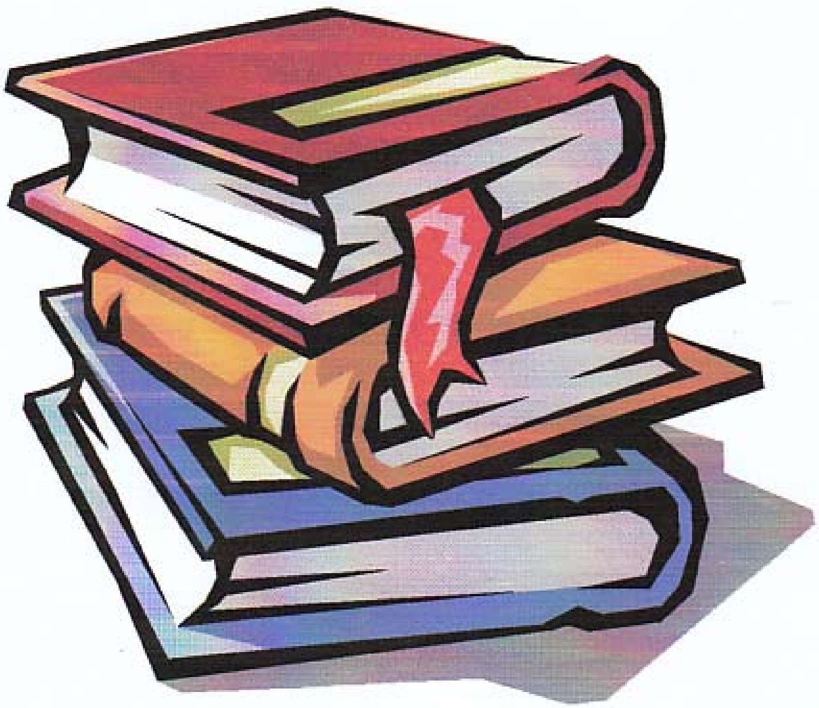
Greywater Recycling

''Greywater can be defined as any domestic wastewater produced, excluding sewage''.



''Our quest to achieve an equilibrium in nature will only be met if we gradually explore ways of living that are not detrimental to the environment''. (Simangolwa,B)

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INTRODUCTION

The Namib Desert Environmental Education Trust (NaDEET) was formed in 2002 with the aim of providing non-profit environmental education in order to empower Namibian youth for a sustainable future. The centre's approach towards education is two-fold i.e. sustainable living and biodiversity education, whereas conservation is a crosscutting topic through out the programme. The sustainable living curriculum includes the use of renewable energy sources such as the sun (solar energy), ways to save water and waste management. Biodiversity entails taking learners out for a practical experience of the desert and teaching them about the wildlife, plants and how they have changed (adapted) to survive in the desert. The centre has also adopted a learner centred method of education where learners are actively involved and are encouraged to participate.

The centre would like to minimize the water use by reusing wastewater from the kitchen and showers to irrigate a vegetable garden. Greywater from the kitchen and showers was used to irrigate tomatoes for the pilot project. This was done to determine the feasible impacts the water might have on the plants and to seek a biological or environmentally friendly manner of cleaning the wastewater. About 90% of the wastewater produced at the centre is from the shower and the kitchen. This water contains little or no pathogens and nitrogen than black water (toilet water). Because of this, it requires 90% less treatment (http://www.health.wa.gov.au.). Some of the benefits that will be achieved from using greywater is that the centre will expand on its concept of waste recycling. The centre also aims to provide the visitors with homegrown vegetables and cut on its running costs. Similar ventures have proved beneficial at tourist establishments such as Swakopmund Bungalows (Schachtschneider *et al*. n.d.).

Study area

NaDEET is located within the NamibRand Nature Reserve, a 100 km south of Sesriem in the Hardap region. The reserve is located in the desert and specifically in the semi desert and savannah biome (Giess, 1998). The most important climatic feature of the desert is its sparse and highly unpredictable annual rainfall. In this area fog is rare and the mean annual rainfall increases from 50 mm to a maximum of 85 mm in some places (Lovegrove, 1993). Temperature variations between day and night are extreme in this part of the desert. Daily and seasonal temperatures increase sharply and become highly variable, with temperatures of below 0° and above 45°C recorded at some locations (Lovegrove, 1993).

The flora consists mostly of sparsely distributed *Acacia erioloba* trees on flat gravel plains, in the sand dunes; grasses such as *Cladoraphis spinosa* and *Stipagrostis* spp. are common. Certain desert adapted plant species are also found within this area. These include *Euphorbia* and *Aloe* species on rocky outcrops on these plains *(Pers. obs*).

The fauna consist of a small number of species of ungulates and variety of reptiles, some of which are endemic to the Namib Desert. Most evident are the larger ungulates such as the gemsbok (*Oryx gazella*), springbok (*Antidorcas marsupialis*) and kudu (*Tragelaphus strepsiceros*). Hartmann's zebra (*Equus zebra hartmannae*) can also be seen in some areas on the reserve. Other mammals include Grant's golden mole (*Eremitalpa grantis*), which is near endemic to the Namib Desert, its range extending into South Africa. This area also boasts a wide variety of species of beetles. The Namib Desert is best known for its high species richness of beetles, particularly those belonging to the family Tenebrionidae (Lovegrove 1993). Several endemic reptiles, including two desert lizards, the wedge-snouted sand lizard (*Meroles cuneirostris*) and the small-scaled sand lizard (*M. micropholidotus*), the barking gecko (*Ptenopus kochi*) and the day gecko (*Rhoptropus bradfieldi*), also inhabit this area.

The most common bird found in this area as its typical of the desert is the ostrich (*Struthio camelus*). Other bird life includes the dune lark (*Certhilauda erythrochalamys*) and Rüppell's korhaan (*Eupodotis rueppellii).*

Another unique and curious feature of the Namib Desert, the fairy circle, are spread out in the open plains on the reserve. The origin of these circles has generated interest and speculation for centuries (Lovegrove, 1993).

AIMS AND OBJECTIVES

Aim:

- To determine the viability of recycling wastewater from the kitchen and showers (greywater) and to reuse it to water a vegetable garden.

Project objectives

- To compare the difference (dissolved substances) between the different types of greywater.
- To determine if and how the different water types affects the growth (plant and fruit growth, fruit number etc.) of plants.
- To determine a low-cost, environmentally appropriate method that can be used to clean the wastewater.

Personal objectives

- To gain experience with regard to wastewater management.
- To gain more information on how different factors in the ecosystem function interdependently.
- To advance my skills on data collection and analysis.
- To do research and make recommendations based on results.

METHODS AND MATERIALS

Methods

- **To compare the difference (dissolved substances) between the different types of greywater:**

  This is necessary because biodegradable soap is used in the kitchen while in the showers the visitors use a variety of scented detergents. Hypothetically it is believed that the scented products used in the showers, e.g. shampoo, will have harmful effects on the growth of plants and the biodegradable products used in the kitchen will have lesser effects. This water however does accumulate fat and oils from the food. Though it passes through a fat trap before it drains into a tank, it is assumed that not all the fats and oils are filtered out of the water. Therefore the fats and oils in kitchen greywater are also expected to influence the growth of plants. Six samples of the greywater, two unfiltered and four samples filtered were sent to the laboratory for a conductivity test, which is basically a measure of dissolved salts in the water. It was also assumed that high content of salt in the water would potentially have adverse impacts on the plants.

  The other method was to plant tomatoes and irrigate the plants with the different types of greywater, and thereafter have people taste the fruits and develop a scale to evaluate the taste. The fruits would be graded on a scale of one to ten, with one being soapy and ten the normal taste. Initially seeds were planted into yoghurt containers, 3 mm below the soil surface, and watered with the different types of greywater. Later when the seedlings were large enough, they were transplanted into large plots made in old car tyres. In total 7 plots were made for this purpose, two for unfiltered greywater, four for filtered greywater and one control plot. The control plot was watered with clean drinking water and this is the same water used in the kitchen and for showering. The control plot would serve as a benchmark on which all the other plots would be evaluated against. Three plants were put into each tyre, 20 cm apart, and were watered every other day. A 100 ml of water was applied to each plant per treatment. The same amount of compost, shade and soil were also provided for every plant. The plots were made in an enclosure completely covered by shade cloth to reduce water loss from the soil and plants. The density of the shade cloth was 80%. The density of shade cloth recommended for growing plants is between 40% and 60% (*pers. comm.*). A total of 5 persons were likely to taste the fruits and evaluate the taste on the given scale.

- **To determine if and how the different water types affects the growth (plant and fruit growth, fruit number etc.) of plants i.e. the possible effects of greywater on plants:**

The potential effects of the greywater on the plants were evaluated by looking at the growth, number and weight of fruits and whether the plants were struggling or not (physical growth). To assess the likely effects of greywater on the growth of plants, measurements of the average length of plants, number of leaves per plot, diameter of stems and length and width of terminal leaves were collected. The data was analysed and results were compared to the benchmark. The diameter of stems was calculated using the following formula: C=Pie x d, e.g. average circumference of the stems from the plot watered with unclean shower water is 2cm.

C=Pie.d
2=3.14.d
2/3.14=d
d=2/3.14
= 0.63, round off=0.6

The measurement for the terminal leaflets was collected from three stalks in the upper areas. All the results from the measurements and calculations were rounded off to one decimal point. Photographs of the plants in the plots were also taken. The average size, weight, and number of fruits per plot would also be recorded and analysed.

- **To determine a low-cost, environmentally appropriate method that can be used to clean the wastewater:**
  A method that is perceived safe from a health point of view, cost free and not harmful to the environment was explored and used to filter the water. Using sand (dune and gravel sand) was the logical choice because it cleans the water naturally and is abundant in the area. Dune and riverbed/gravel sand were used separately to filter the greywater. It is believed that using dune sand to filter water will produce suitable results compared to using gravel sand. It was also anticipated that plants watered with filtered greywater would yield better results than the plants that were watered with unfiltered greywater. The filtered greywater was used to water plants in four of the seven plots in the garden. Another alternative was to use reeds to filter the water, but this was not feasible given the amount of time for the project and because the centre is located within a nature reserve.

Materials:

- Centrifugal pump
- Plastic containers (to filter the water)
- Tomato seeds
- Compost
- Garden house (covered by shade cloth)
- 7 Garden plots that will be watered with;
  - Greywater from the showers
  - Greywater from the kitchen
  - Cleaned greywater from the showers (two plots irrigated with water filtered by dune and gravel/riverbed sand)
  - Cleaned greywater from the kitchen (two plots irrigated with water filtered by dune and gravel/riverbed sand)
  - Control plot (watered with normal clean water)
- Dune and gravel sand
- 20 litre black drums
- Measuring jug
- Yoghurt containers

RESULTS

Table 1 Amount of dissolved salts in water in milli-siemens/cm

Water type	**Milli-siemens/cm**
Shower (unclean)	3.45
Shower (filtered with gravel sand)	3.53
Shower (filtered with dune sand)	3.73
Kitchen (unclean)	1.76
Kitchen (filtered with gravel sand)	1.96
Kitchen (filtered with dune sand)	1.89
Control	0.05-1.5 *

*http://www.health.wa.gov.au.

Table 2 Average diameters of plant stems per plot in centimetres

Type of water used to irrigate plants	**Average diameter of stalks (cm)**
Shower (unclean)	0.6
Shower (filtered with gravel sand)	0.6
Shower (filtered with dune sand)	0.3
Kitchen (unclean)	0.6
Kitchen (filtered with gravel sand)	0.3
Kitchen (filtered with dune sand)	0.6
Control	0.6

Table 3 Average lengths of plants per plot in centimetres

Type of water used to irrigate plants	**Average length of plants (cm)**
Shower (unclean)	29
Shower (filtered with gravel sand)	24
Shower (filtered with dune sand)	20
Kitchen (unclean)	31
Kitchen (filtered with gravel sand)	24
Kitchen (filtered with dune sand)	18
Control plot	36

Table 4 Average numbers of leaves of plants per plot

Type of water used to irrigate plants	Average number of leaves per plot
Shower (unclean)	77
Shower (filtered with gravel sand)	77
Shower (filtered with dune sand)	59
Kitchen (unclean)	90
Kitchen (filtered with gravel sand)	75
Kitchen (filtered with dune sand)	64
Control plot	95

Table 5 Average length and width of terminal leaflets

Type of water used to irrigate plants	Average length and width of terminal leaflets (cm)	
	Length	Width
Shower (unclean)	7	3
Shower (filtered with gravel sand)	6	3
Shower (filtered with dune sand)	6	3
Kitchen (unclean)	7	3
Kitchen (filtered with gravel sand)	6	2
Kitchen (filtered with dune sand)	7	3
Control plot	8	4

Photographs

1

1. Shower-unclean
2. Kitchen-unclean
3. Kitchen-gravel sand
4. Control
5. Shower-gravel sand
6. Kitchen-dune sand
7. Shower-dune sand

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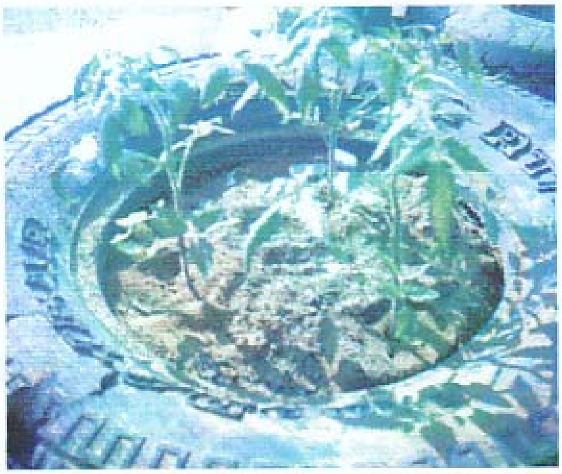

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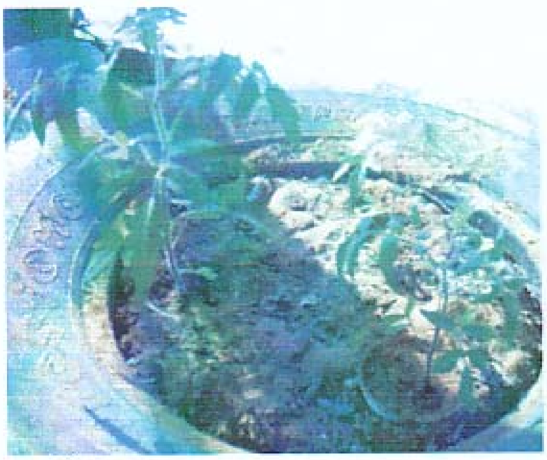

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DISCUSSION

Table 1 shows the amount of dissolved salts in the water from a conductivity test done on the samples. The results show that samples from the kitchen have a less amount of dissolved salts per centimetre compared to samples taken from shower water. This can be attributed to the scented detergents used by guests in the showers. Similar case studies have revealed that there is a build up of dissolved substances such as sodium and boron in shower greywater water as a result of the detergents (http://www.health.wa.gov.au.). In this case however, the difference is not that significant to affect the growth of plants. Filtered water from both the showers and the kitchen show an insignificant amount of dissolved salts more than the unclean greywater and this could be a result of the substances in the soil. Some salts from the soil could have been leached into the water. Compared to the quantity of dissolved salt in clean water, the disparity between greywater and clean water is not that extensive. Clean, natural water has conductivity between 0.05 and 1.5 (http://srm.www.gov.bc.ca/risc/pub/aquatic/interp-01.htm). Therefore even though greywater has slightly higher amount of dissolved salts compared to the clean water, this does not imply that it cannot be used for irrigation of plants. However, a more detailed test for irrigation needs to be done on the samples, but this is more costly. This analysis would look at all the substances, e.g. nitrogen, that is in the water and which might affect the growth of plants. Testing for conductivity does not specify whether the water is good for irrigation or not. Regrettably by the time of the report the plants had not produced fruits and therefore the taste of the fruits was not evaluated. The fruits were imperative to this study as is the current results, because without health plants you cannot have fruits.

Table 2 shows the average diameter in centimetres of the plant stems from the different plots. Plants from the plots watered with cleaned shower and kitchen greywater that was filtered with dune and gravel sand respectively had a smaller diameter on average than all the other plants. It is assumed that the difference is not correlated to the effects of the water but is normal. There is no considerable difference in the average diameter of stems between plants watered with shower and kitchen greywater as well as the cleaned water. Therefore it is assumed that there is no direct link between the diameter of plant stems and the type of greywater used for irrigation. There is a difference between the average lengths of the plants per plot, with the control plot having the tallest plants than the other plots (Table 3). This might suggest that plants watered with clean water develop more rapidly than those watered with greywater. Unclean greywater from both the kitchen and shower had the second tallest plants respectively compared to the plants from the plots with cleaned water. This may possibly mean that the substances in unclean water do not harmfully affect the growth of plants. It may perhaps also be assumed that the sand used to filter water did trap some of the nutrients from the unclean water, e.g. nitrogen and phosphorus. Such nutrients provide an excellent food source for plants (http://www.Sustainable.au/greywater.html.). Plants from the plots watered with greywater, both shower and kitchen, cleaned with dune sand showed an underdeveloped pattern of growth. The average lengths of plants in such plots were between 18 cm and 20 cm on average compared to the other plots that were between 24 cm and 36 cm on average. This could indicate that greywater filtered with dune sand can cause a underdeveloped growth in plants.

Table 4 and 5 shows the average number, length and width of leaves of plants on average from the plots. Plants from the control plot had the most number of leaves on average, followed by plants watered with unclean greywater from the kitchen (Table 4). This could possibly mean that the type of water used had reflective effects on foliage production and therefore plants watered with clean water and unclean kitchen greywater had enhanced leaf production. Plants from plots watered with greywater filtered with dune sand produced the least amount of leaves. The control plot also had the longest and widest leaves on average compared to the other plots. Few inferences can be made on the effects of greywater on the length and width of leaves of plants. Therefore it is assumed that the type of water used will not certainly affect the size of leaves. The results established that even plants watered with greywater that was cleaned with dune sand, which had an underdeveloped growth pattern, had the same length and width as the plants watered with unclean water.

Generally, the results show that there is a little and inconsequential difference in the growth of plants that are watered with unclean greywater from the kitchen and the shower. The only notable difference is the amount of dissolved salts, but this seems trivial and has fewer effects on the growth of plants. There is also no evidence that may point to the probable effects of the fat and oils presumed to be in the kitchen water. The difference in growth of plants watered with clean water and plants that were watered with greywater is also not that significant. At this stage results from the data collected show that greywater has fewer effects on the growth of plants than anticipated. But it impulsive to hypothesize the effects of the water on fruit production and taste based on the results achieved so far. The size of the plants should also not be viewed as a pre- requisite for bearing good and more fruits. This is evident, as some of the plants watered with greywater have started to bear flowers at the same time as the plants in the control plot. Results also show that plants watered with greywater that is not filtered were slightly healthier than plants watered with filtered greywater. This could suggest that the sand traps some nutrients in the unclean water during the process. Alternatively this may possibly have something to do with substances that are in the soil that might perhaps be leached into the water. But pending the full results of the study, it would be immature to say such suppositions do the cause of the disparities.

Plants watered with greywater that is filtered with gravel sand appear healthier when compared to the plants in plots watered with greywater that was filtered with dune sand. The length of stems and amount of foliage on the plants watered with greywater filtered with gravel sand are slightly healthier on average, indicating better development of plants. On the contrary, results on conductivity done on the samples show dissimilar results. Shower water cleaned with dune sand shows a slightly higher quantity of dissolved salts compared to the same water cleaned with gravel sand whereas in the case of kitchen water it is the reverse. This could have something to do with the material composition of the soil and how some substances in the soil may react when mixed with water. Filtering the water with dune sand seemed a logical method because of the amount of silt in the soil. From the results, it may be assumed that the silt in the sand trap some of the required nutrients in the soil and therefore plants did not obtain such nutrients, hence the underdeveloped growth. Filtering the water using gravel has another advantage in that it is more permeable and therefore the water passes through the soil much faster.

CONCLUSION

In general plants watered with clean water seem healthier than the plants watered with greywater, both filtered and unfiltered. This may be a consequence of the material in the greywater that it collects from its initial use in the shower and kitchen. However using this water is beneficial since it reduces the need for clean water, and essentially it is a way of saving water. Another benefit is that the nutrients in the greywater that might have been otherwise lost are reclaimed and this maintains fertility of the soil. There are case studies that show that using greywater to irrigate vegetables is viable (http://www.Sustainable.au/greywater.html.). The current results from the study show that greywater does not seem to have adverse effects on the growth of plants. The difference between plants watered with clean water and plants watered with greywater is also not that significant to indicate that there are harmful substances in the wastewater! The only fundamental question is if the food plants irrigated with greywater will taste bad compared to fruits watered with clean water and if it will affect the health of people. Similar case studies have revealed that there are no documented cases of people getting sick from eating such food (http://www.health.wa.gov.au.). In essence the results obtained at the time of this report are preliminary and do not warrant proposals. Therefore no recommendations will be made until all the data is available and analysed.

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