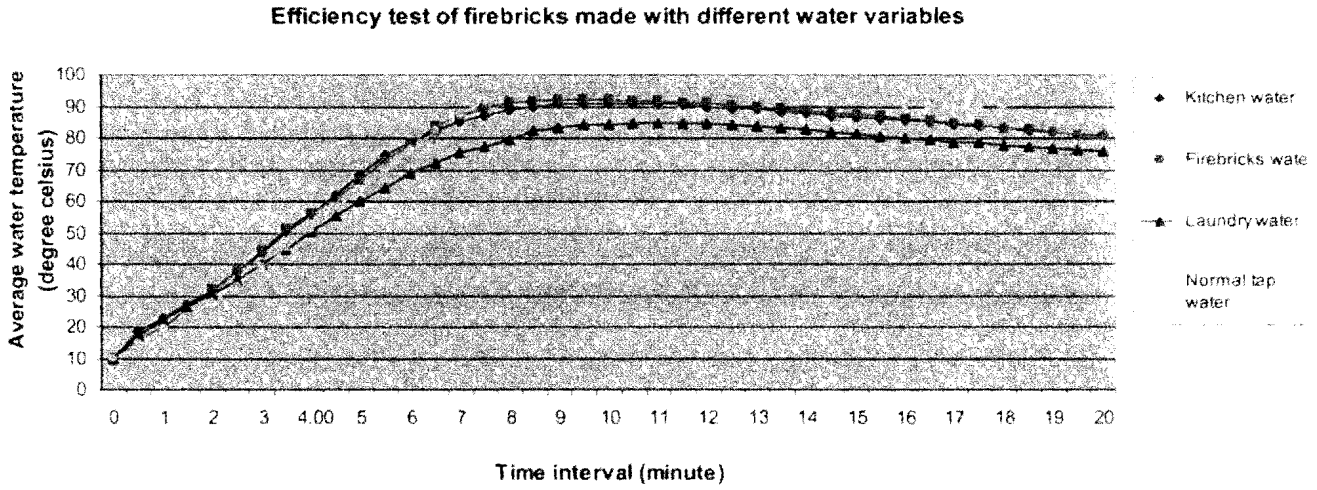


Figure 9: Average water temperature recorded in every 30 seconds over 20 minutes for firebricks made with four different water variables (kitchen water, water previously used in firebricks, laundry water and normal tap water).

3.4. To investigate the possibility of preparing recycled materials for firebricks, without shredding, in order to save time and labour.

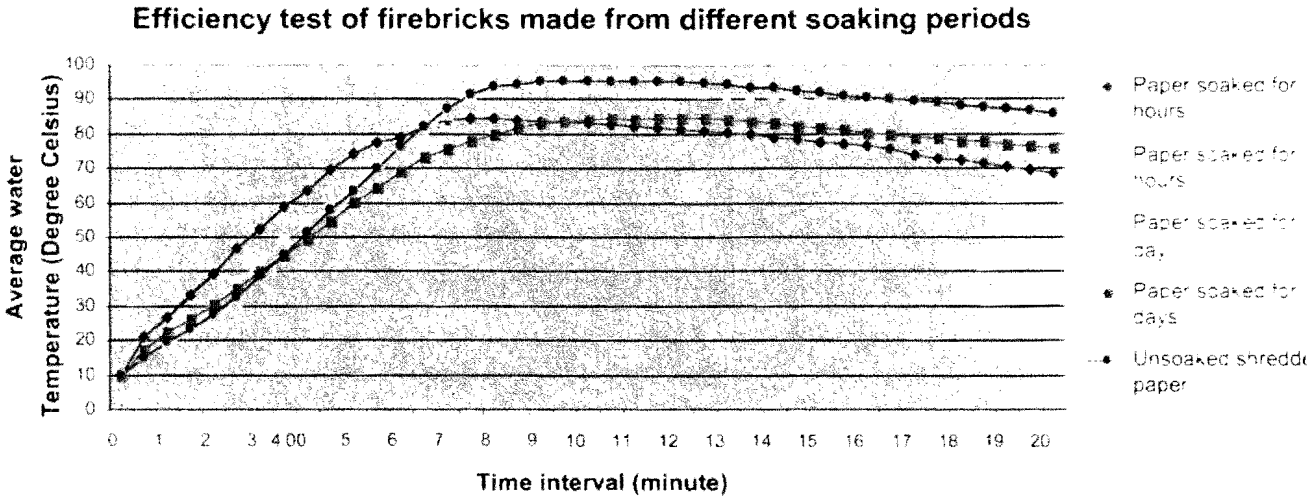


Figure 10: The average water temperature recorded in every 30 seconds over 20 minutes for firebricks made with papers soaked for different periods of time.

NB: Firebricks efficient testing experiment:

The boiling water temperature is 100°c, but during the experiment water was boiling at the temperature of 94°c. This is because, the higher the altitude, the lower the atmospheric pressure therefore boiling point of water will be lower. The boiling point increases or decreases in proportion to the pressure only up to a particular temperature after which it can neither be increased nor decreased (retrieved on the 26 October from http://www.tutorvista.com/chemistry/water-boiling-point-temperature).

4. Discussions

4.1. To retest the rate of burning of the various firebricks by using a "Vesto-stove" and by starting with the same water temperature for each test to determine the best firebrick.

According to figure 4, all materials brick was the best firebrick because it obtained the highest average water temperature (95°c) in a short period of time, which was 8 minutes. In figure 5, there is a clear indication, that all materials firebricks had the highest average water temperature (94.4°c) more than the other two efficiency tests (Without sawdust and Ruusa's best firebrick). Firebrick without sawdust was the 2nd with the highest average water temperature of 90.8°c and Ruusa's best firebrick had the lowest average water temperature, which was 85.8°c. Between Ruusa's best firebrick and firebrick without sawdust there is a clear indication that office paper had an effect on firebricks, because when office paper was added, the highest average water temperature increased from 85.8 to 90.8 even without saw dust. The more different paper materials are added to the firebrick, the effective the firebrick. Figure 5, also support figure 4, that all materials firebrick was the best brick (composed of newspaper, office paper, food wrapping materials, egg cartons and sawdust).

During the efficiency testing I observed that, 92°c was the starting of a complete boiling or rolling boiling. I also observed that during the manufacturing of firebricks, some paper materials remain in water even though a sieve was used and also some paper remain on the drying rack. Since paper materials were weighed, I believe that, these can also have an effect on the results.

4.2. To make a more financially viable low cost firebrick press that will also improve the burning process of firebricks and address the best compression method.

During the efficient testing of firebricks made with 3 different presses (Tin firebrick press, welded firebrick press and NaDEET firebrick press), tin firebrick press was the best brick maker according to figure 6, because its average water temperature is higher than other two presses as its temperature went up to 95°c in 9 minutes than any other firebrick press. NaDEET firebrick press was the 2nd with high average water temperature and it also obtained almost the same higher average temperature with the Tin brick press, especially between 8 and 10 minutes. This is because during the efficient testing of firebricks made with NaDEET press, ~~were broke~~ into 3 pieces to make sure that, firebricks fit in the vesto-stove, thus why the result at some time interval almost close to that for the tin press. I believe that breaking up of a firebrick into pieces, especially those made with no hole will also help to boost the amount of air in firebrick during the burning, whereby air can pass through and circulate in the vesto-stove.

Although firebricks made with NaDEET press was broke in 3 pieces, firebricks made with tin press still had the high average water temperature. Even though the welded firebrick press was looking good and with 6 metal rods, the results did not support it. The welded brick maker obtained the lowest average temperature and this is because the 6 holes were small. According to figure 7, there is a clear indication that firebricks made with tin press had 62.84 cm^3 of air which is high than welded firebrick press. This is also proves and fully supports the results obtained in figure 6, that tin brick press is the best, since the welded brick press had low air volume which is 5.28 cm^3.

The whole issue of compression method was not able to be addressed because; the firebrick press (tin press and welded press) were not made with a stopper to control the compression. Firebricks were kept constant, by weighing all paper materials during manufacturing of firebricks.

The manufacturing material of the firebrick maker is therefore not relevant. The most important guideline in the brick press is the amount of airflow within the brick.

4.3. To investigate, if it is possible to reduce the amount of water used for firebrick manufacturing.

Normal tap water firebricks were the best as it is indicated in figure 9, which shows that firebricks made with normal tap water obtained the highest average water temperature more than any other water variable. This might be, because tap water is clean and does not have any foreign substance or impurities to affect the burning like the other water variables. Firebricks made with water previously used in firebricks were the 2nd with high average water temperature of 92°c in 9 minute. Water previously used in firebricks and kitchen water had almost the same average water temperature. Firebricks made out of laundry water were the ~~last one~~ with the high average water temperature 85°c.

During the efficient testing of firebricks made with different water variables, I observe that kitchen water burn slowly with more smoke than other firebricks; which might be because the water contains fat which can also trap moisture in the firebrick and affect the result negatively. Some negative issues concerning kitchen water were observed during the manufacturing of firebricks, which can be lead to health problem, because the water smells and can have bacteria in it which can penetrate the skin and cause diseases during the smashing of papers with hands. Because water were gathered before hand, and water started to smell with time especially laundry water and water used in firebricks previously. Kitchen water already smelt from the fat trap.

4.4. To investigate the possibility of preparing recycled materials for firebricks, without shredding, in order to save time and labour.

According to figure 10, paper soaked for 1 day made best firebricks, because its average water temperature was 96°c high than other soaking periods. Paper soaked for one day and Un-soaked shredded paper, show an interesting results, that they almost similar to each other, which is real good that there is no different between Shredded papers and papers soaked for 1 day.

During the efficient testing of paper soaked for 6 hours; these firebricks burn fast to reach their highest temperature and also the temperature drop down rapidly as it is shown in figure 10, I think this is because in the bricks there still some normal paper material which seems like nothing happen to them during soaking and mashing of paper for 5

minutes after soaked. I also observed that firebricks made with paper soaked for 2 days, will tend to become harder after they had dried and made it difficult to burn properly. In the efficient test of firebricks made with paper soaked for 2 days, the bricks real burn slowly. Although paper soaked for 12 hours was the second one to obtain high average water temperature, they did not reach the high average temperature than the paper soaked for 1 day.

5. Conclusion

The result shows that all materials firebrick is the best firebrick which is composed of Ruusa's best firebrick plus office papers. The result also show that tin firebrick press with the most air flow was the best brick press according to figure 6 and figure 7, because its average water temperature is high than the other two presses, as it went up to 95°c in 9 minute. This tells me that not only welded press can be used to press firebricks. The study shows that effective firebricks can only be manufactured by using normal tap water. Soaking of papers for 1 day will help to save time spent on papers shredding.

6. Recommendations

The study could be improved by having more time available to test more firebricks to get more reliable result because, only 10 firebricks was made and tested per experiment. 20 firebricks will be the best, in order to get more reliable results.

According to my result, soaking of papers for one day at NaDEET Centre will help to reduce the amount of time spends in wrapping of papers. I also recommend to the NaDEET centre to use different paper combination for firebricks, in order to manufacture effective firebricks. I recommend the NaDEET Centre to implement the new firebrick press to produce effective firebricks. Water previously used in firebricks can also used at NaDEET Centre to make firebricks, as long as the water can be used as quickly as possible before starting smelling, as this water was the 2nd to produce good firebricks according to figure 10. These can help to reduce amount of normal tap water put in firebricks, even though normal tap water produced best firebricks, than other water variables.

To the community, firebricks press can be also be made from tins, especially 2kg, because most community people always complaining that, they do not have money to buy or to weld firebricks presses. I believe this is the answer to problem of community people, because making firebricks press by using a tin press is cheaper and it is also help in dealing with waste management because it enhances re-using of tins. I recommend more community people should visit NaDEET Centre and learn more about the latest methods of manufacturing firebricks.

I finally recommend that, if someone in the future is interested in doing a study on firebricks, he/she must consider the stopper on the presses in order to address the compression issues. Also must consider the shape of the presses, to make sure that firebricks are in the same shape e.g. all press must be rectangular shaped or circular shape, because for this study the tin press was in rectangular and the welded was in circular shape which might have an effect on the results. I also believe that the implementation of firebricks as soon as possible will be an answer against deforestation. .

7. Acknowledgements

A project of this size would not have been possible without the generous assistance, and supports from my mentor, NaDEET director Victoria Keding and her husband Andreas Keding (technical director), especially in gathering papers and sawdust from different companies. I would also like to extend my sincere appreciation to my tutor Mr. Willie Adank for advising and making suggestions toward my project. Special thank to Mrs Louise Theron and Kolja Lichtenthäler for helping me with graphs. I do not want to forget Danie Joubert Primary School for helping me in wrapping of papers.

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