Testing ways to produce the most efficient firebrick out of waste paper at NaDEET, as a sound alternative to firewood cooking.

INTRODUCTION

Deforestation is one of the major environmental problems in Namibia. But just what is deforestation? Deforestation is the permanent removal of naturally growing trees by humans. Trees in Namibia are removed for various reasons such as for firewood, building materials and to clear croplands. 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, soil erosion, biodiversity loss and desertification.

According to Ward (2002) "There is more of a problem than the depletion humans cause to trees and that is the effect these removals of trees have on the environment. These removals are changing the way energy from the sun enters and escapes the earth's atmosphere thus changing the global climate". As more and more trees are removed, more and more carbon dioxide is being released into the atmosphere as there are fewer trees to absorb the carbon dioxide in the atmosphere. This carbon dioxide is then left out in the atmosphere contributing to climate change.

The way to reduce deforestation in Namibia is to find and test a practical alternative to firewood. A suitable alternative being promoted at the Namib Desert Environmental Educational Trust (NaDEET) is re-using waste paper to make firebricks that can be used in the place of wood. This has the added advantage of recycling a waste product originally made out of wood. NaDEET is located on the NamibRand Nature Reserve which is located in the Namib Desert. It is therefore important that trees are saved in this area due to the fact that there is low rainfall and therefore very few trees are found in the area. Firebricks are not only easy to make, they are good for the environment and people do not have to travel long distances in search of firewood. Firebricks solve the problems of waste in many places as waste paper is used in the making of the firebricks and not as much carbon dioxide is released into the atmosphere as with firewood.

Because it is the aim of NaDEET to teach Namibians about sustainable living, the firebricks are used as a way of teaching people about ways of reusing different materials for other useful products, such as firebricks that are more eco-friendly and contribute to the conservation of the natural environment. Using firebricks is a good thing as studies show that they release less carbon monoxide into the atmosphere than burning firewood does (Carty, 2009).

The focus of the project was recycling and the aim of the project was to determine which waste products, and which production method is the best to create the most efficient firebrick. Two criteria were used to determine the ideal firebrick. It was the one that brought a litre of water to boil in the shortest period of time or which got the temperature of the water to be the highest.

OBJECTIVES

The overall aim of the project was to contribute to sustainable living by reusing the waste paper generated at NaDEET Centre and NaDEET Base. School children are already being taught how to make firebricks from this waste paper but the firebricks do not always burn well. Therefore this project aimed to test different materials and methods of making firebricks to try to improve the firebricks that are currently made at NaDEET. An added advantage was that by making firebricks the project will provide an environmentally-friendly alternative to firewood, and so meet the ecological aim of reducing deforestation.

The specific objectives of the project were:

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.

MATERIALS AND METHODS

Materials

- Old newspapers
- Food wrappers
- Cereal boxes
- Saw dust
- Water
- Buckets
- Kettle
- Timer (watch)
- Egg cartons
- Office paper
- Cardboard boxes
- Drying rack
- Fuel-efficient stove
- 1 litre container
- 1 kg yoghurt container

Figure 1: Materials to be used to make a more efficient firebrick

METHODS

Objectives 1 and 2 were tested using a series of experiments

1. ADAPTING AND TESTING DIFFERENT METHODS OF MAKING FIREBRICKS:

The method that used to be used to demonstrate how to make firebricks at NaDEET is given in the box below. A series of experiments were done to try different materials and two different amounts of compression to see if the method could be improved. All the firebricks made were tested in a fuel efficient stove to see how well they burnt.

OLD METHOD THAT USED AT NaDEET TO MAKE FIREBRICKS:

1. The materials are torn into the smallest possible pieces.
2. All the pieces are then put in a bucket.
3. Water is added (just enough to make the papers wet).
4. Once the mixture is wet, it is mixed into a smooth paste.
5. Sawdust is added to the mixture to increase its ability to burn more effectively and it is then well mixed in the bucket (as sawdust is relatively scarce, the amount added is limited).
6. The mixture is placed into the brick maker (full)
7. The mixture is well compressed to get rid of as much water as possible.
8. The water is captured and re-used on the compost.
9. The brick is carefully removed from the brick maker press.
10. The firebrick is then placed on the drying rack to dry out (for more than two days) (Pfenning, person communication, 23 February 2010)

Control Experiment

2.1 First five control bricks were made, using the same ingredients as currently done at NaDEET. The efficiency of these firebricks were tested.

Note: Although it would have been interesting to test bricks using different amounts of sawdust, the supply of sawdust at NaDEET is too limited to have allowed experimentation.

Experiment 1:

Five bricks were made from each of the five different types of waste paper i.e. cereal boxes, egg cartons, food wrappers and old newspaper and used office paper. These were made using the original recipe, dried and then tested to develop the best firebrick. The efficiency of the bricks made was then tested in a fuel efficient stove by timing how long each firebrick took to boil a litre of water as well as timing how long each remained burning afterwards.

Once all the firebricks made from each of the materials had been tested, the three materials used in the firebricks that allowed 1 litre of water to boil or that reached the highest temperature were selected for further testing in the next experiment.

Experiment 2:

The selected materials were combined in and used to make five new firebricks. Once dry, the efficiency of the bricks were again tested in the fuel efficient stove to see how long each took to boil a litre of water and keep burning.

Experiment 3:
The 3 waste material combinations that proved most efficient in Experiment 2 were further tested to see if the application of less compression when squeezing out the water might improve the burning efficiency of the firebricks.

Ten firebricks were made using the most promising waste material combinations. Five firebricks were compressed as much as possible before drying and five were less compressed. The volume of water pressed out of the fully compressed firebricks was measured. The remaining firebricks were then compressed until only half that water had been pressed out. A suitable drying rack was made using a 1m x1m wooden frame and mesh wire. Both sets were placed on a drying rack to dry completely. Once dry, both sets were tested in a fuel-efficient stove to time how long each took to boil water and how long each continued to burn. The results obtained from fully compressed firebricks were compared to that of the half compressed firebricks.

Experiment 4:
In this experiment, the method that worked best in experiment 3 (half compressed) was used to make five new firebricks using all the materials excect cardboard boxes. Cardboard boxes were omitted because they can be directly used with the firebricks to start the fire in the fuel-efficient stove and are too difficult to tear.

Experiment 5:
Following a visit by the community members from Mariental, an additional method used by them of adding more paste to the firebricks after compression to make very large bricks was also tested. In this experiment, five more firebricks were made using all materials except cardboard boxes. These firebricks were made from the same paste as the firebricks made above in experiment 4. The only difference was that additional paste was added after compression to the compressing machine and the water again pressed out. This was done until the press could no longer accommodate any more paste. The five firebricks were therefore bigger than all the other firebricks. This was done to test whether size had got any effect on the burning of the firebricks.

2. CREATING AWARENESS OF THE VALUE AND EFFICIENCY OF FIREBRICKS:
In future, the new recipe of making firebricks would be introduced to all the visiting school and community groups visiting NaDEET. It will be explained to these groups why the new recipe is being used and why it is important that this recipe should be used within the communities from which these groups come. The school children will be encouraged to pass on what they have learnt about firebricks to the communities.

Figure 2: How firebricks are made at the NaDEET Centre Source: NaDEET

Now that the project has been completed and all the data collected and analysed, the new improved recipe will be written up and included in a book called "*It's time to be efficient*". The new, improved

recipe will be used at NaDEET to teach the visiting school and community groups that there is a more environmentally sustainable way of obtaining fuel than cutting down trees for firewood.

4. TESTING THE EFFICIENCY OF THE FIREBRICKS WITH OTHER FUEL SOURCES
During one of the visits with the community group, tests were done to determine how much water a given amount of firewood, cheetah blocks and firebricks could heat. The fuel sources were used in different fuel efficient stoves.

Results

Figure 3 shows the results of how long each of the firebricks made in the old way. These were used as the control firebricks. The time that each firebrick took to burn varied from 7-10 minutes.

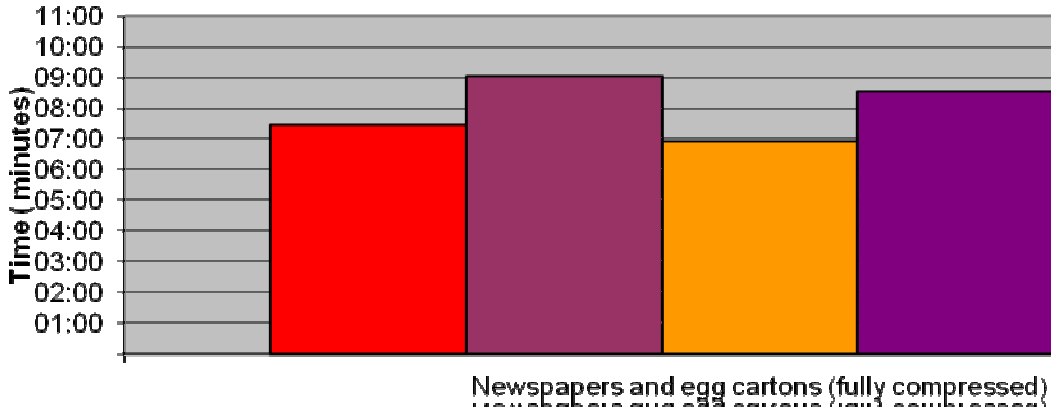

Figure 3: Total time that each of the control firebrick took to burn. These firebricks were made using only newspapers and cardboard boxes using the way that NaDEET was making the firebricks before the project.

Experiment 1

The graph in figure 4 shows the time in minutes that each of the five firebricks made out of each of the materials took to burn in the fuel-efficient stove. Although one of the office paper firebricks burnt the longest this was only because it was smoldering and needed fanning.
The newspaper firebricks burnt most quickly. Otherwise the results were similar for all the firebricks tested and these results could not directly be used to determine which to choose for the next experiment. They took 5-7 minutes to burn.
Therefore the number of firebricks that successfully boiled1 litre of water was assessed. Figure 6 shows the results and the most successful were the four food wrapping material firebricks and the three cereal boxes firebricks. Two each of the newspapers, egg cartons and cardboard boxes boiled water. To choose which of these were successful. I looked at the temperature the water reached and this is shown in figure 8.

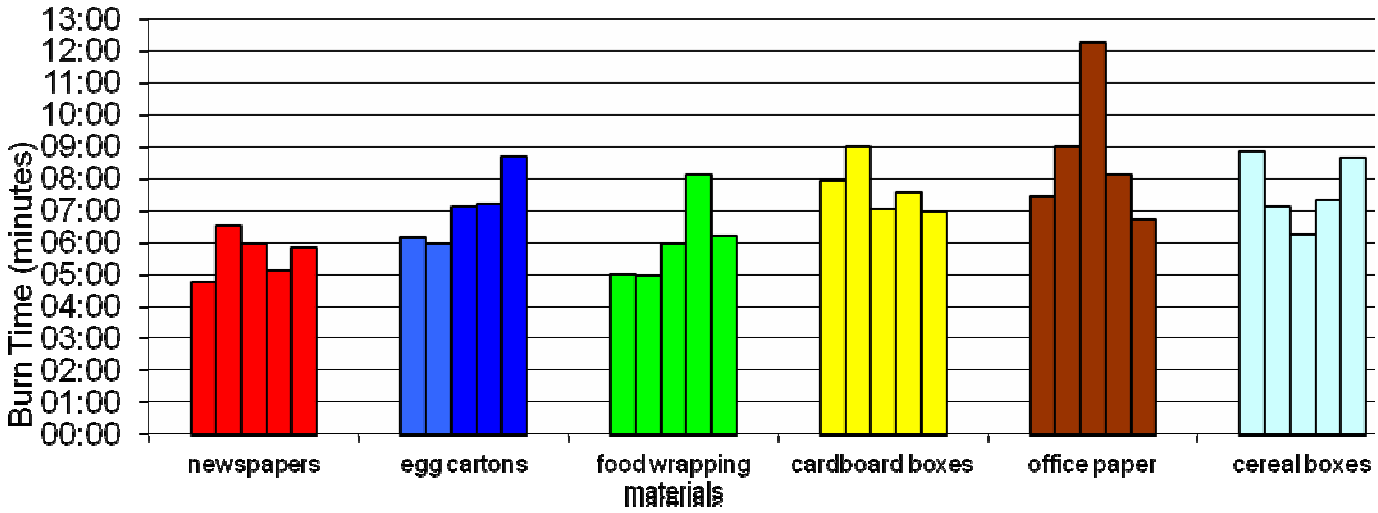

Figure 4: The time that each firebrick made from the individual materials took to burn.

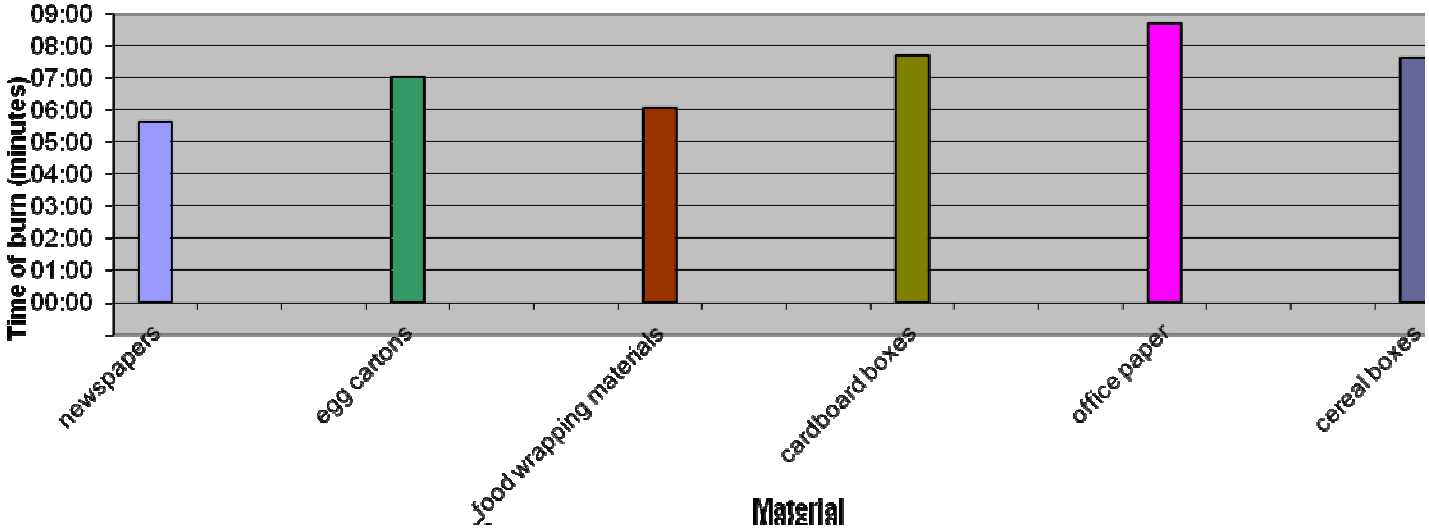

Figure 5: The figure shows the average time that each firebrick made from the individual materials took to burn.

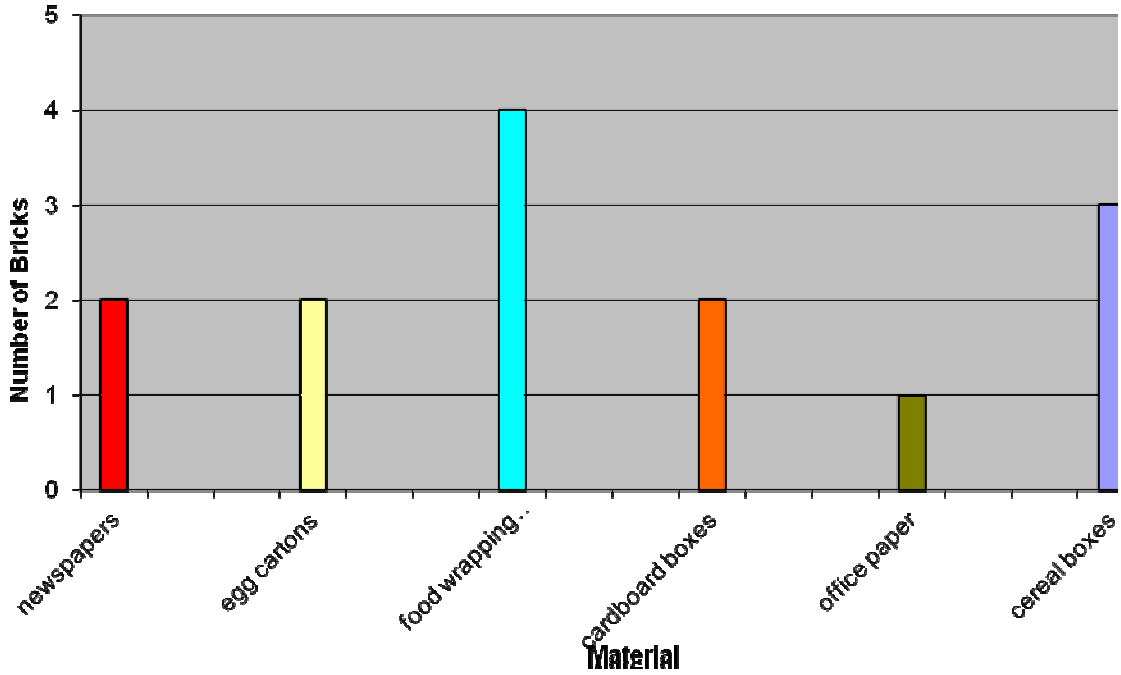

Figure 6: The number of firebricks from the individual materials that boiled water out of five trials.

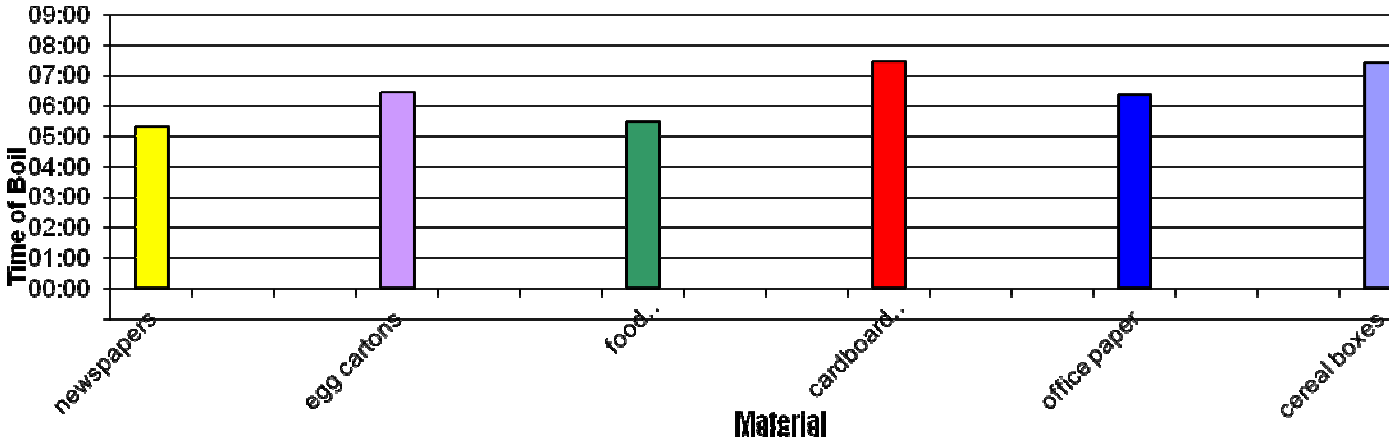

Figure 7: The average time that the five firebricks from the individual materials took to boil water in the first experiment.

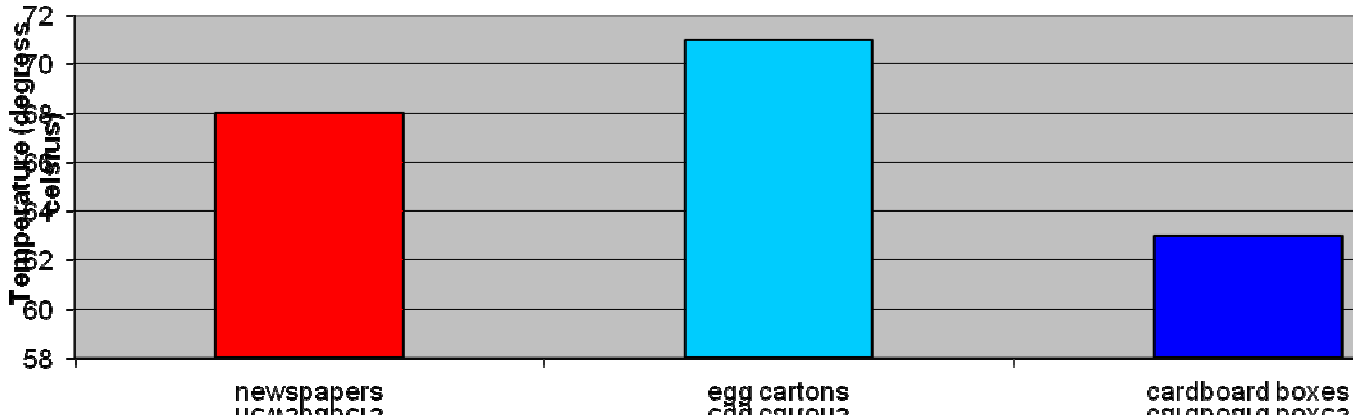

Figure 8: The average temperature of the water that did not boil in the newspapers, egg cartons and cardboard boxes.

Experiment 2

Figure 9 below shows how long each of the combined firebricks burnt. This graph shows that even the firebricks made from the same materials and at the same time have different efficiencies. Burning time varied from 4-8 minutes.

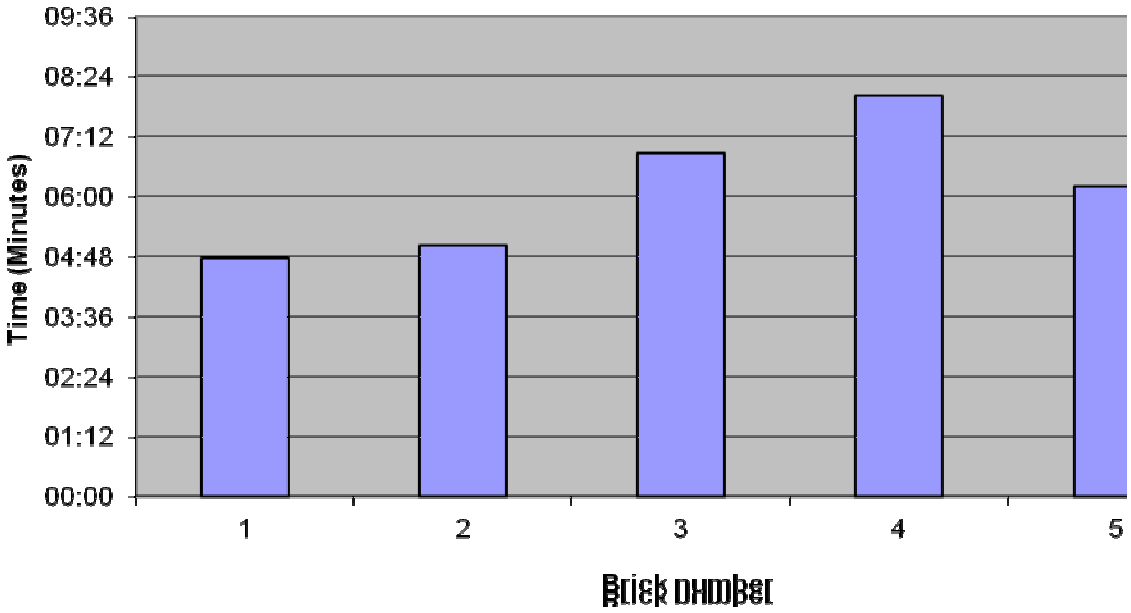

Figure 9: The total time that each firebrick from the newspapers, egg cartons and food wrapping (fully compressed) took to burn.

Experiment 3

Figure 10 clearly shows that the half compressed firebricks burnt more quickly while figure 11 shows that these firebricks heat water in a short time. Even though the fully compressed firebricks burned for a longer time on average, they often went out and needed to be relit. Therefore the half compressed firebricks were considered to be more efficient.

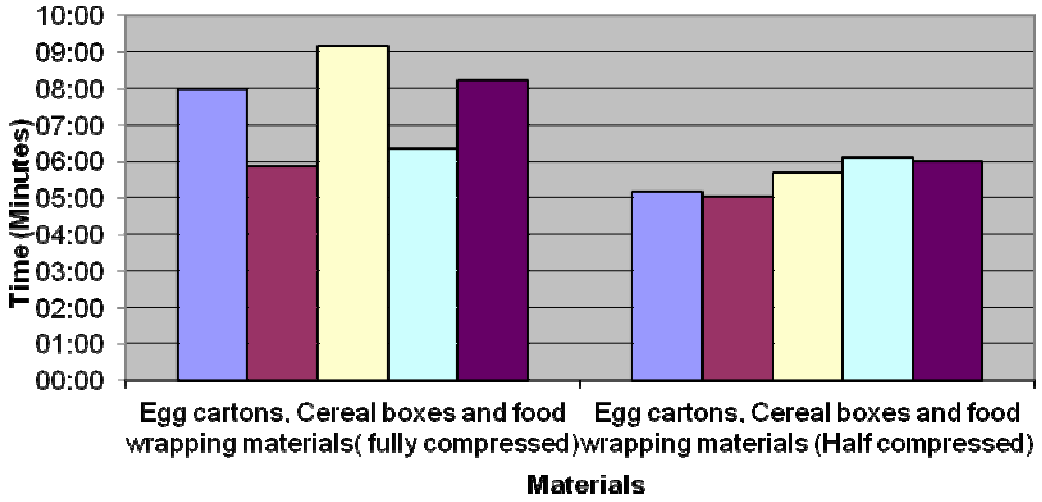

Figure 10: The comparison of the burning time in each firebrick from the half and fully compressed firebricks.

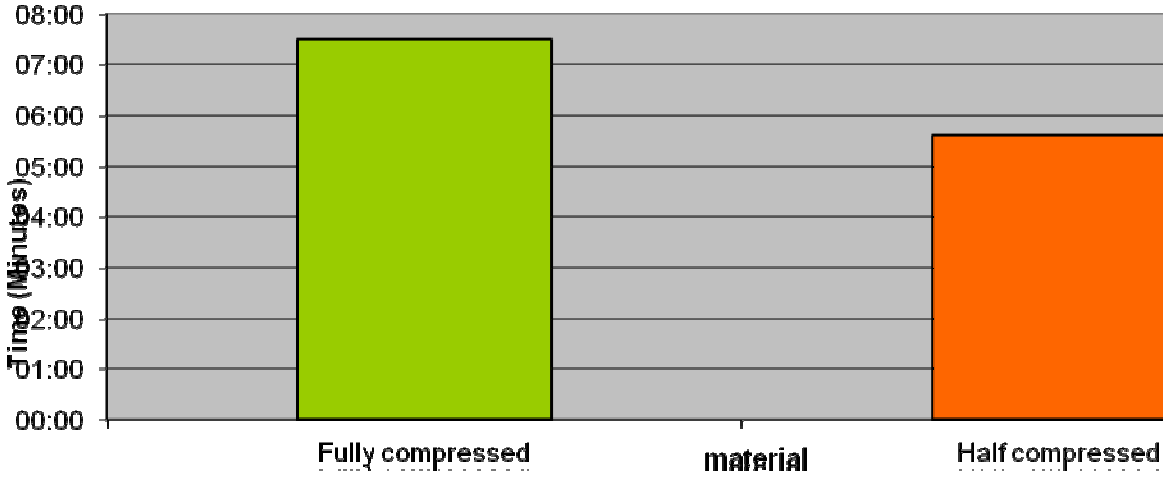

Figure 11: The average total time that each firebrick in the second experiment burned

Experiment 4 and 5

Figure 12 and 13 compare half compressed and fully compressed large firebricks made using a combination of all the materials except cardboard boxes. Figure 12 shows the burning time of each brick and figure 13 gives the average burning time.

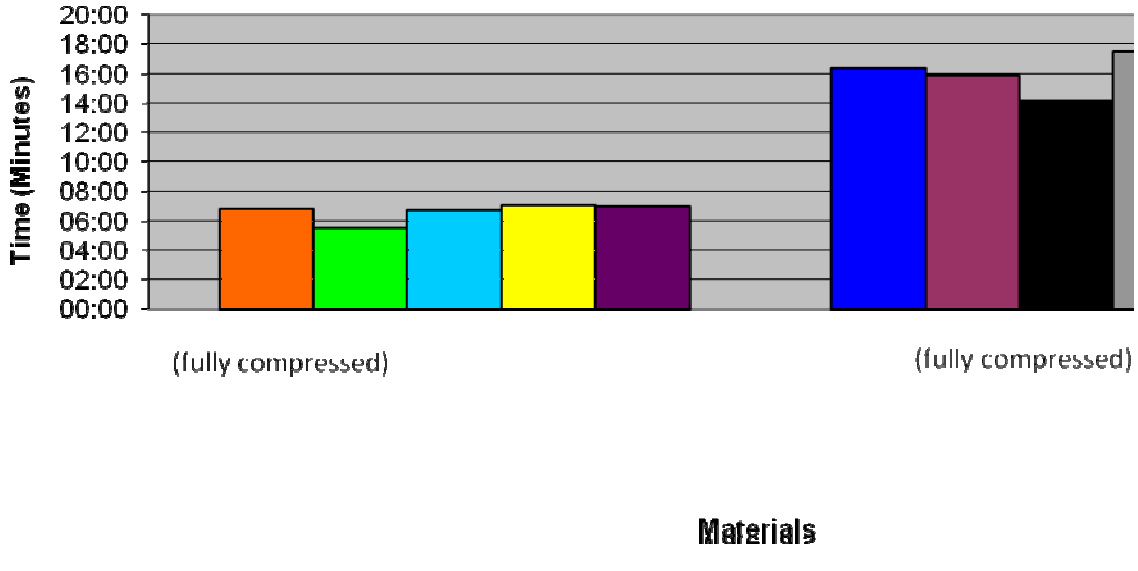

Figure 12: The total time that each firebrick burned in the fifth and sixth experiment. The experiments dealt with making firebricks using all the materials except cardboard boxes.

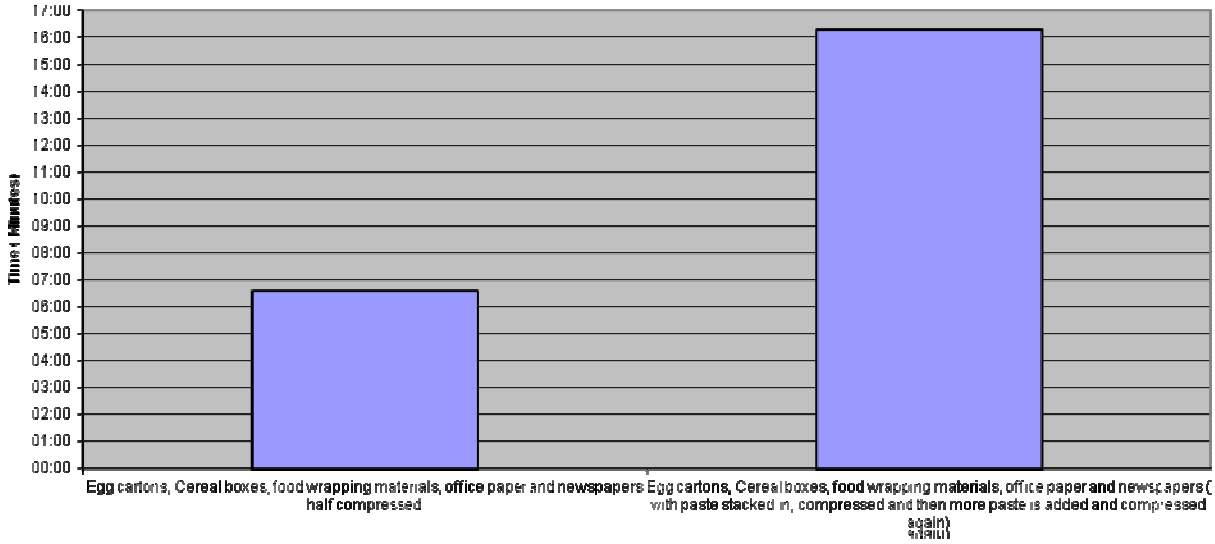

Figure 13: The average total time that the firebricks burned in the firebricks made using all the materials except cardboard.

Figure 14 shows the average time of burning for the half compressed firebricks and the fully compressed larger firebricks, even though the larger fully compressed firebricks have a higher average, this does not mean that they burned better. In fact none of these firebricks boil any water.

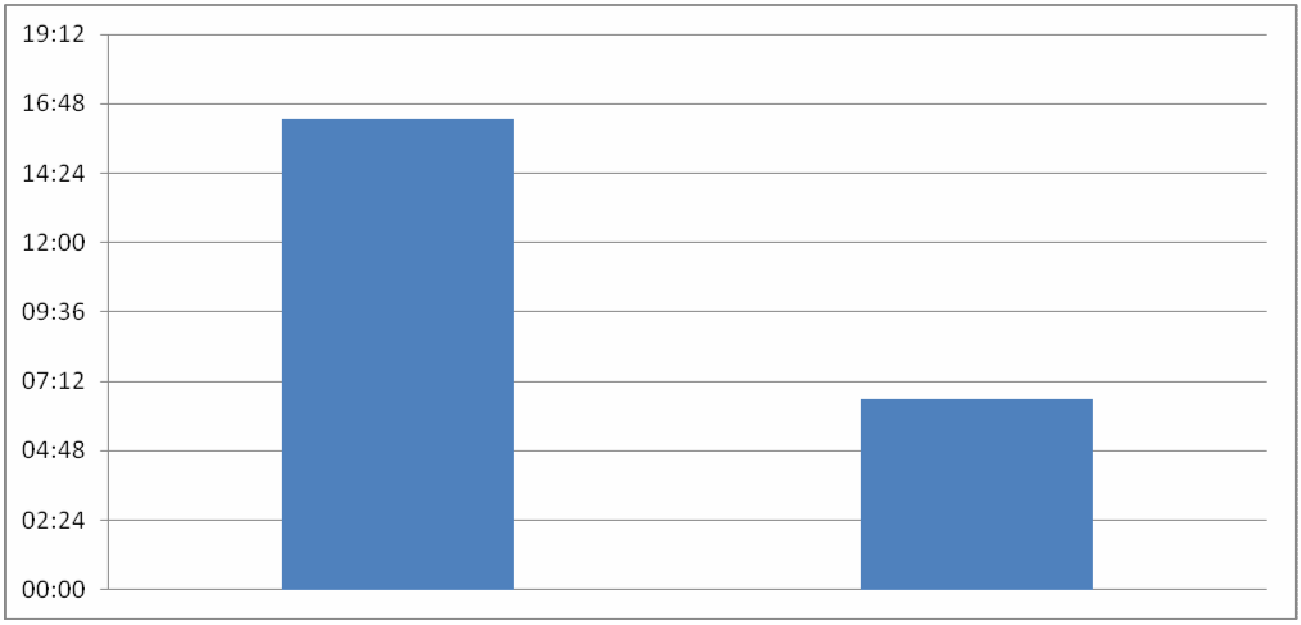

Figure 14: The average time of burning in the half and fully compressed firebricks.

Efficiency test

The graph shows the time taken for different fuels to boil 2 litres water. It shows that the firebricks in a fuel efficient took 5 minutes to boil a litre of water and that the fuel efficient with firewood is only faster than the firebricks by 30 seconds. It therefore shows that the firebricks is efficient and can therefore be used as an alternative to firewood. The bushblocks took the longest time to boil 2 litres of water.

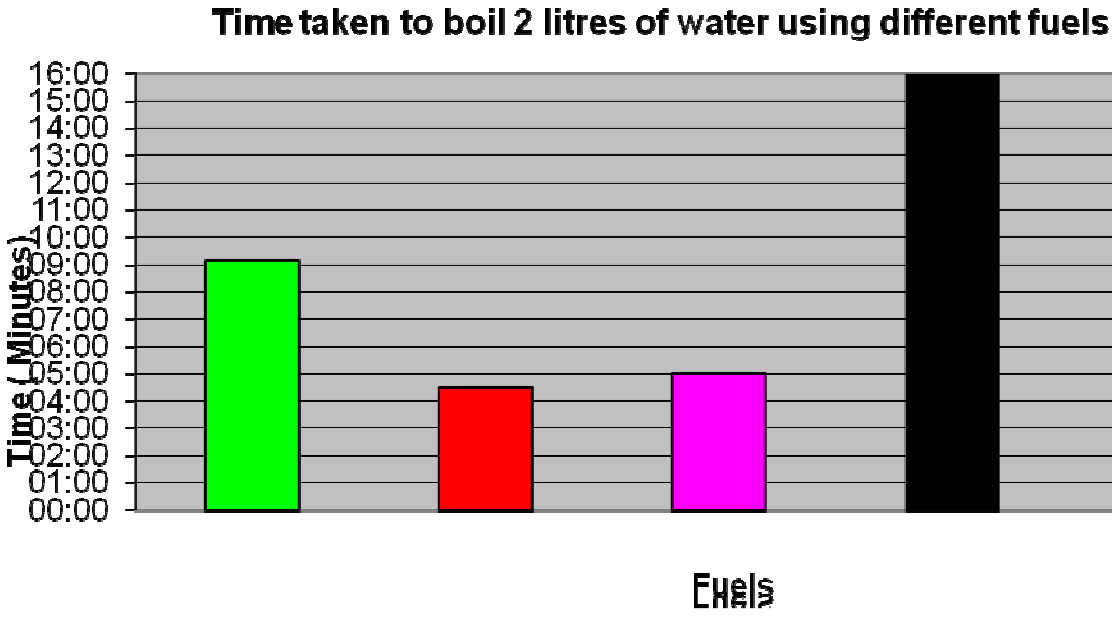

Figure 15 Shows the results of how long the different fuels take to boil 2 litres of water.

The best recipe was developed and will be used as a new method for making firebricks at the NaDEET and given to visiting school groups.

Recycled firebricks

Easy to make * Saves time * Protects the environment

Firebricks are a renewable form of fuel made out of waste paper

Benefits:

1. Reduce deforestation
2. Reduce carbon dioxide emissions (CO_2) into the atmosphere.
3. Recycle waste locally
4. No long walking to collect firewood
5. Reduced fossil fuel consumption
6. Increased biodiversity

How do I make firebricks?

Materials needed

- Any sort of waste paper material
- Sawdust (optional)
- Compressing tool, i.e. brick-making press, tin or simply your own hands

Directions

Part 1

1. Collect waste paper.
2. Sort waste paper into newspapers, egg cartons, cereal boxes and food wrappers.
3. Do not use office paper as it makes the firebricks too compact (one or two sheets is not a problem).

Part 2

1. Rip waste paper into small pieces (like the size of a potato chip).
2. Once waste paper is ripped, combine the same amount of each material in a large bucket.
3. Add water to the ripped waste paper (just enough to soak).
4. Make the papers into a mash (like stamp mielies).
5. Once mashed, if you have saw dust, add 3x 1kg yoghurt containers of sawdust.
6. Mix properly.

Part 3

1. Now you need to press the water out of the mash.
   i) If using a pressing machine, only half compress (do not press all water out)
   ii) If using your hands or a tin, press out as much as you can
2. Put in a well-ventilated and sunny area to allow drying.
3. Do not store the firebricks until they are completely dry.

100 g of waste paper = 1 firebrick

Discussion

The firebricks in all of the five experiments were made using a 100g of waste paper for every firebrick. In the first experiment, a total of 3000g of waste paper was used. This is all the paper from all the materials used. In all the experiments, the firebricks of the same material were made on the same day and left out to dry for the same amount of time when it was possible.

The control firebricks were made using the old method. These firebricks were fully compressed and were made using only egg cartons and newspapers with saw dust. The firebricks did not burn well and some were smoking instead of burning and therefore needed to be relit or to be fanned. The time that each burned varied from 06:56-10:02(minutes). Only two of the firebricks boiled water and the water boiled just when the firebricks were about to go out. The temperatures that the water got to for the three firebricks that did not boil water were 51, 57 and 67 degrees Celsius.

In the first experiment, 5 five firebricks were made from each of the 6 different types of materials. This was the only experiment were the firebricks of all the different materials were not made on the same day but the firebricks from the same materials were made on the same day. The firebricks were then burned once all got dry, the best burning firebricks were those made out of food wrapping. Four of the food wrapping materials boiled water with 3 of the cereal boxes boiling water. These two types of materials were in for the next experiment. The newspapers, egg cartons and cardboard boxes firebricks boiled two kettles of water each and the temperature that the water got to had to be looked at to determine the third material that was to be used with the cereal boxes and food wrapping materials in the next experiment. The egg cartons had the highest temperature and were therefore used in experiment 2. Only one of the firebricks made from office paper boiled water. Potato bags were excluded from the experiment because they do not easily get wet.
The second experiment had only five fully compressed firebricks to be made using the top 3 promising materials from the first experiment. The burning time of each of the firebricks ranged from 04:45- 08:01 (minutes). Only two of these firebricks boiled water and the ones that did not boil water got the water to reach temperatures of 66, 79 and 88 degrees Celsius. These firebricks did not burn any better than most of the firebricks made in the first experiment.

The third experiment compared the fully compressed firebricks and half compressed firebricks made from the promising materials from the first experiment. The fully compressed firebricks did not burn that well and also needed to be relit at some time. The average burning time for the fully compressed firebricks was 07:30 minutes and for the half compressed firebricks it was 05:36 (minutes). The half compressed firebricks boiled four kettles of water and the one that did not boil got to 81 degrees Celsius. The fully compressed firebricks boiled two kettles of water and the water that did not boil got to temperatures of 51, 64 and 84 degrees Celsius. This therefore meant that the half compressed firebricks were more efficient than the fully compressed firebricks.
With the fully compressed firebricks most of the water would be pressed out and used on the compost. With the half compressed firebricks, half of the water was be left in the brick and so lost to the atmosphere. Also, the half compressed firebricks take longer to dry than the fully compressed firebricks but burn much better.

Experiment four and five compares half compressed firebricks with fully compressed large bricks that one of the community groups made. Cardboard boxes were excluded from the experiment as they can be used directly with the firebricks in the fuel-efficient stoves. The experiment was to test whether all the materials used in the first experiment can be combined and used to make firebricks. The materials were torn up and divided up into equal proportions of 300g each. These made a total of 15 firebricks were 5 half and fully compressed firebricks were made. The fully compressed firebrick large firebricks did not boil any water and smoked and went out a lot. This showed that size does have an effect on the burning of the firebricks, especially when the firebrick is large and compressed. The air flow becomes almost impossible and the firebricks will therefore not burn. The half compressed firebricks boiled two kettles of water and the water

that did not boil got to temperatures of 67, 79 and 80 degrees Celsius. The fully compressed got to temperatures of 49, 50, 51, 59 and 65 degrees Celsius.
Although the half compressed firebricks using only food wrapping, cereal boxes and egg cartons from the second experiment were more efficient, NaDEET was forced to make firebricks from all waste paper except office paper and cardboard boxes. This was because the truck that took the waste for recycling to Windhoek stopped doing so and it was better to use most of the waste paper for direct recycling at NaDEET. The office paper was excluded for the reason that it is too fine and it makes the firebrick too compact and therefore these firebricks did not burn well.

During one of the visits with the community group, tests were done to determine how much water a given amount of firewood, cheetah blocks and firebricks could heat. The fuel sources were used in different fuel efficient stoves. The gas stove was also tested as to how long it took to boil 2 litres of water. There was open fire, fuel-efficient stove with cheetah blocks, fuel-efficient stove with firewood, fuel-efficient stove with firebricks and a gas stove. The results show that the fuel-efficient stove with firewood was efficient as it has boiled 2 litres of water in 04:30 followed by the fuel efficient stove with firewood at 05:00 minutes. The firewood was faster than the firebricks by 30 seconds. The firebricks were also almost twice as an open fire and gas stove. This proves that the firebricks are indeed efficient and can be used as an alternative for firewood.

A recipe that works best was created and can be used to make firebricks. The firebricks can therefore be used instead of firewood and trees are saved in that way. This recipe was introduced to schools and community groups that visited NaDEET. The purpose of the project was explained to all the groups that visited NaDEET and the results were discussed and explained to the group but this was done according to when the group came and how far I was with the project when these groups came. The school children also made firebricks during their visit that way a practical was done and much was learned through the making of the firebricks.

Conclusion and recommendations

The results show that the aims and objectives of the study were achieved and the firebricks can be used as an alternative for firewood as they do work. Firebricks can be recommended to people to use and that way the trees are saved. As shown in the efficiency test, firebricks are faster than some of the cooking fuel-sources that most people use. The half compressed firebricks are good and would work best as according to American chimneys “firebricks work best when air is left between the firebricks”.

I would recommend that in future if someone is to do a project on firebricks that more help is offered in shredding the papers. The shredding of the papers takes up the most time and it really would be helpful if other people helped with this.

Acknowledgements

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