INVESTIGATING THE EFFICIENCY OF FUEL-EFFICIENT STOVE USE AT NaDEET CENTRE

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1. INTRODUCTION

There is concern about the use of different types of stoves and fuels used to prepare food or boil water for domestic use. In Namibia, people use many different stoves and fuel types that range from the simplest and common open fire, using fire wood as source of fuel, to more modern electric stoves and electric kettles. The choice of stoves mainly depends on affordability and safety, however, most people know little about the fuel-efficiency of these stoves.

The study at Namib Desert Environmental Education Trust (NaDEET) tested different types of fuel-efficient stoves as well as the type and amount of fuel needed to cook or boil water within a given period of time.

Simple fuel-efficient stoves are made from recycled paint drums and wire. The fuel-efficient stove allows the user to better capture the energy from a smaller amount of fuel. This technology can cook food quicker and cheaper than an open fire, gas or electricity (Brown, 2010). According to Keding (2009), energy is wasted when one uses an open-fire, because much of the heat produced escapes. By using a fuel-efficient stove, the heat is trapped around the pot. Therefore, less firewood or other fuel source is needed to cook food. In addition, fuel-efficient stoves reduce deforestation, mitigate climate change and reduce health hazards to users.

The research project presented below shows the comparison of different types of fuel-efficient stoves made of different materials.

2. STUDY AREA

NaDEET is a Namibian Trust established in 2003, located 100 km south of Sesriem/ Sossusvlei on the NamibRand nature Reserve (Figures 1 and 2) in the Hardap Region. It is the largest private nature reserve in Southern Africa and borders on the Namib-Naukluft Park. Animals found in the vicinity of NaDEET includes the Gemsbok (*Oryx gazella*), Springbok (*Antidorcas marsupialis*) and a few nocturnal animals such as the Four-striped Grass Mouse (*Rhabdomys pumilio*), Hairy footed Gerbil (*Gerbillurus paeba*), Grant's Golden Mole (*Eremitalpagranti namibensis*), Bat-eared Fox (*Otocyon megalotis*), Striped Polecat (*Ictonyx striatus*) and Cape Porcupine (*Hystrix africaeaustralis*) (Ehrenbold and Keding, 2010), as well as birds such as Sociable Weavers (*Philetairus socius*), Scaly feathered Finch (*Sporopipes squamifrons*), Dune Lark (*Calendulauda erythrochlamys*) and Southern Pale chanting Goshawk (*Melierax canorus*) (Chittenden 2009). The common species of flora are the Camel-thorn Tree (*Acacia erioloba*) and Smelly-Shepherd's Bush (*Boscia foetida*) (Mannheimer and Curtis, 2009). NaDEET Centre (Figure 1) offers week-long programmes for schools, youth, educators and adult groups in the Namib Desert. The groups include community groups, primary and secondary schools within the Karas, Hardap and Khomas Regions. The programme aims to engage participants in sustainable living through first-hand learning and living experiences. Activities include solar cooking, water monitoring and saving techniques, and exploration of the Namib's biodiversity and dune landscape. Since the Centre was established in 2003, it has received over 5000 visitors (Keding, Personal communication 2011).

Figure 1: NaDEET Centre (Photo: NaDEET Photo Library)

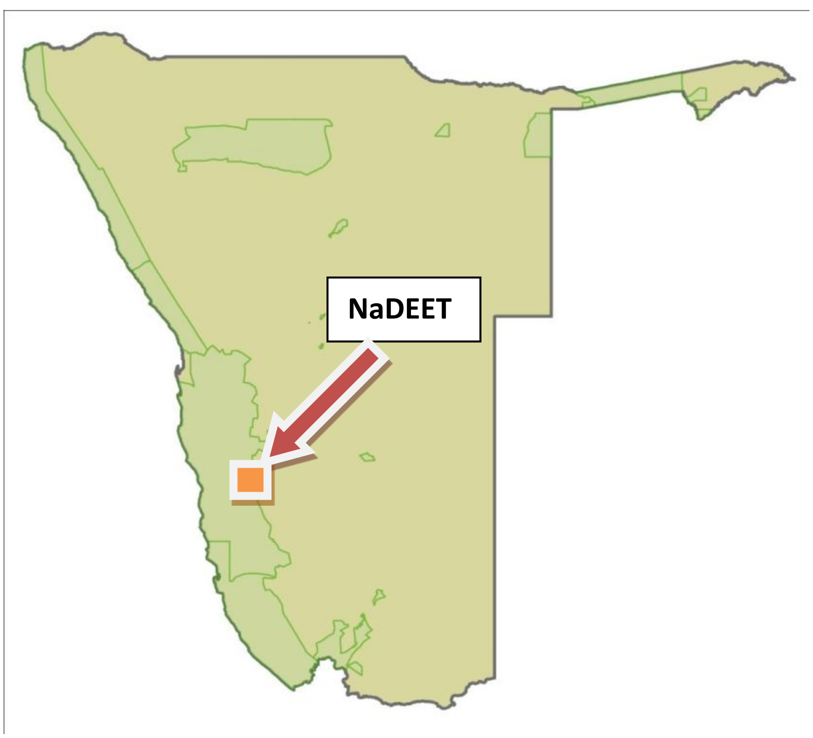

Figure 2: Map of Namibia with NaDEET within NamibRand Nature Reserve (Credit: Theo Wassenaar and Absalom Vilho)

3. PROJECT OBJECTIVES

3.1 To compare and determine the best type of fuel-efficient stove.

3.2 To compare and determine the best types of fuel used in the fuel-efficient stoves.

3.3 To determine the amount of fuel needed for optimal efficiency.

3.4 To improve fuel-efficient stove use at NaDEET Centre and within communities.

4. MATERIALS AND METHODS

4.1 Comparison and determination of the best type of fuel-efficient stove

The aim was to compare different types of fuel-efficient stoves made of different materials. Old paint drums were used to make a home-made fuel-efficient stove. The home-made stove was made as follows:

- A 20 litre empty paint drum was used
- Holes at about 5cm above the base of the drum were made around the drum for air circulation.
- Six more holes at 2cm above the air circulation holes were made for inserting strong wires crisscrossed across each other. These wires were for holding fuel while burning.
- A rectangular hole of 12cmx 8cm was cut at 15cm above the base as a space for putting the fuel in.
- Four holes were made at 30cm above the base to hold metal rods where the pot/kettle sits.
- Metal shears, a pair of plier, nail, hammer, 3mm thick wires and measuring tape were used to make one home made fuel-efficient stove (Figure 3).

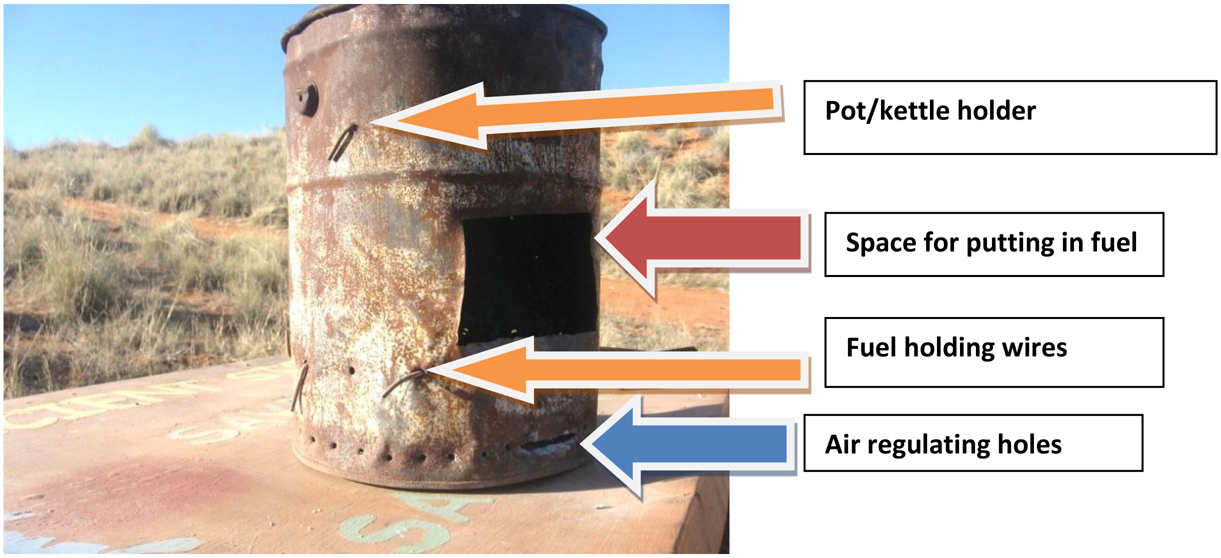

Figure 3: Home-made fuel-efficient stove (Photo Vilho)

A Comparison between 4 different types of fuel-efficient stoves was made. These were:

- the home-made stove (Figure 3)
- Vesto stove (Fig 4)
- Fuel-efficient stove made of fire-resistant bricks (Figure 5), and
- The recently developed Ezy stove.

A standard amount of 100 grams of fuel was used in each stove to determine how long it took for each stove to boil a litre of water. The same experiment was repeated using 200 grams of fuel in order to determine how much fuel is needed for each stove to heat efficiently. This method helped to determine the best stove.

The best stove was determined based on the shortest period of time it took and the smallest amount of fuel used to boil a litre of water. This experiment was as far as possible carried out at the same time of the day and under similar weather conditions, i.e. on a cool and calm afternoon rather than on a windy, foggy, hot or cold day which might delay or speed up heating times.

This method was also applied for objectives 4.2 and 4.3 below. In order to determine the best-performing stove, this study also focused on the usability of the different types of stoves, i.e., how user-friendly each stove was; how long it could be used; and how portable it was. The project aimed to find the least expensive, yet most fuel-efficient stove and to give guidelines to potential user on how to use the stoves most efficiently.

Figure 3: Home-made fuel-efficient stove (Photo Vilho)

Figure4: Vesto Fuel-Efficient Stove (Photo: Vilho).

The materials used to conduct the experiments to test the efficiency of the different fuel-efficient stoves are summarised in Table 1.

Table 1 Materials used for the experiment to test the efficient

Materials	**Use**
1. A pair of Pliers	Bend wires in the construction of the homemade fuel-efficient stove
2. Hammer	To punch a nail into a stove
3. Nails	To create ventilation holes around the home-made fuel-efficient stove with
4. Metal shears	To cut out the space for putting in fuel
5. Kitchen scale (grams)	To measure all the fuel to be used in the experiment in grams
6. Matches	To start a fire
7. NaDEET's recycled fire bricks	Source of fuel
8. *Prosopis* firewood	Source of fuel
9. Scrap wood off-cuts	Source of fuel
10. CCF Cheetah Blocks	Source of fuel
11. Tape measure	To measure the space in-between holes
12. Starter (2 pages of newspaper)	Start the fire
13. 4 litre aluminium Pot	To boil water
14. water	For the experiment

15. Stop watch Timer	To measure the time
16. Mercury Thermometer	To measure water temperature

Figure 5. Resistant fire-brick stove (Photo Absalom Vilho)

Figure 6. Kitchen scale (Photo: Laura Pietrasch)

4.2 Comparison and determination of the type of fuel used in the fuel-efficient stove

The different fuel types tested were weighed (in grams) on a kitchen scale (Figure 6). For each fuel type 100 and 200 grams of different fuel were used in all the stoves at the same time. Water kept in a fridge at 12 ° c was used for all experiments. All experiments thus started with water of exactly the same temperature. The alternative fuel sources compared were: NaDEET's recycled firebricks, scrap wood off-cuts, *Prosopis* firewood and CCF Cheetah Blocks. A stopwatch was used to count how long each fuel source took to boil water in each type of fuel-efficient stove using the same type of pot and under the same weather conditions. A thermometer was used to measure water temperature changes after every one minute.

4.3 Determination of the amount of fuel needed for optimal efficiency

After identifying the best fuel source, the amount of this fuel needed to cook or boil water was then determined and therefore recommended. The fuel which took the shortest amount of time to boil a litre of water was determined to be the best fuel.

4.4 Improvement of fuel- efficient stove use at NaDEET Centre and within Communities

Improved usage of fuel-efficient stoves at NaDEET Centre has been made based on the outcomes of this study. A presentation of this study was also made to NaDEET staff and a poster is currently being designed to display at NaDEET Centre in order to create awareness to all the groups that come to NaDEET for environmental education programmes.

5. RESULTS

It was found that almost all stoves performed well with 200 grams of fuel, especially using the scrap wood and recycled firebricks. The boiling temperature at NaDEET is 93°C not 100°C. This is because NaDEET is 1000m above sea level.

Table 2 below shows the comparisons between the different stoves, using different types of fuels.

Table 2: Comparison of stove type with various fuel types (100g and 200g)

Stove type	**Fuel type**	**100 grams**		**200 grams**	
		Temperature in °c	**Time in minutes**	**Temperature in °c**	**Time in minutes**
Brick stove	*Prosopis*	44°c	11	73°c	20
Brick stove	Bush blocks	51°c	10	64°c	16
Brick stove	Scrap wood	51°c	8	90°c	12
Brick stove	firebricks	49°c	9	70°c	11
Ezy stove	*Prosopis*	73°c	7	93°c	10
Ezy stove	Bush blocks	66°c	8	91°c	11
Ezy stove	Scrap wood	60°c	9	93°c	8
Ezy stove	Firebricks	60°c	8	93°c	14
Homemade stove	*Prosopis*	60°c	11	70°c	14
Homemade stove	Bush blocks	68°c	16	88°c	11
Homemade stove	Scrap wood	63°c	8	93°c	12
Homemade stove	Firebricks	62°c	9	91°c	13
Vesto stove	*Prosopis*	76°c	10	93°c	11
Vesto stove	Bush blocks	92°c	9	93°c	5
Vesto stove	Scrap wood	93°c	5	93°c	4
Vesto stove	Firebricks	87°c	7	93°c	8

Table 3: list of stoves and fuels (various amounts) that reached boiling

Stove type	**Fuel type**
Vesto stove	Scrap wood (100g)
Vesto stove	*Prosopis* (200g)
Vesto stove	Firebricks (200g)
Vesto stove	Scrap wood (200g)
Vesto stove	*Prosopis* (200g)
Ezy stove	Bush blocks (200g)

Ezy stove	*Prosopis* (200g)
Home made stove	Bush blocks (200g)

Experience and the cost of the four stoves were than used to compare the affordability, usability lifespan and portability of each stove. The results are summed up in Table 4.

Table 4: Comparison of affordability, usability, lifespan and portability of the different stoves.

Stove Type	Affordability	Usability	Lifespan	Portability
Ezy stove	Expensive	Need instructions on how to use it.	Depends on the user's care.	Heavy to move it.
Brick stove	Expensive	You don't need instructions to use it	Depends on the user's care.	It can not be moved.
Vesto stove	Expensive N$550	It's not easy to operate; you need instructions on how it works.	Depends on the user's care.	It can be moved.
Home made stove	You don't buy it	You don't need instructions to use it.	5-6 years.	It can be moved.

Figure 7 and 8 shows the difference in the amount of fuel used in the fuel-efficient stove made of fire resistant bricks.

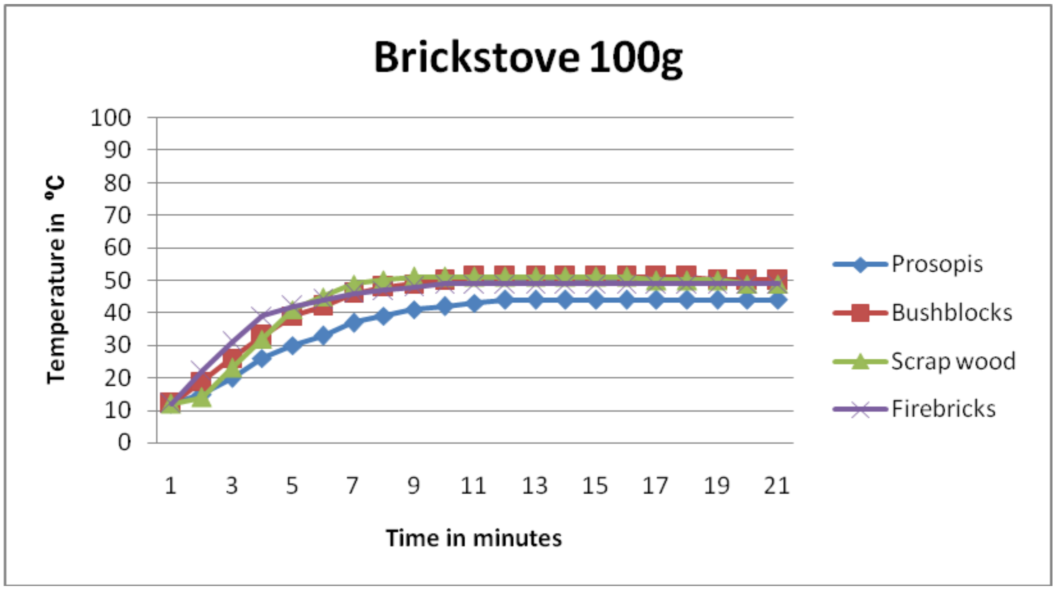

FIGURE 7: Brick stove with 100 grams of fuel

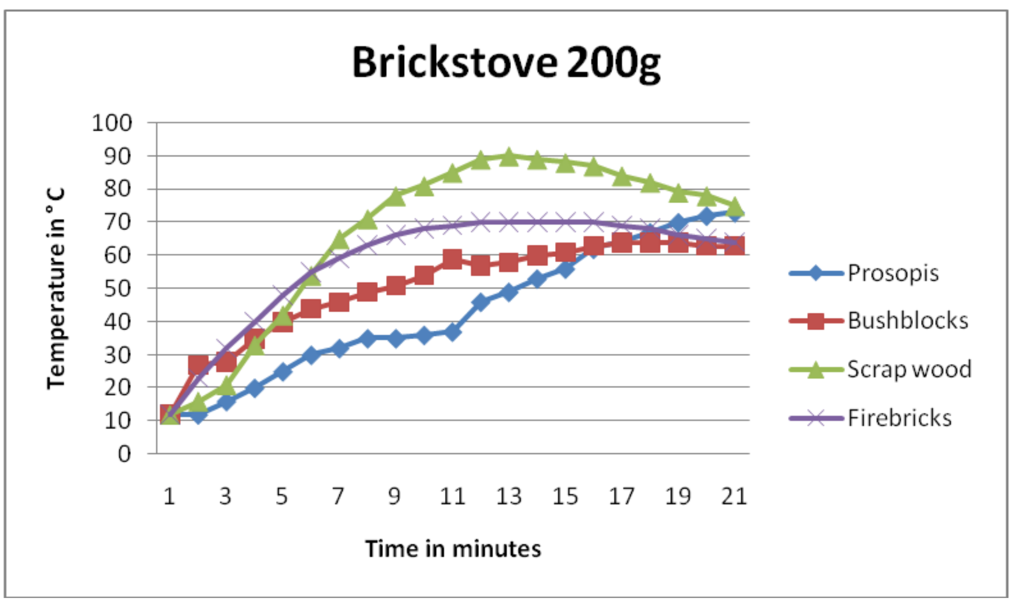

FIGURE 8: Brick stove with 200 grams of fuel

It shows that 100 grams of all four types of fuel heated one litre of water up to 50 ° c and stayed constant. With 200 grams (especially the scrap wood and recycled firebricks) water temperature went up to 90 ° c using scrap wood and 70 ° c using recycled firebricks. However, *Prosopis* wood also heated water up to 70 ° c only after all the fuel has been used up and only coal remaining, while bush blocks kept water temperature constant in the last 5 minutes.

Figure 9 and 10 compares the difference in water temperature using different amount of fuel.

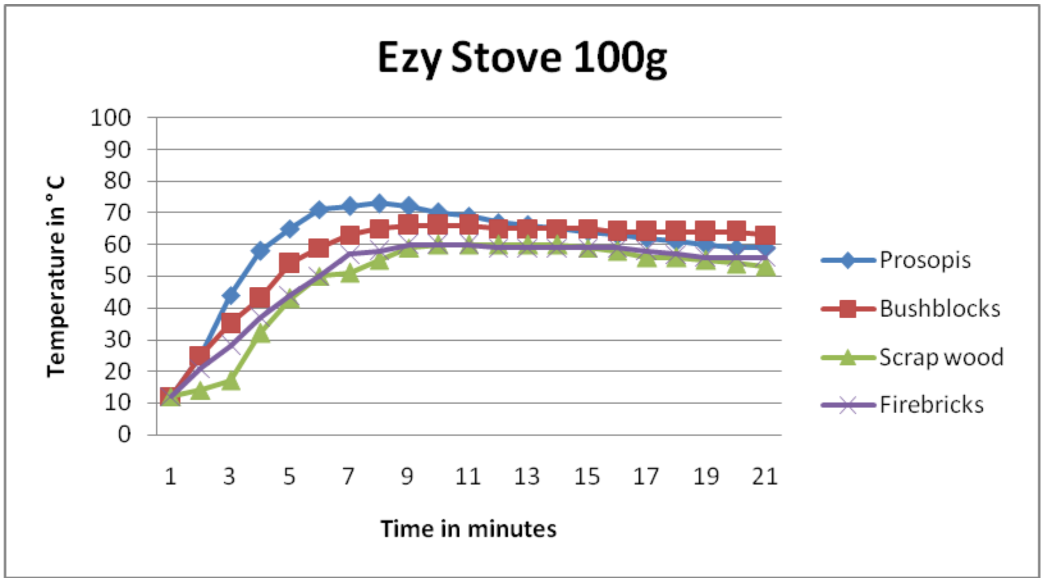

FIGURE 9: **Ezy Stove with 100 grams of fuel**

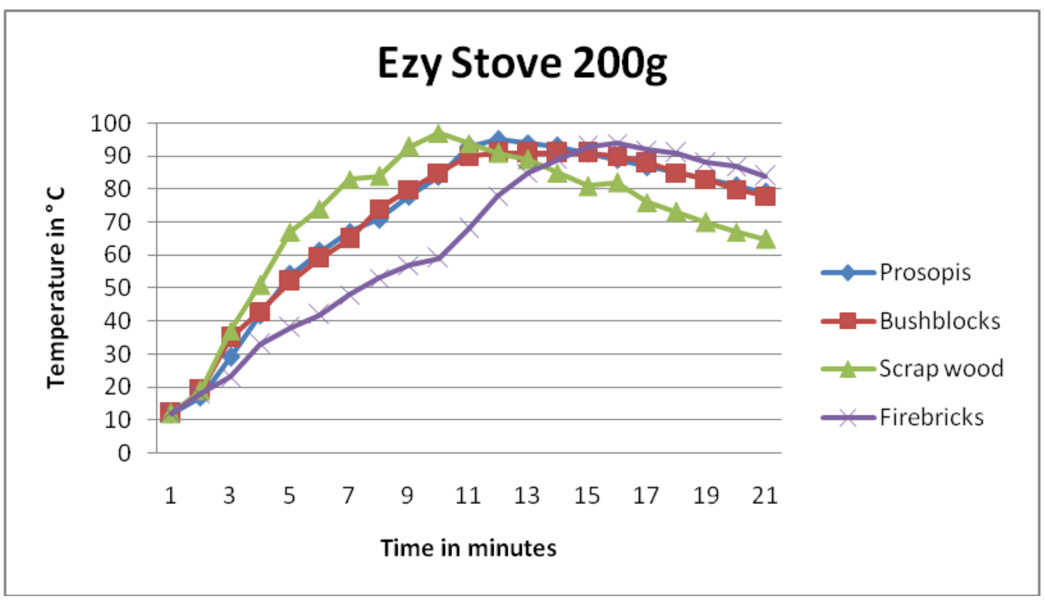

FIGURE 10: Ezy Stove with 200 grams of fuel

Using 100 grams of fuel, only *Prosopis* wood heated water up to 73 ° c while Bush blocks kept water temperature constant for almost 10 minutes and recycled firebricks and scrap wood were almost the same at all time (Fig 9).The Ezy stove boiled water with 200 grams of three types of fuel except 200 grams of bush blocks which almost boiled water (Fig 10).

Figure 11 shows 100 grams of fuel used in a homemade stove

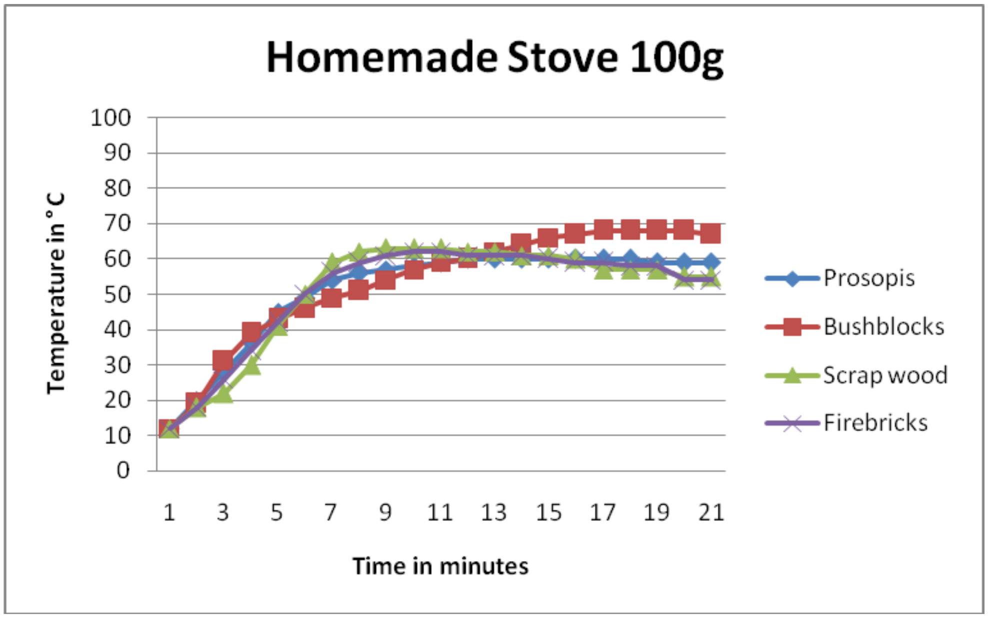

FIGURE 11: Home-made Stove with 100 grams of fuel

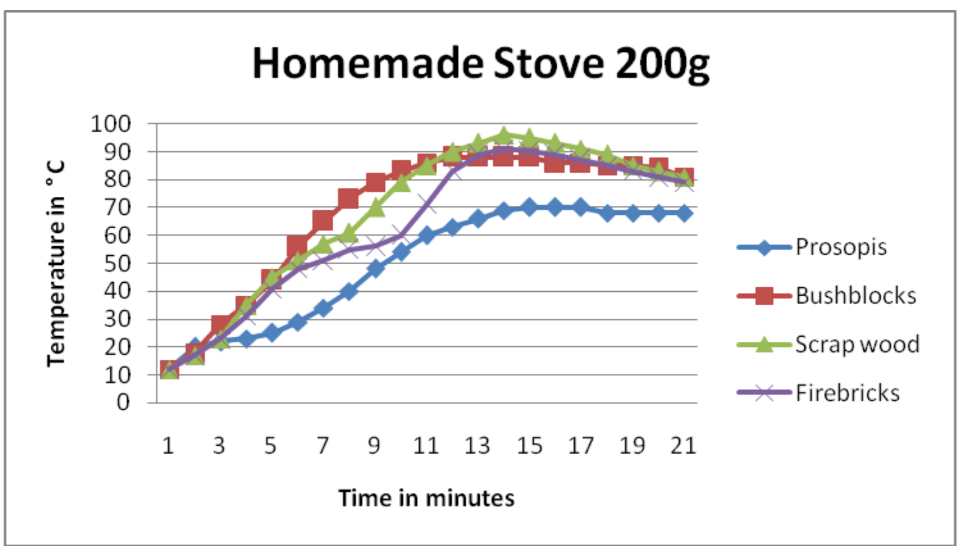

FIGURE 12: Home-made Stove with 200 grams of fuel.

Three fuel type kept water temperature constant except for Bush blocks were water temperature went up to 69 ° c after a long period of time. However 200 grams of scrap wood in a Homemade stove boiled water in 13 minutes while Bush blocks and recycled firebricks kept water temperature constant after 13 minutes (Fig 11).

Figure 13 and 14 shows the rapid increase in water temperature boiled on a Vesto stove with different types and amounts of fuel.

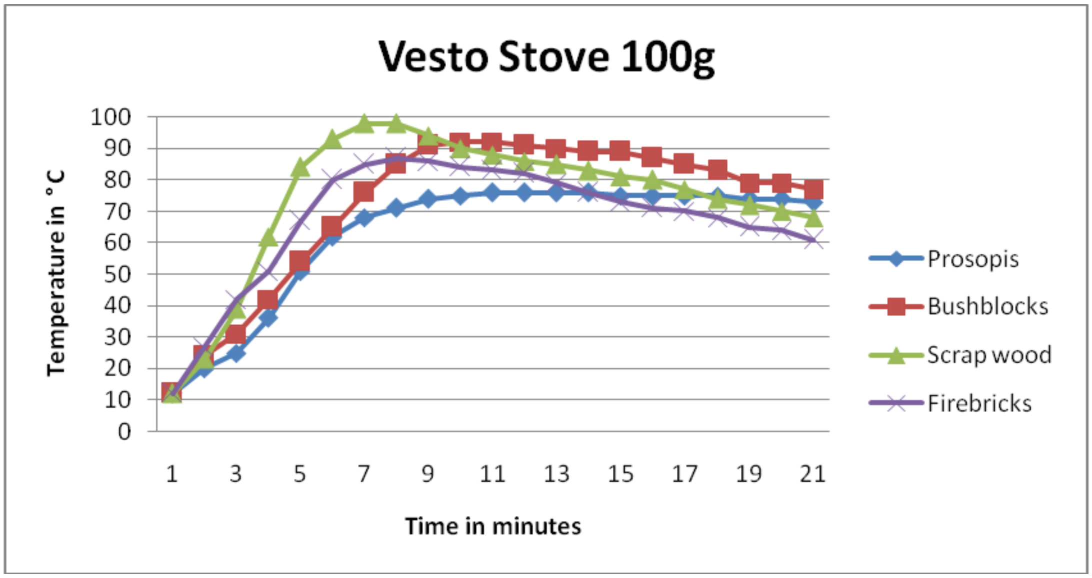

FIGURE 13: Vesto Stove with 100 grams of fuel

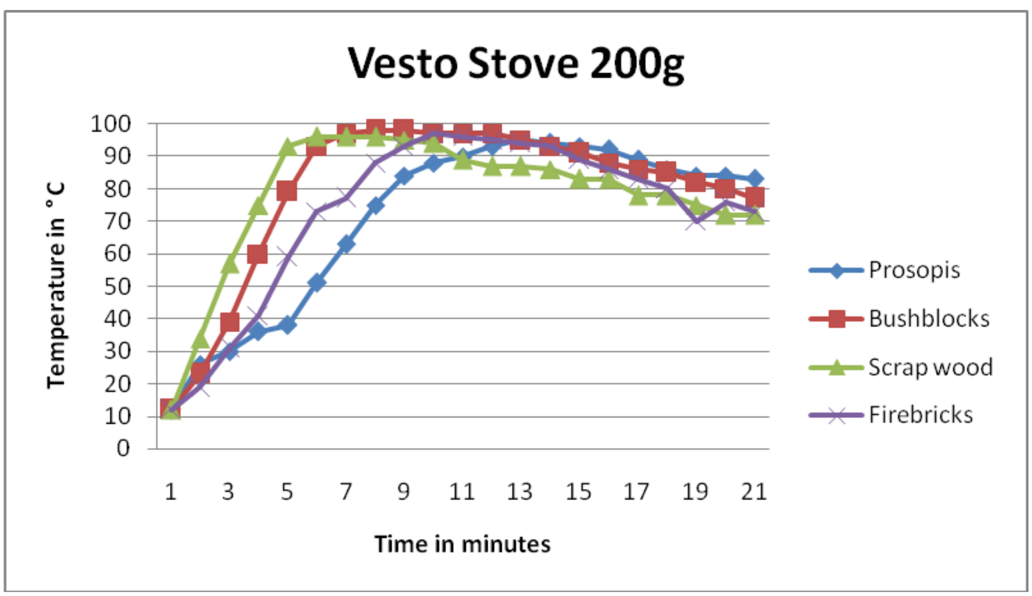

FIGURE 14: Vesto Stove with 200 grams of fuel.

The Vesto stove seems to be the best of all the stoves with regards to the type and amount of fuel used. 200 grams of all fuel types boiled water, with scrap wood being the fastest boiling water in 4 minutes, followed by Bush blocks, recycled firebricks, *Prosopis* which boiled water only after 15 minutes.

6. DISCUSSION

This study shows that the Vesto stove is the most efficient stove since it required not more than 200 grams any of the four types of fuel used in the experiment to boil a litre of water. However, since this study was not only looking at the efficiency of stoves but also the affordability, usability and portability of the stoves, it was found that although the Vesto stove is the most efficient stove, it is not affordable to many people in Namibia, it is also not that easy to work with in order for it to be efficient. One need to know exactly how to operate it.

The home-made stove was found to be the second most efficient stove. As the home-made stove was found to be easy to make and replace once it is worn out, this made it the most efficient stove in the study. Replacement of this stove is due to the wearing out of wires which are burned every time the stove is used. The materials are easily found and do not need to be purchased. The stove is user- friendly and it is portable. From all the fuel types used in the home made stove, it showed that it only needs an addition of a small amount of fuel above 200 grams to boil a litre of water. The 200 grams of scrap wood seemed to perform the best. This could be due to the fact that scrap wood was all pine which burns and makes coals quickly.

Bush blocks are not a good source of fuel as they can only catch fire faster when you use Blitz rather than a simple starter such as newspaper or twigs. Therefore, this study does not recommend Bush blocks as a good fuel source.

It was also found that the Ezy stove and the Brick stove were not that efficient and therefore require improvements. The Ezy stove is a recently developed stove and this study suggest it needs further refinement as it is more like an open fire at the moment. Furthermore, the design of the Ezy stove is not easy for everyone to make. The materials the Ezy stove is made up of are not easy to find and can be expensive.

Brick stoves have a wide burning chamber and therefore use more fuel. Additionally, not everyone can afford to buy bricks, cement to construct it.

Figure 7 and 8 shows the difference in the amount of fuel used in the fuel-efficient stove made of fire resistant bricks. It shows that 100 grams of all four types of fuel heated one litre of water up to 50°c and stayed constant. With 200 grams (especially the scrap wood and recycled firebricks) water temperature went up to 90°c using scrap wood and 70°c using recycled firebricks. However, *Prosopis* wood also heated water up to 70°c only after all the fuel has been used up and only coal remaining, while bush blocks kept water temperature constant in the last 5 minutes.

The Ezy stove boiled water with 200 grams of three types of fuel except 200 grams of bush blocks which almost boiled water (Fig 10). Using 100 grams of fuel, only *Prosopis* wood heated water up to 73 ° c while Bush blocks kept water temperature constant for almost 10 minutes and recycled firebricks and scrap wood were almost the same at all time (Fig 9).

Figure 11 shows 100 grams of fuel used in a Homemade stove with three fuel type kept water temperature constant except for Bush blocks were water temperature went up to 69 ° c after a long period of time. However 200 grams of scrap wood in a Homemade stove boiled water in 13 minutes while Bush blocks and recycled firebricks kept water temperature constant after 13 minutes (Fig 11).

The Vesto stove seems to be the best of all the stoves with regards to the type and amount of fuel used. Figure 12 and 13 shows the rapid increase in water temperature boiled on a Vesto stove with different types and amounts of fuel. 200 grams of all fuel types boiled water, with scrap wood being the fastest boiling water in 4 minutes, followed by Bush blocks, recycled firebricks, *Prosopis* which boiled water only after 15 minutes.

7. CONCLUSION

In summary, this study answers the question as to what makes a stove a fuel-efficient stove, the amount of fuel needed in a stove to cook something, and also the usability, affordability and how accessible the stove is, or the materials needed to make one are. The results show that the Home-made fuel-efficient stove is indeed the most efficient stove, since it is easy to make and replace once it is worn out. This study also makes suggestions on the improvement needed to the newly developed Ezy stove.

8. RECOMMENDATIONS

During the study experiments, one fuel type used a different type of starter than the other three fuels used. This is due to the fact that the Bush blocks were so hard that they did not burn easily using two newspaper pages as the starter (which was the main starter method and material used for this study). It was decided to use Blitz as starters for the Bush blocks only and it turned out that Bush blocks produced good and strong coals after it has burned out, making it work best in a stove like the Vesto stove. This is because the coals hold heat for a long time. The results would have been better if all variables were constant throughout the study.

The stoves made out of resistant fire bricks at NaDEET need to be improved as the burning chamber is too wide encouraging a user to put in more fuel, and the heat is spread out instead of being concentrated. NaDEET staff should continue using both Vesto and the Home-made stove. Everyone should know exactly how the Vesto stove works and pass on this knowledge to anyone who comes to NaDEET.

9. ACKNOWLEDGEMENTS

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