Improving Solid and Human Waste Management in Rural Namibian Communities

A Participatory Approach to Centralized Waste Collection and a Dry Sanitation Evaluation in the Communities of Gründorn South and Nico Noord

By:
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Enhancing decision making for sustainable development

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A Participatory Approach to Centralized Waste Collection and a Dry Sanitation Evaluation in the Communities of Gründorn South and Nico Noord

An Interactive Qualifying Project
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degree of Bachelor of Science

by
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Report Submitted to:
Desert Research Foundation of Namibia

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Abstract

Improper solid and human waste management endangers rural Namibian farming communities. Our goal was to conduct a pilot study in an effort to reduce the effects of waste in the Odendaal Farms of southern Namibia. Through interviews, community meetings, waste audits, and the construction of a centralized solid waste collection center, we eliminated the need for the burning of waste at the household level. In addition, we evaluated seventeen of the nineteen Otji dry sanitation toilets installed in 2011. We proposed a set of recommendations that the DRFN, and other organizations, can use to further improve waste management in rural Namibia.

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Executive Summary

Introduction

Solid and human wastes are polluting natural resources and becoming some of the most distinctive markers of growing societies, especially in developing nations. In a country such as Namibia, with a markedly arid climate, water sources mainly stem from aquifers replenished by groundwater in a manner that allows for contamination. As a result, increased instances of illness amongst human populations are becoming a great concern. While pilot studies to improve human sanitation have commenced, a lack of access to water and funding restrict efforts for reduced contamination. The Desert Research Foundation of Namibia (DRFN) seeks to implement a pilot study for improved solid waste disposal methods with one rural community's participation and monitoring.

Background

The Hardap region is rich in a historical heritage that has had an immense effect on its population and current resource infrastructures. During the 1960's, the then-present government of Namibia instituted a plan to relegate the indigenous populations of the southern part of the country to lands of lesser farming value. We carried out our project at two of these so-called Odendaal Farms, which are each centered around one to two water points. The specific communities that we worked with are Gründorn South and Nico Noord. Studies have shown that the water points, or boreholes, often provide contaminated water to the local population. In addition, the reduced potential for farming has contributed to the high poverty levels of the region, with most households relying on bi-annual small stock sales and government pensions as their main sources of income, averaging to N$500 per month. With such small individual revenue, there are limited funds available to repair and maintain the antiquated water supply infrastructures. Exposed pipes and broken parts allow for contaminants, such as animal excrements, to enter the water provisions system, which has also experienced a reduction in efficiency. Due to the lack of available water, solutions to the farms' solid and human waste management problems must use little to no water so as to avoid adding stress to the system.

Currently, water provision, monitoring, and repairs are coordinated through the Directorate of Water Supply and Sanitation Coordination, NamWater, and the Desert Research Foundation of Namibia (DRFN), which is the sponsor for this waste management project. The DRFN was founded with the objectives to "enhance environmental decision making, manage the natural environment, support sustainable livelihoods, and encourage sustainable development" (DRFN 2012). It engages in research

projects that span several sectors, including water, energy, land, and knowledge management. The DRFN and the aforementioned organizations provide continuous efforts for improved sanitation, such as the Otji dry sanitation toilet. Projects such as this are helping to ensure the continued improvements of the Odendaal Farms in the areas of solid and human waste management.

Conditions of solid and human waste management are largely dependent on the implementation of improvement methods, which rely on data gathered from the population's current practices. A waste audit follows the path of waste from generation to recovery and helps to analyze the varying nature of waste generated by a given community. Waste management systems must incorporate the input of the community in order to be able to foster participation and to ensure that residents will adapt any improvements that are made over an extended period of time.

Methodology

Establishing community perceptions of waste was paramount to the establishment of an understanding between community members and our team. We conducted a focus group in Gründorn South with the aid of our translator, Lucky !Ganeb, a researcher at the DRFN, delving into such topics as the community's concerns about waste management practices and the impact it has on their community. In accordance with measures set by the DRFN in the *State Of The Environment Report On Waste Management And Pollution Control In Namibia,* we sought to attain a greater understanding of the present quantities and qualities of generated waste for the purpose of designing a pilot waste collection and monitoring system. To accomplish this, we conducted waste audits and utilized that data for the design and implementation phases of our pilot waste collection facility. During our final community meeting in Gründorn South, we altered the design to accommodate their suggestions, discussed the necessity and use of such a facility, and built the structure in conjunction with the community members. Finally, we wanted to determine both the effectiveness of the Otji toilets installed last year in the community, as well as the best disposal method for the human waste that the residents generated. To accomplish this, we conducted interviews, site evaluations, and had fecal matter samples tested at a lab for pathogens.

Findings

Waste Audits

Finding 1. The difference in population density between Gründorn South and Nico Noord leads to variations in the residents' levels of concern for their community's current solid waste disposal methods.

Finding 2. In Gründorn South, residents are most concerned with small stock ingesting waste, especially plastic packaging, because small stock is their primary source of income.

Finding 3. In Nico Noord, residents expressed mixed reactions regarding their levels of concern with their current waste disposal practices.

Finding 4. In Gründorn South and Nico Noord, waste generation is growing, but reduction is not viable because residents only purchase the necessary goods for their households.

Solid Waste Management

Finding 5. Economic incentives are driving the community members of Gründorn South and Nico Noord to recycle glass, showing that the sale of waste products can provide a supplemental income to residents.

Finding 6. The residents of Gründorn South identified the need for a centralized collection site in order to improve their waste disposal methods.

Finding 7. The use of familiar construction materials and techniques helped to facilitate community participation in the project.

Otji Toilets

Finding 8. Over the past year, all community members interviewed have identified the Otji toilets as a successful solution to their sanitation problems.

Finding 9. Residents expressed concerns with the Otji toilets as there were insects entering the chamber, a lack of reinforcement of the roof, two broken drying plates, and a problem regarding the safety of children near the toilets.

Finding 10. Although five households in Gründorn South and Nico Noord initially agreed to share their Otji toilets, disagreements regarding maintenance have caused three of the households to revert to the bush or the bucket method, putting themselves and their small stock back at risk.

Otji Toilet Waste Management

Finding 11. In the past year, the perceptions of nine of seventeen interviewed residents on the reuse of human waste have altered, allowing them to consider composting, but only with increased education and training.

Conclusions and Recommendations

After analyzing our findings and results, we worked with the DRFN and the local communities in order to formulate the following recommendations focused on the improvement of solid and human waste management. The recommendations are grouped based on the communities, the DRFN, and the DWSSC. We recommend that:

Communities

Waste be sorted at the household level then brought to the centralized collection site

In order for the households of Gründorn South to be able to reuse as much of their waste as possible, it is necessary for them to sort it at their houses before it is brought to the collection center. This will also help to ensure that residents do not bring medical waste to the center. Once sorted, community members will bring their waste to the collection center, measure the volume using the monitoring sheet, and place it in the appropriate bins.

No solid waste, other than medical waste, be burned near any household in Gründorn South

With the addition of the collection center, all waste can be safely stored in an area that is approximately 250 meters away from the nearest household or small stock pen. This will not only reduce the amount of smoke that community members breathe in, but it will also increase the available space in their yards and keep the waste away from children and small stock.

Desert Research Foundation of Namibia

The collection site be monitored by the DRFN on a monthly basis

In order to ensure the success of the project, a monitoring form has been created that will track the usage of the collection site. In addition, the community member in charge of the site should perform

routine checks on the collection center in order to be able to inform the DRFN of any problems as early as possible. Included in the monitoring should be educational sessions geared towards the proper handling of solid waste and use of the collection center.

Structural updates to the design of the Otji toilet occur, including the addition of hand washing facilities

In order to implement the Otji toilets on a larger scale, we recommend that the DRFN work with Eco Solutions CC to make necessary updates to the design of the roof, the ventilation pipe, and the drying plates. These changes will help in ensuring the longevity of toilets without the need for maintenance or repairs. We also recommend that each household construct a fence around their toilet in order to protect it from animals, and to keep unsupervised children away from it. In addition, the construction of hand washing facilities will help to ensure that residents follow proper sanitary practices when using the toilets.

Composting be used for the management of human waste from the Otji toilets

Due to the results of our lab tests, which came back negative for pathogens, we recommend that community members use composting as a means to manage the human waste from the Otji toilets. We also recommend that the DRFN use a structure and method similar to those found in Appendix X to ensure the safe use of the compost on gardens and in yards.

Directorate of Water Supply and Sanitation Coordination

Otji toilets be constructed for all households in Gründorn South and Nico Noord

This is because of the high demand for toilets amongst those residents that did not have one, and the successful implementation of the toilets over the past year. In addition, those people that do not have toilets continue to use the bush or the bucket system, which causes environmental hazards that could be avoided.

The DWSSC increases education on sanitation to at least two sessions per year

Because the DWSSC has taken over responsibility for improving sanitation in these communities, it is their responsibility to educate community members on topics such as hand washing and the proper handling of solid and human waste. Going forward, their involvement with the communities will be vital to the success of the Otji toilet and the collection center pilot study.

Summary

In conclusion, the recommendations outlined above are important steps that need to be taken in order to ensure the continued improvement of both solid and human waste management in the

Odendaal Farms of southern Namibia. Going forward, the continued involvement of the communities and the DRFN will help to ensure the success of the pilot studies that have been implemented. Overall, with the elimination of the burning of solid waste on a household level, and the proper management of the Otji toilets, the communities of Gründorn South and Nico Noord will continue to see improvements with their sanitation for years to come.

Authorship

All members of the group participated in interviews, data collection, and the implementation of this project. They also equally contributed their efforts to the writing and revision of this report.

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Definitions

Solid Waste: consumer goods and organic materials utilized and disposed of by human populations

Human Waste: the excrement of human populations (e.g. urine and fecal matter)

Ecosan: human waste that has been sanitized over time and is safe for reuse as fertilizer or other products

Recycling: the act of reusing waste materials on a large, centralized scale

Sorting: the act of separating waste into the categories of plastic bags, plastic bottles, paper, cardboard, metals, glass, hazardous waste, medical waste, and general waste

Dry Sanitation: the separation of human waste from the environment to prevent contamination to groundwater sources, animal populations, etc.

Boreholes: the pumping and storage area of water from aquifers, usually shared by multiple households, with pipes leading to various faucets

Water Point Committees: a collection of persons organizing water allocation, necessary repairs, and maintenance

Indigenous: Native African people of color from various tribal regions and ethnicities

Waste stream: the process through which materials go from their original point of purchase, or point of origin in the environment, to their ultimate disposal

List of Acronyms

DRFN: The Desert Research Foundation of Namibia

DRWS: Directorate of Rural Water Supply

DWSSC: Directorate of Water Supply and Sanitation Coordination

ECAP: Sustainable use of Namibia's Natural Resources: contributing toward enhancing the capacity of future decision makers

IIASA: International Institute for Applied Systems Analysis

MAWF: Ministry of Agriculture Water and Forestry

N$: Namibian Dollar

NamWater: The Namibian Water Corporation

NGO: Non-Governmental Organization

SWAPO: South West Africa People's Organization

UDDTs: Urine Diversion Dehydration Toilets

USD: US Dollars

WPI: Worcester Polytechnic Institute

1. Introduction

Solid and human waste is a global threat due to the increase in land used for waste dumping, growing populations, and increasing consumption rates. Worldwide, 55% of people living in rural areas do not have access to improved sanitation facilities for human waste such as composting toilets (CIA 2012). As groundwater is the primary source for aquifer replenishment, human waste can seep into the soil and lead to water source contamination or ingestion by animals (State 2001). Since in Namibia, only 17 percent of the rural population has access to improved sanitation methods, waterborne diseases such as hepatitis A and typhoid fever are becoming more frequent (CIA 2012). According to Lorato Khobetsi, an author for the All Africa Global Media, "58 percent of children who die before the age of five years die because of pneumonia and diarrheal-related diseases due to poor sanitation." If solid and human wastes are not properly managed before its disposal, it can eventually pollute not only water sources, but also air and soil (Troschinetz and Mihelcic 2009). Overall, solid and human wastes are more than unsightly; they are hazardous to human health.

In Namibia, while efforts by the government, rural communities, and non-governmental organizations (NGO's) to improve sanitation and waste disposal are increasing, several economic, social, and technological challenges are impeding this progress (Klintenberg 2012). One key constraint is Namibia's arid climate, which only brings 50-200 millimeters of rain per year to the southern part of the country (Country Briefs 2012). Thus, solutions must not only be technically feasible, but must also use little to no water in the process. A second constraint is the lack of funds available to support proper sanitation and waste management systems due to the fact that Namibia's current unemployment rate is at approximately 51 percent, and 35 percent of people live on less than USD $1 a day. In the rural communities of the Hardap region, which were the focal point of this project, each household must pay approximately N$10 (USD$1.30) each month for access to a potable water source (paid to the water point committee). Many families can neither afford this expense nor water borne sanitation as the water is too expensive to simply flush down the drains (Boutin et al. 2011). Third, a lack of information regarding waste streams and disposal methods often keeps citizens from recognizing the importance of safely managing their waste. We have considered these constraints in our formulation of an improved sanitation solution for the rural communities of the Hardap region.

Our sponsor, the Desert Research Foundation of Namibia (DRFN), works with residents of rural communities in Namibia to sustainably manage their natural resources, specifically in the areas of land, water, and energy. The DRFN has worked to realize its goals through the use of participatory approaches, which allow for community members, as well as researchers, to learn more about the problem at hand while improving the natural environment (DRFN 2004). For example, studies in the first phase of the *Sustainable use of Namibia's Natural Resources: Contributing Toward Enhancing the Capacity of Future Decision Makers* (ECAP) project, which was completed in 2011, indicated that rural communities need improvements to achieve proper water quality and sanitation levels (DRFN 2012). As part of this project, a group of researchers from Worcester Polytechnic Institute traveled to the Hardap region in 2011 to help with the construction of and education about the use of Otji dry composting toilets (Boutin et al. 2011). There have been nineteen Otji toilets built over the past year, which have significantly helped to alleviate some of the problems with sanitation and human waste management. However, there is still much to learn about the effectiveness of these systems as well as safe human waste disposal practices.

In the Hardap region, researchers had focused their capacity building on the rural communities of Gründorn South and Nico Noord, but there was still a need to gather information in regards to specific categories, quantities, and perceptions of solid waste, as well as alternative waste disposal methods. These two farming communities are approximately 350 kilometers south of the capital city of Windhoek and lie approximately three and fifteen kilometers off highway B1, respectively. The major difference between them is their population densities. In Gründorn South, the houses are located adjacent to each other, while in Nico Noord, there is usually a cluster of two or three homes together, with the rest up to a kilometer away. While each household has a solid waste disposal method and access to sanitation, they are not necessarily sustainable or suitable for the betterment of their present or future living conditions. These conditions are causing harm, not only to their health, but also to their small stock and the environment. In an effort to understand the scope of the problem, our team has examined the perceptions of the community members in regards to waste, the manners in which they dispose of solid waste, and their assessment of the effectiveness of the previously implemented dry composting toilets as solutions to improving sanitation and human waste disposal.

The two main goals of this project were to work closely with community members to gain a better understanding of waste generation and disposal in Gründorn South and Nico Noord and to

evaluate the Otji dry composting toilets, which were installed in 2011, to formulate a long-term monitoring system. To complete the goals of the project, we collected information during community meetings, one-on-one interviews, site visits, and questionnaires. To better assess the scope of the communities' solid waste management problems, we performed waste audits in order to characterize and quantify the discharged waste (Behanzin 2011). Additionally, we performed an evaluation of the toilets to ensure that they were functioning at their full capacity. With the information we found and the recommendations we presented, more rural communities in Namibia will have the opportunity to improve their solid waste disposal methods and human waste management.

2. Background

The following chapter examines the history of the Hardap region as well as the present conditions of waste, water, and sanitation in the Hardap region and other parts of southern Africa. We also examine methods of solid and human waste management in order to identify acceptable sanitation methods. Finally, we study the lessons learned from the case of one project conducted in a more humid climate, but with comparable socioeconomic conditions and geographical challenges.

2.1 Historical Marginalization and the Odendaal Farms

Figure 1. Map of Namibia (Namibia 2008)

A developing country in southwestern Africa, formerly called South West Africa, Namibia is almost twice the size of California and has a population of approximately two million. The country gained its independence from South Africa in 1990 by following the lead of the South West Africa People's Organization (SWAPO), which was founded on April 19, 1960 (Country Briefs 2012). SWAPO is the present ruling party under the guidance of the chief of state, President Hifikipunye Pohamba. The majority of the research for this project took place in the Hardap region (see Figure 1), which has a population of about 68,000. Stretching across the width of the country in one of the southernmost portions, the Hardap region has a very arid climate (Country Briefs 2012). The population density of the Hardap region is lower than the other regions in Namibia as indicated in Figure 2. Within the Hardap region, the research took place in the two small communities of Gründorn South and Nico Noord, each with no more than fifteen households.

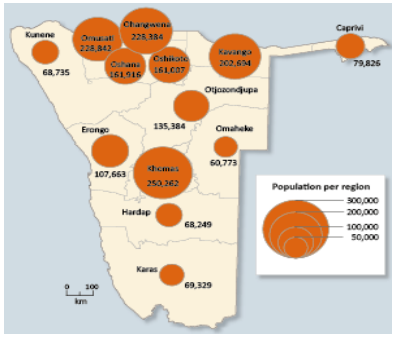

Figure 2. Population Map of Namibia (Distribution 2012)

Odendaal Farms exemplify apartheid land policy from when South Africa ruled Namibia and include communities such as Gründorn South and Nico Noord. The government purchased these farms in 1963 from a commercial farming entity as part of the Odendaal Plan. The South African government put this plan into action to move indigenous persons onto these new farmlands and divide the different ethnic groups into separate regions (Botha 2012). These communities were purposely placed far apart and were set aside for single or multiple indigenous families so that different groups could not easily interact and form a movement for equality against the government.

The indigenous families were moved to new farms that were not equal to the lands for Caucasian families. The water supply and quality were not ideal since the farms were formed around boreholes that were the only source of water (Falk 2008). These boreholes were often open to the environment causing them to become polluted and face regular maintenance problems. Additionally, the government put a fence around each farm to define its border. Although the Odendaal Plan did increase the farmland size for indigenous people, the land they received did not have agricultural potential (Odendaal 2006). Due to the poor conditions of these farms, today they exist with substandard sanitation and water provision for the residents of each community.

2.2 The Communities of Gründorn South and Nico Noord

Figure 3. An example of small stock roaming freely through the community

One of the communities where we carried out our project was Gründorn South, which is located 100 kilometers south of Mariental in the Hardap Region off highway B1. Gründorn South originated as a community for the elderly, and because of this, the average age of a household representative is approximately fifty-five years old. It is a relatively densely populated community of households with a church and a meeting center at the Helga Egger Kindergarten. There are approximately twelve households and seventy-five residents in total. As several people seek work outside of the area for months at a time, the demographic information could change slightly depending on the time of year. The residents primarily speak Damara. With the majority of the residents being farmers, all of the land surrounding the community is for the grazing of small stock such as goats and sheep (as shown in Figure 3). Since farming does not provide a steady monthly income, residents over the age of sixty rely on a government pension of N$550 each month. However, the largest source of income comes from the auction of small stock to local vendors, which takes place two or three times a year.

We also worked in Nico Noord, a community to the north of Gründorn South off highway B1. This community has approximately fifteen households and all of the community members are farmers. On average, fifty people live there, but this number fluctuates because people move out or go to nearby villages for work for weeks or months at a time. Unlike Gründorn South, not all of the houses are close to each other, and the distance from one household to the next can be as much as a kilometer. The residents primarily speak Afrikaans. Lastly, similar to Gründorn South, most community members

receive the largest proportion of their yearly income during small stock auctions that occur only a few times annually. In both communities, with most of the residents' time going towards farming and providing food for their households, little energy or expense is devoted to improving sanitation.

2.3 Water and Waste Sanitation Infrastructures in Nico Noord and Gründorn South

For water, residents of each community rely on one or two boreholes. These boreholes are essential for providing potable water for the families, as well as for animals and chores, because rainwater is scarce and there is no other natural body of water near the communities (Boutin et al. 2011). Today, the boreholes do not always provide potable water to the communities on a consistent basis. Pollution of the water stems mostly from improper sanitation practices and small stock, which defecate near the borehole. Broken and exposed pipes also lead to inefficiencies in the distribution and conservation of the water. A team of researchers in 2011 recommended a number of improvements to the infrastructure, including the use of ion exchange filters, the addition of calcium hypochlorite powder, and the continued implementation of Otji dry sanitation systems to improve water quality. The DRFN has implemented nineteen Otji toilets, but there are still many improvements to be made. Overall, while it can be challenging to identify the problems surrounding water quality in these communities due to all of the confounding factors, this lack of basic maintenance of the water source has and will continue to be a problem if it is not addressed (Simataa 2011).

The communities of Nico Noord and Gründorn South have a high probability of suffering from sanitation-related diseases, including diarrheal and gastrointestinal diseases, in part due to the poor management of their water sources (see Table 1 below)(Myers 2011). Despite this, a 2011 interview with a sampling of people from a few of the Odendaal Farms showed that they made little or no connection between the unsanitary conditions in which they were living and the harm done to their health (Boutin et al. 2011). Therefore, it is necessary for the water infrastructure to be maintained in accordance with the standards of the World Health Organization, as these communities need the boreholes to provide potable water in order to maintain their health (Planning 1997). This is often a challenge because the boreholes are used at a community level but managed on both national and regional levels by the Directorate of Water Supply and Sanitation Coordination. The citizens pay a monthly fee to be a member of the Water Point Committee that arranges for necessary repairs and maintenance. Maintenance often takes a significant amount of time because local citizens are not

trained to accomplish these tasks. Also, due to their poor economic standing, the communities have neither expendable income nor currency to exchange for repairs to the boreholes (Boutin et al. 2011).

In addition to the economic limitations, the geographic disconnect between the citizens of different communities leads to a lack of shared information and resources. This is most prominently seen in the area of solid waste management, where the distances between the communities inhibits the introduction of a centralized waste pick up system (Boutin et al. 2011). Commonly, in rural communities, the majority of solid waste is organic matter such as plants, sand, and ash, as well as, to a much lesser extent, metals, glass, plastic, paper, and rubber (Sanneh 2011). Prior to this project, the quantity of each type of waste in the communities of Gründorn South and Nico Noord were largely unknown given that the majority of community waste is burned (Boutin et al. 2011). Overall, the present conditions within these areas limited the opportunities for improved waste management solutions.

2.4 Characterizing Waste Streams in Rural African Communities

Waste audits are performed as a means to analyze waste sources and discharges, as well as community demographics, landscape, and climate. In order to collect this data, researchers use methods such as group and one-on-one interviews, questionnaires, and general observations. The following two case studies show processes that can be used to perform a waste audit as well as complications that can occur.

In a 2010 study that examined the possibility of recycling in two Namibian towns, Magen et al. (2010) interviewed a broad spectrum of residents, ranging from school children, to the community leaders who manage the towns' waste streams. They also investigated current recycling and management processes regarding metal, plastic, paper, electronic waste, medical waste, hazardous waste, biological waste, and glass. Magen et al. (2010) concluded that waste management in these towns was inefficient and inconsistent. The improper waste management practices mainly stemmed from the fact that communication was often delayed or non-existent. Local government and health officials and community members very rarely passed down information regarding waste management far enough to make an impact. Communication barriers aside, opportunities for success included the relocation of one of the dumpsites away from a residential area so that it could be properly maintained, as well as the collection of batteries by the Fuji photo shop in Keetmanshoop. On a larger scale, the authors mentioned the possibility for advancement in the areas of widespread waste management education and dry toilet sanitation systems. Overall, these waste audits were very comprehensive due

to their attention to detail and the fact that the researchers analyzed everything from the perspectives of the local citizens to the different categories and amounts of waste that were being produced (Magen et al. 2010).

Looking deeper into waste audits, Troschinetz and Mihelcic (2008) define the waste stream as having three, consecutive processes: generation, composition, and recovery. In developing countries, these steps are often difficult to isolate and characterize, either due to a lack of data, or cultural barriers such as a lack of personal education and access to technological resources. In order to overcome such obstacles in categorization, the diverse methods of data collection noted in the Magen case study are often implemented (Troschinetz and Mihelcic 2008). One example of improper waste characterization occurred in Mali, a country in northwestern Africa, where farmers generated and recovered waste, but failed to characterize its composition. The farmers were using unsorted waste on their crops that contained organic pathogens such as E. coli and inorganic materials such as heavy metals from batteries. These materials not only presented a risk to crops, but also to the farmers who were handling the compost on a day-to-day basis. This led to an increased danger to public health for farmers and locals alike. Eaton and Hilhorst concluded that this problem would only be resolved if more effective forms of waste characterization and separation, as well as composting, were implemented (Eaton and Hilhorst 2003).

While recycling and reuse systems have not yet been formally adopted within the Hardap region, they have been effective in other rural areas. The success of these other recycling systems is directly related to the communities' input and participation. Instances of failed recycling programs are often found because legislation commonly ignores the attitudes of local community leaders. This can then lead to a communication gap that causes fewer people to recycle waste products at the source and increases pollution within communities. A study completed by Bolaane (2006) in Botswana used surveys and interviews with local community members to gather qualitative data regarding their opinions and current recycling practices. Bolaane conducted interviews with local authorities within the communities as well as at the household level. From these interviews, it was found that solutions ranging from benefit programs, to recycling funds, to increased education of local officials would be most effective going forward (Bolaane 2006). Without the interviews that established both the baseline knowledge of residents in regards to recycling as well as without the desire to follow through on the part of the community, new solutions would not have been fully realized. Unique approaches to encouraging community involvement, such as the use of videos and other forms of media, have also proven to be

very effective tools for ensuring the long-term viability of a project (Gutberlet 2008). These participatory approaches to recycling have been studied, proving that community involvement is one of the most important factors behind a successful waste management program (Jones et al. 2010).

2.5 Water and Solid Waste Management Oversight in the Hardap Region

Currently, the Directorate of Water Supply and Sanitation Coordination (DWSSC), NamWater, and the Desert Research Foundation of Namibia (DRFN) monitor and study the water supply quality and sanitation conditions within Gründorn South and Nico Noord. Two of these, Namwater and the DWSSC, provide water delivery and management services to the rural communities of the Hardap region. The Ministry of Agriculture Water and Forestry (MAWF) manages the water supply to the Odendaal Farms. A sub division of the MAWF is the DWSSC, which ensures the functionality of the boreholes, and services them with necessary repairs. NamWater is a provider of water to all different parts of Namibia and supplies the DWSSC with water. (Boutin et al. 2011). Figure 4 shows the connections between these organizations.

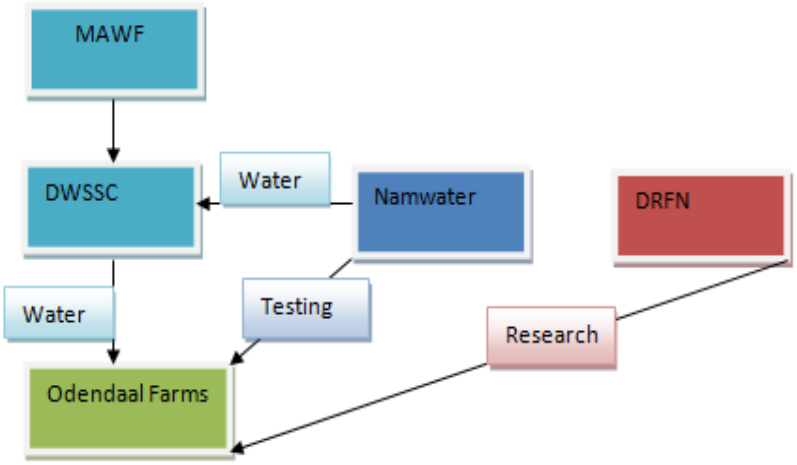

Figure 4. Organizational Focus Flow Chart

There are also constraints within the standards and services of NamWater and the DWSSC, as both entities are not providing suitable drinking water to the communities. Besides providing water, NamWater also evaluates the sanitation conditions of water sources. NamWater gives each water source a grade, ranging on a scale from A to F, depending on how clean a population's water system is. What constitutes an 'A,' or any other letter grade, is much lower quality than what would constitute an acceptable drinking water quality standard in the United States (Boutin et al. 2011). For example, in

terms of nitrate concentration, the acceptable level in the United States is 10 mg/L, whereas it is 40 mg/L in Namibia (National 2012). Due to budgetary constraints, repairs to any borehole or water delivery system under the aegis of the DWSSC can take up to a month. In addition, if a part needs to be ordered for repairs, it can take even longer (Boutin et al. 2011). During this period, the community must continue to use the contaminated water until the problem is fixed. In order to better understand the nature of this water, researchers who worked with eight communities (see Table 1) in 2011 tested for factors such as pH, total dissolved solids, nitrate levels, nitrite levels, fluoride levels, sulfate levels, and iron levels. The results of these tests can be found in Table 1, and show that Nico Noord's water presented a low health risk, while Gründorn South's water was acceptable. The main concern regarding the contaminants in their water sources was the increase in nitrate levels, since nitrate can put children at a higher risk for contracting methemologlobinemia, which reduces the blood's capacity for carrying oxygen, and can lead to death if not treated. Moreover, water of this quality can cause gastrointestinal diseases. Overall, these test results highlight the importance of the proper maintenance of local facilities as a mechanism for improving overall health and the prevention of disease (Boutin et al. 2011).

Table 1. Average Water Quality Conditions of Communities in the Hardap Region (Boutin et al. 2011)

Farm	Chemical Classification	Bacteriological Classification	Description of Classification
Nico	C	C	Low Health Risk
Laurencia	D	C	Immediate Action Needed
Nico-Noord	C	C	Low Health Risk
Laurencia Pos	B	D	Immediate Action Needed
Gründorn (South)	B	B	Acceptable
Gründorn (North)	C	B	Low Health Risk
Diamond Kop	B	B	Acceptable
Doring Draai	C	B	Low Health Risk

Projects such as the "State of the Environment Report on Waste Management and Pollution Control in Namibia" work to provide more information to Namibia's citizens, so that people throughout the country have the capacity to make informed decisions on waste management practices that consider the local environment. These efforts include a number of waste audits and waste management system evaluations, as well as the testing of local ground water and the environmental impacts of various waste disposal methods. By encouraging data acquisition through continuous monitoring systems and waste audits, organizations such as the DRFN will be able to facilitate sustainable development so as to ensure the preservation of natural resources (State 2001).

The sponsor for our waste management project is the Desert Research Foundation of Namibia (DRFN), a non-profit, non-governmental organization that receives money from government grants as well as individual donations. The organization was founded in 1990 to "enhance environmental decision making, manage the natural environment, support sustainable livelihoods, and encourage sustainable development" (DRFN 2012). The DRFN engages in research projects that span several sectors including water, energy, land, and knowledge management. These focus areas are centrally monitored at their main office in Windhoek, which was established in 1995. This is the first project the DRFN water desk will sponsor in the field of solid waste management within rural Namibian communities.

2.6 Dry Composting and the Otji Toilet

An important aspect of maintaining proper water quality is the management of human waste. One method that has proved to be effective in arid areas such as the Hardap region is dry composting. The premise behind composting at any scale is the decomposition of organic matter of the proper composition into its basic nutrients to return them to the environment. An example of a successful composting strategy for toilets is ecological sanitation, better known as "ecosan." Most dry composting toilets utilize this method because it helps to keep waste from reaching the environment before it has decomposed to a safer nutrient level. Once the process is complete, the product is often used as a fertilizer for crops due to its high nutrient content. The main objective of "ecosan" is to reduce the pollution to the surrounding environment, thereby protecting water sources and leading to improved overall health (Huuhtanen and Laukkanen 2006). "Ecosan" is also effective for arid areas such as Namibia because there is no need to transport the waste, and it uses no water. Both of these factors are extremely important because they allow these toilets to be effective on a local scale, where they are often needed the most (Boutin et al. 2011).

Lack of knowledge on "ecosan" limits the amount of people willing to use their human waste for composting. This is because people are skeptical of reusing their human waste on their garden that can produce something that they will eat. An example of reusing fecal matter as compost can be found in India during a training day for municipal waste management in 2009. Researchers and residents discussed the waste management method of converting waste into vermicompost. This reuse strategy uses worms to turn organic waste into nutrient-rich fertilizer. This not only benefited the community by reducing their waste output, but it also helped local farmers acquire low-cost, effective fertilizer (Lessons 2009). Although this project is specific to that particular community, the ideas behind its

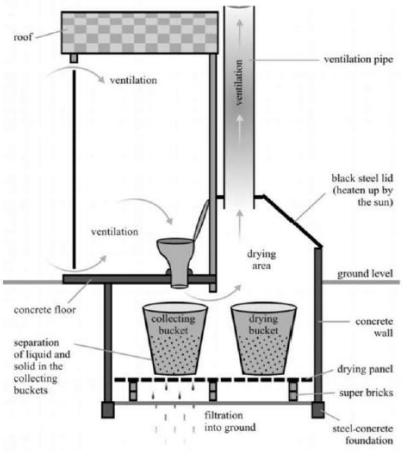

Figure 5. Otji Toilet Diagram (Arndt 2009)

implementation apply directly to the problems in the Hardap region. First off, the farmers in this study, much like those in the Hardap region, needed a way to reduce the amount of waste that they were throwing away due to its impact on the local environment. In order to find a solution to this problem, researchers chose an approach that both included and benefited the farmers. It is also important to note the use of a training day for the new technology in order to confirm that community members understood and were part of the project implementation. Direct community involvement is an integral part of any project in a rural community because it helps to ensure the project's long-term success. Overall, although the technical aspects of this case study do not directly relate to our project, the participatory approaches that were used and the training that took place act as models of how to structure a capacity-building project in a rural farming community.

Another case study regarding rural sanitation can be found in select communities of Swaziland. The main focus of this case study were the problems that arose when the people installing the latrines and the community members using them did not have the same interest or enthusiasm in the project. The problems first arose in regards to the structure of the erected latrines, when termites destroyed the cheap, untreated wood that was used to construct them. An additional problem was the lack of community investment in the project. The community members had no motivation to assist with the project and had a "lack of understanding of the benefits of latrines" (Busari 2007). If community input had been used from the earlier stages of this project, the problems that eventually led to its downfall may have been avoided. Community participation, which was missing from this example, was a crucial part of our project because it gave the community members a sense of ownership in the outcome and motivated them to make the pilot study successful.

In 2011, the DRFN sponsored the installation of Otji toilets in Gründorn South and Nico Noord. Part of this project was for a team of four WPI students, working for the DRFN, to come up with a list of qualifications to assess the overall success of the Otji toilets. Although only one toilet was constructed during that time, nineteen have now been completed in the area. One of the team's main questions at the end of their research period was: would the Otji toilets be effective over an extended period and could they be constructed and maintained by local community members? The positive answers to these questions were the determining factors behind the implementation of Otji toilets on a larger-scale. The

original toilet was constructed by the researchers in conjunction with the community members. The supplies were purchased from the Clay House Project at Otjiwarongo, and the team used the "Otji Toilet Self Builder Manual" as a guide for the design (see Figure 5). One of the main advantages of these toilets, however, is the fact that the design can be modified to fit the available resources of a given community. For instance, instead of purchasing all of the materials new, community members could use leftover materials from past projects in their place. An example of this would be the corrugated iron roofs, which could be constructed from leftover materials. This not only reduces the cost of the toilet, but it also allows community members to take charge of the construction efforts by using familiar materials.

The Otji toilets work by drying out the human waste before it is discharged into the environment. This occurs in two separate buckets underneath the structure, one to collect the waste, and the other to store approximately six months' worth of waste as it dries out. The waste dries out through the evaporation of the water through the vent that runs from the base to the roof of the toilet. In order for the toilets to be effective, each of these steps must occur regularly and the citizens in charge of the toilets must be fully invested in its success.

This system provides two major advantages and constraints. First, the toilets are able to collect and store the waste before discharge, without the use of any water. Second, they prevent the direct contamination of the communities' groundwater, as the waste is dried and stored at an elevated temperature to allow for possible reuse. The two main constraints are the fact that the improper handling of the human waste could be detrimental to people's health and each toilet could only be effective for one family because the citizens of the farms did not want to handle each other's waste (Boutin, et al. 2011).

Overall, Otji toilets and other forms of dry composting toilets have been successful in examples such as this, but must be continuously evaluated in order to ensure that they meet the needs of a given community as they change over time. Examples of evaluation criteria can be found in Table 2. According to each of the authors listed in Table 2, short- and long-term evaluations of pilot dry composting toilet projects are vital to the long-term sustainability of the systems that are put into place. All authors describe different aspects of the toilets that should be evaluated and inspected in order to continuously improve the dry composting systems.

Table 2. Dry Composting Evaluation Criteria

Source	Evaluation Criteria
Diemand 2010	Number of people using the toilet, final mass of the bucket including waste, proximity to houses, necessary education on use and maintenance
Müllegger 2010	Volume of buckets, cost, operation and management needs
State 2001	Nutrient content of waste, human waste discharge per day, current use and/or disposal of waste
Boutin 2011	Water demands, transport demands, smell, effectiveness of materials
Benson 2007	Soil quality in immediate area, time to mature, local temperature and climate

2.7 Case Study: Costa Rica

By analyzing the work of a similar research group in Costa Rica, we found effective manners of data acquisition and assessment. In 2011, a group of student researchers from Worcester Polytechnic Institute traveled to Costa Rica in order to complete a project titled "Waste Management in Squatter Communities in Costa Rica; An assessment of squatter communities and the development of human and solid waste management plans." The group worked with Un Techo Para Mi País, an organization working on sustainable development, in order to evaluate five communities, and then make recommendations regarding waste management plans for both solid and human waste. In order to gather data, group members made use of surveys, interviews, and site assessments. Through these methods, they were able to see current conditions first-hand, as well as ask local community members about their perspectives on the most pertinent issues regarding waste.

Table 3. Solid Waste Management Options (Behanzin et al. 2011)

Management Option	Types of Solid Waste	Advantages	Disadvantages
Recycle	• Glass • Plastic • Cardboard • Aluminum • Paper	• Profitable • Saves natural resources • Saves space in landfills	• Requires time • Requires transport to local center
Compost	• Yard waste • Napkins & paper towels • Shredded newspapers • Manure • Food waste (fruits, vegetables, rice, beans, egg shells) • Food boxes (shredded) • Urine	• Profitable • Environmentally friendly • Useful to fertilize own crops	• Requires maintenance • Requires space
Municipal Collection	• All types of waste	• All waste is collected and treated elsewhere	• Expensive (continuous cost) • Recyclable & compostable material is mixed with trash
Refuse Pit	• All non-recyclable materials	• Compacts waste • No operating cost	• Requires a lot of space • Risk of health hazards

Ultimately, their recommendations for the two communities involved a combination of composting, recycling, and municipal solid waste collection. They then used the information that they had gathered in order to create a waste management manual, containing sections regarding both solid waste recycling and human waste composting. The team recommended that Un Techo Para Mi País use the manual while working in conjunction with the communities, to make future decisions regarding the implementation of waste management solutions (Table 3 portrays examples of waste management options). On top of this, they also made a set of recommendations for two, specific communities that their sponsor chose because the communities had the most potential for improvement. The team of researchers assessed available land, as well as available funding, in order to find feasible solutions to introduce. Also important to note was their analysis of composting, recycling, municipal collection, and refuse pits on both a technical and a cultural scale (see Table 3) (Behanzin et al. 2011). These analyses, as well as the information in their manuals, are relevant to any project dealing with rural communities with the hope of improving their solid and human waste management. There are two main lessons from this case study that apply to our project. First off, the student researchers stressed the importance of a thorough site evaluation when completing fieldwork. Secondly, they showed that the evaluation of community perceptions through both formal and informal interactions is vital to finding solutions that will be effective on both short- and long-term scales.

3. Methodology

Our goals for this project were to help the Desert Research Foundation of Namibia (DRFN) understand how two rural communities in the Hardap region generate then dispose of solid waste and to pilot rural Namibia's first solid waste management system. We have also assessed community perceptions of the Otji dry composting toilets installed in 2011. Our project objectives are as follows:

1. Identify perceptions of the community members concerning solid waste management and waste generation.
2. Assess the current waste stream in the communities in regards to recyclables, non-recyclables, and hazardous waste.
3. Develop a pilot solution to current waste management practices in close cooperation with the community of Gründorn South.
4. Identify appropriate criteria, with community input, that can be used to monitor the Otji toilets over the next year.

Objective 1: Identify perceptions of the community members concerning solid waste management and waste generation.

To gain a better perspective of the problems at hand, we conducted a focus group with the residents of Gründorn South to assess general attitudes towards waste management and to establish a base line for the current conditions. These discussions, with representatives from eight households, delved into their perceptions of waste, beginning with their definition of waste and the effect that it is having on their wellbeing and livelihoods. We covered issues with waste generation and with the handling of waste that were specific to the community. We also addressed reuse methods in order to see if more materials could be reclaimed on a household level. We used the information gained from this session to gauge the attitudes of community members in relation to waste management to determine the desires of the people and how they wanted to improve their current waste disposal practices. Questions that we used to guide this session included:

- How do you define solid waste or trash?
- What do you know about recycling or reuse methods?
- Does the trash have an impact on your home or your community?

Additional questions can be found in Appendix A.

The discussion highlighted several constraints but also showed the willingness of the community to assist with our research. Two of the major challenges during the group meeting were the language barrier and the time constraints for maintaining attention and focus. Although we did get all of the main points translated to us, some small details of the conversations were lost, which kept us from being able to foster a more in-depth discussion while keeping the meeting short. While we had not planned to discuss possible options for improving their current waste management practices, ideas and possible solutions that community members brought forth from meetings prior to our arrival were shared and discussed with us. Following the meeting, the community members brought us out to the site that they had previously established to be their preferred location for a waste collection area. We then had a period of observation and surveying within both communities in order to facilitate any future system implementation. We collected specific information on the land, the animals, and the daily tasks of the community members. We took note of gardening practices as well as cooking methods for consideration of waste reuse as compost or fuel. Due to the nature of these communities, and the fact that some residents seek work outside of the area for months at a time, the demographic information that we collected could change over time. This can have an effect on sanitation and waste management because it can cause a change in the amount of waste that is being thrown away and burned at each household. Also, the amount of time that any given resident spends in the community can have an effect on how they maintain their land and how much effort they are willing to contribute towards its maintenance. In spite of this, we were still able to use this information as a means to characterize the structure and nature of the communities and their residents.

Objective 2: Assess the current waste stream in the communities in regards to recyclables, non-recyclables, and hazardous waste.

We performed waste audits in the communities of Gründorn South and Nico Noord in order to gain a better understanding of the present conditions surrounding waste management. The categories of waste that we analyzed were glass, plastic bottles, plastic bags, paper, cardboard, metal cans, hazardous waste, medical waste, and general waste. In order to conduct the waste audit, we used several forms of data collection and analysis. First, to obtain a broad overview of the waste stream, we conducted interviews with twelve households from Gründorn South and thirteen households from Nico Noord. Through this waste analysis, we gained a more precise knowledge of what quantities and qualities of waste and recyclables were being generated, and by whom. We conducted the interviews

with the assistance of Lucky !Ganeb, a researcher with the DRFN, who was able to translate our questions into Damara and Afrikaans. Some of the questions we asked included:

- Where do you purchase most of your goods (from outside and inside the community)?
- How and by whom were the waste products used before being thrown away or burned?
- Were any products saved (reused or recycled), and if so, which ones?

Additional questions can be found in Appendix B.

There were also several, additional iterations of the waste audit. We asked community members to bring us to the locations where their waste is currently being stored and/or burned. These observations helped to portray the overall movement and final locations of the waste so that it was possible to determine if waste collection in a central location could be feasible for the communities to implement at a later time. On top of this, we incorporated questions into our interviews regarding the community members' habits to gain a better understanding of when and how the materials transition to waste, why they are using their present disposal methods, and whether they are doing anything other than burning their waste (e.g., burying it, simply leaving it in areas outside of the farms, etc.). Some questions we asked in the interviews were:

- What types of things do you throw away and why?
- How do you make use of your waste?

Additional questions can be found in Appendix B.

We also interviewed Andrea Hewicke from the City of Windhoek's Solid Waste Management Division (Appendix E) as well as Abraham Reinhardt from Rent-A-Drum CC (Appendix F) before completing the waste audit. From these interviews, we learned of municipal waste collection and disposal, and of recycling practices in and around the city of Windhoek. Although these systems are on a much larger scale than those in the rural communities, they gave us valuable insight into general waste management methods and how we can apply them on a smaller scale in the communities. These interview visits also included a walking tour of both the Rent-A-Drum recycling center and the Kupferberg Landfill, which allowed us to view specific problems with the sites as well as possible considerations for our design.

Applying a quantitative assessment method, we asked each household that we interviewed to allow us to monitor their household's discarded waste. In Gründorn South, we monitored the waste for three to four days, while in Nico Noord, we monitored the waste for two weeks. We chose these two lengths of time so that we could collect data for short-term disposal analysis, while also having the ability to compare the results to a long-term disposal study. We analyzed the waste by collecting individual households' waste in blue, Rent-A-Drum plastic recycling bags, which we supplied each household with. We quantified the collected solid waste by weighing the bags on a scale (in kilograms). Then, we sorted the waste into the categories of plastic bottles, plastic packaging, paper, aluminum/tin cans, cardboard, glass, hazardous waste, and general waste (non-recyclable). Following this, we weighed the waste within each category in order to gain a better idea as to the amounts of each. While each household that we interviewed did give us a full bag at the end of the collection period, three houses did give us waste that had already been discarded and/or burned several weeks before. Although this data was not relevant to the waste audit, it did allow us to see what types of materials were left over after a collection of waste is burned. The following steps, modeled after measures taken by the Partnership for Local Democracy, Development, and Social Innovation, helped us to correctly assess the current state of disposed waste (Magen 2010):

Waste Audit Steps

1. Determined demographics of each household
2. Collected waste from households
3. Determined the mass of the waste output
4. Identified amounts and types of various categories of materials
5. Calculated average disposal of households, individuals, and of various materials

We then organized and analyzed the data into a table. We based our table on one produced by The Pennsylvania Department of Environmental Protection. We used it to organize the varieties and amounts of waste that were present. The table used is attached below:

Materials	Weight (kg)	Disposal Method	Recycled/Reused	Comments

This table has five columns: materials, weight (kg), disposal method, recycled/reused and comments. The materials column will contain the different categories of materials (e.g. paper, plastic, hazardous waste, etc.). Knowing the disposal method for each material is critical as far as knowing present waste

management habits. We used the recycled/reused column as a way to note if there were any patterns in which materials were being recycled or reused. The weight column had the mass of each category in kilograms. In the comments column, we were able to make notes on additional characteristics of the waste not covered in the rest of our audit. By organizing the data in this fashion, we were not only able to analyze the waste stream in a comparative manner, but we were also able to make recommendations as to how the communities can better manage their waste in the future.

Objective 3: Develop a pilot solution to current waste management practices in close cooperation with the community of Gründorn South.

Figure 6. Showing posters on the benefits of recycling during the final community meeting

As the residents of Gründorn South had already brought forth the idea of a centralized waste collection system, we devised a design and a monitoring system for such a project. Preliminary designs were altered based on community input. In order to solidify the final plans for the collection center, we held a community meeting and workshop with the residents of Gründorn South. The first discussion included the use of a poster we had created on the hazards of waste. It summarized our research and the ideas that the community had brought up to us during our first community meeting. In addition, it was the community members' desire to eliminate waste from their community and we thus emphasized the benefits of recycling and reuse with another poster and discussion (as seen in Figure 6). Both posters can be found in Appendix L through Appendix O. While our goal was to create an agenda to ensure that the meeting was efficient for the short period we were present, we wanted the community to discuss ideas openly to ensure that the system would be effective and utilized over a longer period. The location brought forth by residents for the collection center did not change from the site that they showed us during the first visit, but we did discuss associated hazards, such as ground water contamination and potential harm to small stock. We concluded with the community and our sponsor that the location did not pose an environmental hazard, and was the best option regarding the ease of access for community members. We also discussed ownership and oversight so that we, along with our sponsor, would know how and by whom the site would be cared for. As an essential part of the pilot study, we created a monitoring system for the site. We incorporated the monitoring form to evaluate usage in terms of volumes of each category of waste, frequency of use, and notes on necessary maintenance.

At the conclusion of our meeting, we began the construction phase. This helped to ensure that the community would be involved with the project from the very first step because they walked with us from the meeting room to the construction site. The design devised by our team utilized both the knowledge we acquired from Rent-a-Drum regarding quantities of various recyclables, as well as calculations derived from our waste audit data. Through our discussion, we found that the community also wanted a place for materials that do not presently have value as recyclables, but are still no longer wanted. Due to this, we added a general waste compartment to the original design. We relied heavily on community input for every step, as they were already knowledgeable on the use of various tools, materials, and the environment. The project was a very collaborative effort, with team members working alongside community members throughout. There were a few instances where the language barrier hindered progress, so we used demonstrative efforts for communication. In the end, we constructed a waste collection and sorting center with community members that included compartments for general waste, paper/cardboard, plastic bags, hazardous waste, glass, metals, and plastic bottles.

Objective 4: Identify appropriate criteria, with community input, that can be used to monitor the Otji toilets over the next year.

In the past year, there have been nineteen Otji toilets installed in the Hardap region. These toilets are part of a pilot study focused on using dry sanitation methods to help improve the water quality and sanitation in the region. First off, the evaluation of these toilets has helped our sponsor better understand the extent to which the design and construction are meeting community needs. Second, the evaluation has helped to determine if it will be feasible to expand the project into other regions. We surveyed twenty-five community members, seventeen of whom had Otji toilets. The questions that we asked in order to find out more information about the Otji toilets, based on evaluations of Urine Diversion Dehydration Toilets (UDDTs), were a combination of yes/no, multiple choice (both to ensure more uniformity of responses), and open-ended survey questions. A sample of the questions asked follows below:

- Who is using the toilets (including how many people)?
  Select: Family Guests Both Neither/Abandoned

- Do you feel that you have received adequate training on the use and maintenance of your Otji toilet?

Y/N

- How do you dispose of the waste from the Otji toilets?
  Select: Dispose in the surrounding environment Burn Bury

Further questions can be found in Appendix C.

We reviewed all of the answers to the above questions and synthesized it in data tables that clearly tabulated all information in a logical manner. One section of the tables can be seen below:

Information	**Respondent 1**	**Respondent 2**	**Majority Answer**	**% Majority**
Demand for toilets				
Adequate training				
Able to pay				

Additional criteria can be found in Appendix D.

We used the above table to synthesize information in order to uncover the majority opinion, while still taking into account individual responses to questions for further analysis.

We also formulated a scale rating system regarding the Otji toilets that can be seen below. The individuals whom we surveyed filled out the form at the end of each interview. The community members' answers to the scale rating questionnaire provided current information on the toilets and provided insight on how to further improve the Otji toilets. The responses also gave the DRFN a better idea of the community members' perceptions, as well as the areas that need to be developed in order for the implementation of the Otji toilets in these communities to be more successful. This helped to improve our understanding of the community members' perceptions of the toilets. The only constraint to this method was the difficulty that we often experienced when trying to translate the rating system. This may have led to slightly skewed results, however, every resident that we spoke to gave explanations as to why they chose each number within the respective categories.

Criteria for Otji Toilet Evaluation:					
	[Excellent]	|	[Neutral]	|	[Poor]
Ease of Maintenance:	5	4	3	2	1
Eliminating Odor					
Emission:	5	4	3	2	1
Structural Integrity:	5	4	3	2	1
Overall view of Toilet:	5	4	3	2	1

Additional survey questions can be found in Appendix C.

We put the data from the survey above into the following table in order to be analyzed:

Criteria	**Respondent 1**	**Respondent 2**	**Respondent 3**	**Average**
Ease of Maintenance				
Eliminating Odor Emission				
Totals				

Additional criteria can be found in Appendix D.

We used the above table to synthesize information in order to discover the majority opinion, while still taking into account individual responses to criteria for further analysis.

Figure 7. Collecting fecal matter samples from Otji toilets

In order to analyze the waste from the Otji toilets, and the feasibility of reusing the waste for composting, we examined the waste collection buckets of seven toilets in Gründorn South and three in Nico Noord. As part of this examination, we observed how well the drying process was progressing, and we collected small samples from the upper third of each bucket. The process of removing the samples from the waste buckets is shown in Figure 7. We brought the samples to a lab at the Polytechnic of Namibia in order to be analyzed for pathogens (Salmonella, E Coli, and Shigella). We did this in order to ensure that the waste was safe enough to be reused in gardens and other areas where human contact and animal consumption could occur. The major constraint to this analysis was the fact that the collected waste samples had not all been sitting in the chamber for the same amount of time. This could

have led to some discrepancies in our data, but it ultimately helped to model the inconsistencies in use from toilet to toilet.

Using the information gathered in the field, we devised a draft daily and monthly monitoring system for the Otji toilets. From our fieldwork, we found that we needed to monitor certain aspects of the toilets, as well as perceptions such as the feeling of comfort and disturbance from animals, with a greater frequency over a longer period. The daily monitoring sheets cover the daily usage, perception of temperature, and any animal sightings, and allow for any general comments to be noted. The monthly monitoring sheets evaluate the toilet bowl, door, bricks/structure, drying plate, presence of bugs and animals, odors, roof, and the number of times that the household switched the buckets. Both monitoring forms can be found in Appendix P through Appendix S. This information will be of use to our sponsor and to the community to help foster discussions and make necessary alterations in the future.

4. Findings and Analysis

In Nico Noord and Gründorn South, we analyzed local perceptions of solid waste and dry sanitation, and from our observations and interviews, we discovered differences between the communities. One major difference was the proximity between households, which lead to different solutions, and recommendations for each community. Since the residents of both communities only purchase the necessary items for cooking, cleaning, and hygiene, reducing the generation of waste was not an option for helping improve their solid waste management. The second part of our project focused on an evaluation of the Otji toilets, which the DRFN implemented over the past year. Overall, residents gave positive feedback regarding the dry sanitation systems. From our interviews with the community members of both Gründorn South and Nico Noord, we found that they all wanted and realized the need for improved sanitation in their communities.

4.1 Waste Audits

Finding 1. The difference in population density between Gründorn South and Nico Noord leads to variations in the residents' levels of concern for their community's current solid waste disposal methods.

In order to find feasible solutions to their solid waste problems, we analyzed the size and density of both communities. The community of Gründorn South covers an area of approximately 0.125 square kilometers and most houses are approximately three to twenty meters apart. The exception to this is the Anzel Gründoring Winkel shop, which is nearly a kilometer away, and surrounded by a cluster of three houses. The short distances between most of the houses allow for more interactions between neighbors and a greater knowledge of each neighbor's disposal practices and sites. In Nico Noord, distances between houses and clusters of houses vary greatly and can be up to a kilometer apart. These separations have a large impact on their level of concern regarding each others' waste disposal methods.

Not only do these distances have effects on perceptions of community waste, they also have an impact on the means of travel within the communities and where residents purchase their goods. Nearly half of the waste in Gründorn South originates from items purchased at the Anzel Gründoring Winkel shop, while some households are able to find transport, by donkey cart or automobile, to the nearby towns of Gibeon, Mariental, or Keetmanshoop to purchase their goods. In Nico Noord, the waste came

almost entirely from items purchased in these surrounding towns. The two kilometers of dirt and gravel roads from highway B1 to Gründorn South allow for the area to be traversable, but at a slow pace. Though this does not impact the connections between households, which are close together, it does impact the residents' connection to the main road and route of travel. In Nico Noord, the road system also impacts the connections between households and is in a similar condition in regards to difficulty of travel to the roads of Gründorn South. Because most residents are able to afford cars, the conditions of the roads does not affect their connection to highway B1.

Figure 8. An example of small-scale gardening practices in Gründorn South

While traveling between interviews, we noted a number of developments for possible human waste reuse within the communities. As shown in Figure 8, Gründorn South has a few planted trees scattered about, at most one or two in each yard, and this is the extent of gardening practices and visible possibilities for compost use. The land surrounding the houses and community buildings has been stripped of most plant life for approximately twenty meters in each direction, thereby reducing the amount of materials available for cooking fuel and composting. Nico Noord, by contrast, is much more dispersed and varying. There are some houses clustered in two's or three's, each with a fenced in yard with gardening. The houses in Gründorn South are uniform in size at approximately five meters in length and two meters in width. Each house has two rooms and is constructed using painted cement blocks. A few houses were constructed using corrugated iron and other scrap materials. These building materials were seen sitting about the community in piles, as they are used for necessary repairs to structures as well as fences for their kraals and yards. The houses in Nico Noord are also made out of cement blocks, but these houses tended to be larger than those in Gründorn South. The differences between the communities dictated the proposed solid waste management solutions that we presented within this report.

From our interviews, it was clear that disposal methods in both communities differed in method and frequency. In most of the households of Gründorn South, waste was contained in a bin that was placed in the corner of their fenced off yard. When the bin filled up, they would burn their waste with lighter fluid and a match. In Nico Noord, the people had a disposal site that was not directly in their yard or enclosed in any kind of container. Since there was no specific time that the waste had to be

burned because there was a larger area to fill up, they did not burn their waste as often. One downside to that was the fact that it allowed their waste to blow around more, making it easier for their small stock to consume. Since community members were already dedicating time to the disposal of their waste, devoting time for participating in a centralized collection system did not seem to be an issue.

Finding 2. In Gründorn South, residents are most concerned with small stock ingesting waste, especially plastic packaging, because small stock is their primary source of income.

During our first visit to Gründorn South, we came to find that "what one no longer needs" is the community's definition of waste and would qualify a product for disposal. Residents burn waste products such as papers, tins, and plastics whenever they reach a certain level of waste at their storage site. Community members realize the hazards of their disposal practices and are primarily concerned about the waste having a negative impact on the environment and their small stock. The eleven people present at the first community meeting expressed concern for waste that had not been fully burned. This was because the waste could blow off a waste pile into the surrounding environment, where small stock may ingest it and children might hurt themselves playing in it. Not only is this a problem regarding health, but also economics, as small stock are the main source of income for most residents.

Finding 3. In Nico Noord, residents expressed mixed reactions regarding their levels of concern with their current waste disposal practices.

Unlike Gründorn South, Nico Noord is too dispersed to hold a community meeting, so perceptions about their disposal methods were gathered solely through individual interviews. While some residents expressed concerns over solid waste disposal practices and the frequent occurrence of wind-blown waste, most concerns were in regards to their neighbors' methods. The problems in Nico Noord were not as urgent as in Gründorn South because of the dispersed nature of the community layout. While there has been no community discussion mentioned in regards to waste disposal, the community activist, Sara Bock, has expressed concern over current disposal methods. One example that she noted was when shattered glass in the fields acted as magnifying glasses to concentrate light and heat, thereby starting a fire in the parched, barren lands, which farmers rely on for grazing. Ms. Bock suggested that a centralized location for disposal would eliminate such hazards, even though the location would be difficult for the community to agree upon. Due to the distances between households,

overseeing the site and making sure people were using it correctly would be more difficult here and it would take more effort for some community members to dispose of their waste than others.

Finding 4. In Gründorn South and Nico Noord, waste generation is growing, but reduction is not viable because residents only purchase the necessary goods for their households.

Figure 9. (Left) Qualifying solid waste categories and determining volume measurements

Figure 10. (Right) Quantifying solid waste output from households

By following the waste stream from its source to disposal, we have been able to understand that waste reduction is not a viable solution for improved solid waste management in rural communities. This is because the majority of purchased products include the very basics: coffee, tea, sugar, flour, cooking oil, rice, various household cleaning products, and hygienic products. With our waste audit data from Gründorn South, which we conducted over a four-day period and included eight households, we created the pie chart in Figure 11 below, depicting the estimated amounts per month of each waste category that we found at Rent-A-Drum in Windhoek (Reinhardt 2012). To get a more accurate representation of the community, we multiplied the results from the eight houses by 1.5 in order to display results for a total of twelve households. From this, we found that the waste output per household over a period of one month was approximately 8.3 kilograms. The process by which we calculated the weight of each category is shown in Figures 9 and 10 above. This data was instrumental in allowing us to calculate the amount of space needed for the collection site as well as the space for each category, as discussed in Appendix J. In addition, forty-six percent of the waste was recyclable, pointing to future opportunities for recycling collection. This knowledge will be most beneficial for our sponsor to understand the possibilities of recycling in the region in the future.

As the community members of Gründorn South identified that windblown waste is their greatest concern due to its impact on their small stock, it is important to note that ten percent of their waste by kilogram consists of plastic bags, which can be easily blown around the community and consumed by small stock. To minimize the effects of this problem, we concluded that the bins for general waste and plastic containers needed to be the largest, and that the bins for general waste, plastic containers, and paper and cardboard needed to have mesh lids. General waste, as shown in

Figure 10, was not categorized and includes, but is not limited to Styrofoam containers, metallic wrappers, articles of clothing, sand, organic materials, wood, and construction waste. These general waste products have little to no market value as raw materials and are not necessarily pertinent to a recycling solution. One limitation to this analysis was our sorting of the waste. While we did separate as much as we could from the general waste into its respective pile, some items, such as small pieces of broken glass and soiled plastic packaging remained, adding to its final weight in kilograms.

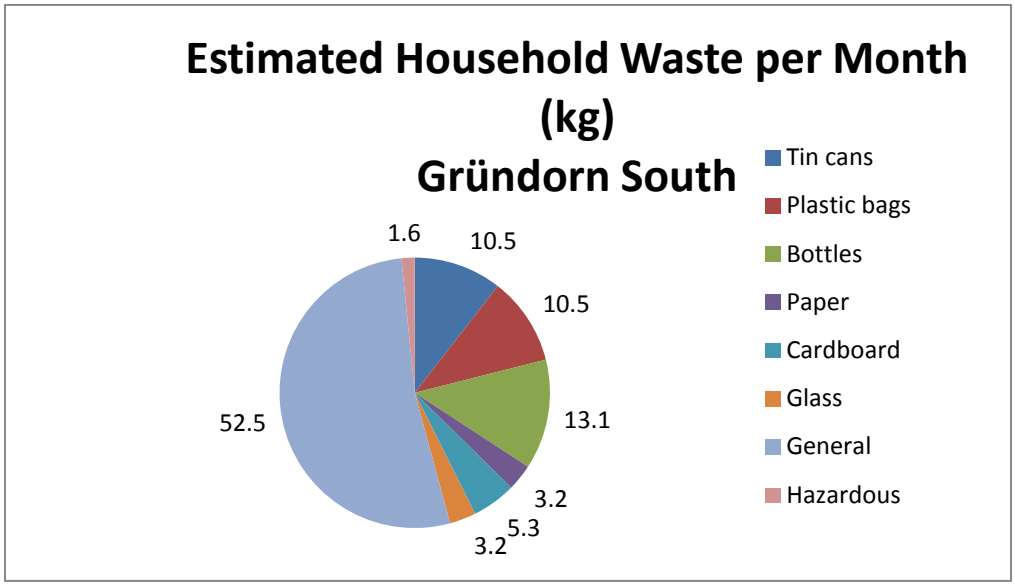

Figure 11. Estimated waste per month in Gründorn South (kg)

In Nico Noord, we conducted a waste audit as well, but it lasted for a period of two weeks and included 11 households. We did this so we could get more precise data over a longer time frame. Again, we estimated this data based off twelve households for consistency in our results. At 15.2 kilograms, the total output per household over the period of one month was a significant increase in comparison to Gründorn South. From the data shown in Figure 12 below, we found that this community had a lot more glass bottles in their waste. In Gründorn South, residents kept glass bottles at their houses until they could bring them into town for deposit to receive money for them. In contrast, the community members of Nico Noord did not seem to care as much about depositing their glass bottles. This was most likely because the residents of Nico Noord had a higher average income than in Gründorn South. When we built the waste collection and sorting center in Gründorn South, we did consider the fact that there could be more glass bottles accumulating if people fail to deposit them, so we did increase the size of the bin for that reason. Also, the amount of plastic bags collected actually decreased from our short

waste audit to our longer waste audit in Nico Noord. We have discovered that in Nico Noord more residents have cars or trucks for transportation than in Gründorn South. This enables them to buy their groceries and other supplies in bulk while the people in Gründorn South cannot carry as much back with them. For this reason, they must go to stores more frequently, and in turn accumulate a greater amount of plastic bags. This highlights the increased concern regarding waste management in Gründorn South as opposed to Nico Noord, because plastic bags were identified as the biggest problem amongst the different types of domestic waste that were discussed. Lastly, the quantity of paper and cardboard is low in both communities. The reason for this is that residents use these materials as kindling and fuel for cooking fires. Therefore, instead of throwing away the paper and cardboard, most of it is reused. Overall, the extended waste audit provided us with additional information regarding the waste streams of these rural communities.

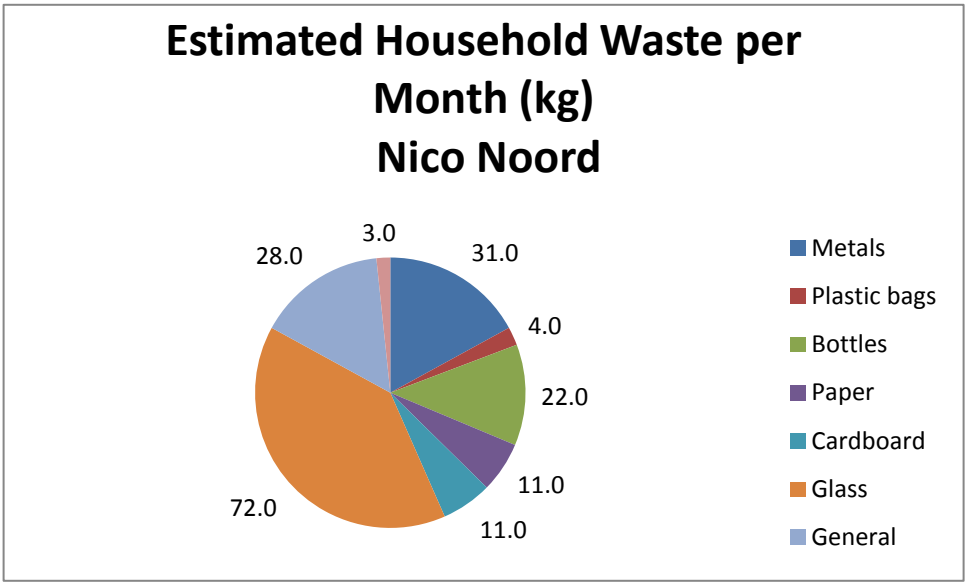

Figure 12. Estimated waste per month in Nico Noord (kg)

4.2 Solid Waste Management

Finding 5. Economic incentives are driving the community members of Gründorn South and Nico Noord to recycle glass, showing that the sale of waste products can provide a supplemental income to residents.

Within both communities, small-scale reuse has been taking place as the residents retain some containers and building materials, which they feel they can reuse again. The main constraint to this is the fact that residents only keep what they can use at that moment, and do not store items such as plastic bottles or metal tins for future use. This leads to the disposal of many goods that could be reused, and are instead burned.

The only product that they have consistently recycled is glass bottles. This is because community members can sell back glass bottles for N$1 in the towns of Gibeon, Keetmanshoop, and Mariental. Residents who do not have access to these towns on a regular basis use the glass as a bartering system for other goods that they may need. This highlights the possible effectiveness of an incentive program for recycling within the community. It also shows that there is already an internal system in place for the sale of recyclables, and that there is a possibility that it could grow if the opportunity arises. Since transportation of the waste from the collection center in Gründorn South to Windhoek or Keetmanshoop for recycling is one of the biggest constraints of the project, it is important to note that residents could transport the waste as part of their regular trips, thereby cutting down on the overall cost. Even though there are not a lot of products being recycled, the fact that the communities made an effort to reuse some materials showed its interest in improving solid waste management.

Finding 6. The residents of Gründorn South identified the need for a centralized collection site in order to improve their waste disposal methods.

In the past five to ten years, concern has grown because of an increase in the use of plastic packaging throughout the community. Through our waste audit, we discovered that 10% of Gründorn South's household waste by kilogram is comprised of plastic packaging, and that burning is still the primary method of disposal. Proper removal methods for plastic bags are largely unknown to the people and dealing with them in the same manner as the rest of their solid waste has largely added to the problem of wind-blown waste. Also, the community expressed interest in having a uniform system of

waste storage and disposal. Complex social interactions among community members have impeded community waste management systems and have limited them to household waste management solutions including the burning of their waste in piles, holes, or drums in their yards. Before our arrival, the community had held meetings to discuss waste disposal practices and solutions with members of the DRFN. The conclusion was that a centralized waste containment area for everyone, to the south of the main residential area, could be a possibility. However, the community did not consider ground water contamination or other environmental concerns.

The proposed site that the residents brought up during our community meetings was a rocky area of land that was approximately 250 meters from the edge of the community. In addition to not being near to any houses, there was also no small stock grazing anywhere near the area. During the meeting, the community members also emphasized the fact that they not only wanted to have their recyclables placed in a centralized location, but also wanted this to include their general and hazardous waste. They also stated that their recyclables, hazardous, and general waste could be in the same place, but that they did not want the centralized location for their Otji toilet waste to be in the same area as their solid waste. Their reasoning for wanting to get all of their waste out of their yards was the fact that the burning of waste was having a negative impact on their lives. After this meeting, it became clear that the people of Gründorn South wholly approved of a centralized waste disposal site.

Since there is no governing body within the community, we posed a question to the residents about how they are going to make sure that everyone is using the centralized sorting site correctly. One man, named Paul Gertze, volunteered himself to be in charge of it since he had to go by the area every day on his way to his small stock. He said that he would make sure no one was stealing any of the building materials and that people were correctly sorting their solid waste into its respective bins. On top of that, the people stated that it was the responsibility of each person to check up on their neighbors and make sure everyone was following the guidelines of the sorting center. The community members also agreed that they would all sign a contract showing their dedication to the use and upkeep of the site. They said that if a community member was not using the site and was still burning their waste in their yard, that one of their neighbors would talk to them and discuss the incentives for recycling and getting their solid waste away from their household. Two posters, entitled “Dangers of Trash” and “Recycling and Re-Use,” were shown and explained during our meeting, and were left in the community. The posters can also help to show neighbors why centralized waste disposal is important. In addition, everyone at the meeting agreed that punishment for not using the site was unnecessary and

that communication regarding the improper use of the site would suffice. In conclusion, the residents of Gründorn South recognized the need to improve their current waste management practices, and worked with us to develop and construct a centralized waste collection and sorting center that they could use and maintain.

Finding 7. The use of familiar construction materials and techniques helped to facilitate community participation in the project.

Extensive community participation in the implementation of the center was largely due to the high demand for the site and the expertise that they were able to bring because of the use of their own tools and building techniques during the construction phase. Community members of all ages and genders came out to help and contribute their efforts in whatever way possible. Community participation will be a key part in helping to ensure the future success of this waste disposal site. It shows that the community is invested in the project and understands its benefits.

In conjunction with the community, we selected the structure of the site and the materials needed to best benefit the residents and ensure that the facility lasts. The construction of the sorting center included such materials as wooden posts, chicken wire, and mesh fencing. Originally, the plan was to make the walls of the sorting center out of corrugated iron. The reasoning for this was because iron is sturdy, relatively cheap, and was readily available, as it is used in almost all households. This idea was quickly changed as we found out that corrugated iron would be more susceptible to theft because it is a commonly used material for local repairs. Another reason for the fencing was that waste in the compartments would be visible through it. This was helpful, because even though there were signs labeling each bin, not everyone in the community is literate. The site design, with a central alley wide enough for a donkey cart (the main mode of transport) to pass through, allowed for ease of access for the depositing of waste. Figures thirteen through eighteen show the step-by-step construction process.

Figure 13. Hole digging using a heavy handle to separate the sand from the gravel

Figure 14. Support poles in cement left to set in the sun

Figure 15. The first support wires are twisted around the support poles

Figure 16. A finer mesh to separate compartments is attached to support poles with twisted wire

Figure 17. The penultimate layer of alley fencing is attached to the support poles

Figure 18. The completed Collection center with attached lids, gates, and demarcations

4.3 Otji Toilets

Finding 8. Over the past year, all community members interviewed have identified the Otji toilets as a successful solution to their sanitation problems.

From our interviews, we found that households with an Otji toilet identified a number of problems with open defecation, specifically the "bush" method, which the Otji toilets helped to remedy. When 'the bush' was still the primary location for defecation, there was a feeling of vulnerability in regards to wildlife and other neighbors who were watching their small stock. To gain a greater sense of security, residents would traverse great distances to use the bush, which would pose a problem to the older residents with limited mobility. Human waste, like solid waste, was also posing a threat to small stock, which were at risk of falling ill from its consumption, as defecation practices often occurred within grazing lands. The main advantages of the Otji toilets, as identified by their owners, are the greater sense of security, the shorter distance to travel, and the ability to prevent their small stock from consuming fecal matter. Although the advantages were exceptional, almost all of the community members said that were it not for a government grant, they would not be able to afford one themselves.

During the interviews, we asked the people to help us rank the toilets in terms of ease of maintenance, the ability of the toilet to eliminate odor, the structural integrity, and their overall view of the toilet (See Appendix C). After receiving twenty-five responses, very few ranked any of these categories below a four or a five. This helped to portray more quantitatively the positive reception of the toilets by residents. In addition, it shows that the toilets can be effective over a long period with regular cleaning and upkeep. Although we did get good results from this method, we often found it challenging to explain the system, and thought that it had the opposite effect of our intentions, which were to limit the language barrier.

In the year since most families received their toilets, not one family had completely filled up their first bucket. In our interview with Sarah Bock, she indicated that poverty and food scarcity were the root cause of the emptiness of the buckets. However, some families had already switched the buckets, as it would be easier to switch while they were lighter. In some cases, older respondents and heads of households would be unable to shift or pick up a full waste collection bucket. For those that were unable to shift the buckets, due to either age or disability, they stated that they would rely on the help of others to ensure the continued use of the toilet. This shows that the residents are very cognizant

of what needs to be done in order to sustain the toilets for as long as possible, and that they are willing to put in the necessary effort.

Finding 9. Residents expressed concerns with the Otji toilets as there were insects entering the chamber, a lack of reinforcement of the roof, two broken drying plates, and a problem regarding the safety of children near the toilets.

Through our analysis, we saw some challenges associated with the design of the Otji toilets shown in Appendix Z. There have been a few instances of insects and small animals getting into the chamber through uncovered openings for ventilation around the door, the ventilation pipe, and a small window. Some community members expressed concerns about the superstructure of the toilet being too narrow, the ceiling tiles not being secured enough to handle strong winds, or the foundation of the toilet sinking due to a lack of reinforcement. During our inspection of the toilets, we observed two broken drying plates in the collection chamber because of the lack of support in the middle of the plate. The drying plates support the collection buckets above the foundation of the collection chamber before they are emptied. One safety concern, stated by multiple community members, was the fact that the Otji toilet was unsafe for small children. They said it would be beneficial to put a fence in place around it to prevent the kids from easily entering. This fence would also help with keeping large animals away from the toilet, since they have caused damaged to the structure on occasion. In regards to sanitation, some residents would consider hand-washing facilities closer or adjacent to the structure beneficial, but most had already devised other means of washing their hands at their houses after using the facilities. Overall, while the general feedback regarding the toilets was positive, there are several problems that still need to be addressed in order for further improvements to be made.

Finding 10. Although five households in Gründorn South and Nico Noord initially agreed to share their Otji toilets, disagreements regarding maintenance have caused three of the households to revert to the bush or the bucket method, putting themselves and their small stock back at risk.

One of the main constraints that we found with the usage of the Otji toilets came when more than one household agreed to share a toilet. In several instances, only one of the households used the toilet consistently, while the others continued to use older, unsanitary methods such as the bush or the bucket system. Community members discussed the reasons why the shared toilets were unsuccessful,

and stated that disagreements regarding who was responsible for its maintenance and upkeep were a major concern. Several residents said that they did not feel comfortable having to clean up after someone else's waste, and that they did not want to have to empty the buckets if more than one family was using it. Even though they had agreed to share it when they were first constructed, that relationship quickly faded, leading to tensions between neighbors. This also presents a challenge for future implementation if the government chooses to give each individual household an Otji toilet. This is because the toilets in these situations are located directly in between the sharing households. If more toilets are constructed, there will almost certainly be debates as to the relative proximity of the new toilet to each household, as all parties would want it closer to their own home. While the Otji toilets have been very successful, several obstacles still lay ahead before widespread implementation will be feasible.

4.4 Otji Toilet Waste Management

Finding 11. In the past year, the perceptions of nine of seventeen interviewed residents on the reuse of human waste have altered, allowing them to consider composting, but only with increased education and training.

As part of our evaluation of the Otji toilets, we examined the current human waste collection and disposal systems at each household. Out of the seventeen Otji toilet owners that we interviewed, four had switched the buckets within the chamber, and only two had emptied their waste. Out of those two, one had burned the emptied waste, while the other had buried it outside of their yard. Of those that had not yet emptied their waste, seven mentioned that they might use it for compost, while the rest said that they would either bury or burn it. We found that unless they had personally seen how composting works, the community members were very skeptical about whether it would be safe. They did not feel comfortable mixing their fecal matter in their garden where they would be growing food for consumption. In addition, some residents even stated that they would simply dump their waste in a field away from their yard. In this case, community members will put themselves and their small stock at risk for the same health issues that the Otji toilets were instituted to help mitigate. We found that a workshop for the community to help them fully understand the benefits of composting and how to do it both safely and effectively would be most beneficial.

4.5 Summary

We have discovered the major problems related to solid and human waste management within Gründorn South and Nico Noord. They are largely the result of a lack of communication amongst residents and the absence of a centralized waste collection and sorting center. Through our fieldwork and analysis, we can conclude that the construction of the collection center will allow the residents of Gründorn South to stop burning waste in their yards. It will also improve the safety conditions for the people and small stock living there. The recommendations that follow will help to ensure the success of this pilot project for future years, and will allow for its implementation in other rural communities.

5. Conclusions and Recommendations

After completing two weeks of fieldwork, personal research, site visits, and interviews with local experts, we have formulated the following conclusions and recommendations for the DRFN, government bodies, and other organizations to implement in the rural communities of Gründorn South and Nico Noord in the Hardap region. The focus of this section is the improvement of solid and human waste management so as to increase sanitation levels within these rural communities.

5.1 Waste Audits

We recommend that residents of Gründorn South sort all waste at the household level into the categories of paper and cardboard, plastic bottles, plastic bags, glass, metals, hazardous waste, medical waste, and general waste. General waste consists of anything that does not fit into the other categories. These categories were chosen because of the composition of the communities' waste and their personal input during interviews and focus groups. The results of the two waste audits we performed showed the importance of managing waste on both a household and a community-wide scale. By doing this, community members are better able to analyze the composition of their waste and identify what can be reused first. Although it may take some time for community members to become accustomed to this system, it benefits them in the long-term because it allows them to use a larger percentage of their goods more than once, and it helps to prevent the build-up of one large pile of waste in their houses and yards.

5.2 Solid Waste Management

We recommend that the community members of Gründorn South bring the sorted waste from their households to the collection center on a regular basis to prevent build up in their yards. It is important that their waste is not stored in their yards because it increases the chance of it blowing away into other yards and being consumed by small stock. The only category of waste not meant for disposal in the collection center is medical waste, such as syringes. This is because community members discussed concerns with the possibility of having to handle other people's medical waste. Therefore, we advise that each household have a separate bin where they keep all of their medical waste completely separate from the rest.

We recommend that no waste, other than medical waste, be burned in or near the yard of any household in Gründorn South. With the addition of the collection center, all waste can be safely stored in an area that is approximately 250 meters away from the nearest household or small stock pen. This will not only reduce the amount of smoke that community members breathe in, but it will also increase the available space in their yards for activities such as gardening and keep the waste away from children and small stock.

We recommend that if one of the waste compartments of the collection center does fill up, that residents analyze its contents to determine possibilities for reuse, or sale in a nearby city, such as Gibeon, Mariental, or Keetmanshoop. **If neither of these is the case, we recommend that one member of the community burns the contents of the bin**. The main constraint regarding the emptying of the waste in the collection site is the lack of access to a centralized pick-up system. However, our results show that it will take approximately seventeen months to completely fill up the first bin, allowing for further research and development. Although this is not ideal, it is an improvement on their current disposal methods, which include the burning of waste on a regular basis in close proximity to their houses and small stock. As this is a pilot study, more research on the feasibility of a centralized waste and recycling collection system for other rural communities of the Hardap region is necessary.

In order to build on our research, we recommend that the DRFN keep in close contact with recycling transport companies such as Rent-A-Drum, as well as the regional council and municipalities, to work towards the implementation of a centralized pick-up system. As part of this system, community members can begin to bring small amounts of waste to Windhoek or Keetmanshoop when they travel to these locations to pick up necessary supplies. The most important material that needs to be transported is hazardous waste, such as batteries, because it presents the most danger to community health in the short term. Since the cost of transportation is the biggest constraint to the successful implementation of this process, using already established travel routes will help to decrease the cost and inconvenience to residents. This will not only eliminate the need for the burning of waste at any level, but it also presents the possibility of providing the community with a shared income generated from their waste.

We recommend that Mr. Gertze, the man in charge of the collection site, examines the site for any maintenance problems at least three times per week, and that he reports to the DRFN at least once a month with any problems, or any positive feedback. Although the entire community has agreed to take responsibility for the proper use and upkeep of the structure, having one person in charge will help to hold community members accountable to the guidelines that they have agreed upon.

As a way to solidify these guidelines, **we recommend that all members of the community sign the contract that we have written, and that Mr. Gertze keeps it** as a constant reminder of their responsibilities.

We recommend that DRFN staff members check the collection site at least once a month for the first year so that they can address any issues, in conjunction with the community, as soon as possible. This could be done over the phone or in person through Paul Gertze, who was selected by the community as the individual who would be the main contact for the project. In order to gauge the successes and challenges of the collection site over time, we have created a monitoring system that the DRFN can put into place at the entrance of the collection center. Community members will place their waste from each category into a bucket with a known volume and record the number of buckets that they have filled each time. While the final goal for the site is for it to be completely maintained by community members, initial assistance from the DRFN will help to ensure that the pilot study is successful over a longer period of time. The monitoring form can be seen in Appendix T and Appendix U.

As a centralized system was not constructed in Nico Noord, we recommend that all households store their solid waste in a hole at least one meter deep, which is surrounded by a fence that is at least 1.5 meters high. Although this is not the ultimate solution, it will help to mitigate the amount of windblown waste within the community, and will help to keep small stock from consuming waste. In order to reduce the amount of waste at these sites, we recommend that residents deposit all recyclable glass in nearby towns such as Gibeon, Mariental, and Keetmanshoop.

We recommend that the DRFN continue to use workshops to educate community members about the dangers of waste, and the benefits of the pilot system at least twice per year. After working with the community of Gründorn South on the construction of the project, and hearing their thoughts and opinions in our focus group meetings and workshop training session, it was evident that continued training and education will be vital to the future success of this and other projects. As such, it will be important going forward to ensure that they can always see the benefits of the newly constructed collection system.

5.3 Otji Toilets

Due to the success of the pilot study in the past year, and the demand for Otji toilets among residents, we recommend that the DRFN work with the DWSSC and other local government authorities in order to provide funding for Otji toilets for every household in Gründorn South and Nico

Noord that does not yet have one. Although the funding will need to come from government budgets, it is important that the DRFN continue its work on the project in order to ensure that the data collected over the past year is used to improve the pilot study in the future.

We recommend that all Otji toilets constructed in the future be the property of one household, and that it be located within that household's yard, if space permits. Although the project as a whole has led to major improvements in the sanitation conditions of both communities, there are still several constraints that will need to be addressed going forward. The first problem that we encountered involved the sharing of toilets between two or more households. While this did work for a short amount of time, it is no longer successful after a year in most cases. In most instances where families were sharing a toilet, only one of the households was still using it, and the other had reverted to methods such as the use of the bush. After discussing this issue with several households, we can conclude that most problems arose from the fact that one household did not want to be responsible for the cleaning and maintenance of a toilet being used by more than just their family. In addition, some community members could not physically maintain or easily access the toilet because of their age or for health reasons. Although this will lead to an increased cost of construction, it will help to ensure that each Otji toilet is being used effectively so as to prevent the use of unsanitary methods.

We recommend that concrete blocks be placed along the middle of the underside of the drying plates during construction, or that the drying plates be reinforced using steel rebar when they are first made. The first structural issue that we encountered was in regards to the drying plates that the collection buckets sit on. In two of the toilets, the plates were completely cracked, meaning that the buckets could not be moved back and forth as needed. In several others, small cracks were visible, but the plates had not yet broken. This reinforcement will ensure that they do not crack or break when the buckets are being moved within the chamber or being placed back on the drying plates after being emptied.

We recommend that all roofs be reinforced using four, 1.23-meter pieces of steel rebar that are placed over the top of the roof and secured with screws going through the roof and into the main frame of the toilet. In several cases, the roof of the toilets had been damaged by the wind or other weather conditions. For those that were damaged, metal rods that were approximately 1.23 meters in length had been placed at each overlap along the length of the roof tiles and were secured using wires. Not only can this be done to new toilets that are built, but it can also be added to existing toilets in order to decrease the need for long-term maintenance of the roof.

We recommend that the top of the ventilation pipe be covered with one-centimeter wire mesh, and that a 0.3-meter diameter cone be placed over the top of the pipe. Although the ventilation pipe was performing its main function of reducing smell and drying out the waste, there were several issues with rainwater and bugs entering the collection chamber through the pipe. The wire mesh will keep larger insects from entering the collection chamber, and the cone will keep most of the rain out, decreasing the time needed for the waste to dry out.

We recommend that each household construct a fence that is at least 1.5 meters high around the toilet, and that the fence be locked when the toilet is not in use. Our findings showed that some people had concerns about small children being able to access the toilet without supervision. Another issue was the possibility of larger animals running into the toilet and damaging it. At one of the households, an animal had damaged the superstructure of the toilet and two of its brick walls had to be rebuilt. Due to the unique nature of each house and yard, it is important that this fence be designed and constructed on a household level, and not be standardized as part of the Otji toilet self-builder set (See Appendix Z). Overall, our results showed that the general structure and design of the toilets have been effective over the past year, but that the recommendations discussed would help to make them safer and more user-friendly.

We recommend that each household construct a hand washing facility that is adjacent to their Otji toilet and that the water not be reused. While this will lead to increased water use, it will help to ensure the health of community members who use the facilities. Our findings show that only some of the toilets have attached hand-washing facilities, and that most are located closer to the house than the toilet. Due to this, it is very easy for residents to avoid washing their hands, especially if they are busy with completing other tasks. This leads to poor sanitation practices that can put them at risk for health problems that could be easily avoided.

We recommend that the DWSSC hold meetings at least three times per year with the community in order to provide education on topics such as hand washing, proper handling of the Otji toilet waste, proper handling of medical waste, and solid waste disposal methods. Over the past year, the Directorate of Water Supply and Sanitation Coordination has taken on the responsibility of maintaining proper levels of sanitation within the rural communities of the Hardap region. Our community interviews and meetings show that this topic has not been properly addressed within these communities outside of the education provided by the DRFN. Community members expressed interest in meetings regarding sanitation, and more exposure to government officials in these meetings may help to hold them accountable for following proper sanitation practices.

We recommend that short and long-term monitoring systems be used by the DRFN for pilot studies such as this, and that they are tailored to fit the specific needs of each community. As a means to evaluate the success of the Otji toilets on a more regular basis, we have developed both a daily and a monthly monitoring system that each household with an Otji toilet will fill out. These forms, which can be seen in Appendix P through Appendix S, were edited and discussed by the community members of Gründorn South during our final meeting with them. They provided valuable feedback on the design of the forms, which included increasing the font size and adding pictures, and agreed to fill them out as needed. Also, by evaluating the toilets before creating a monitoring system, we could see what areas needed to be addressed on a daily basis, and which ones could be examined monthly. In the end, community members were very receptive of the monitoring plans, allowing us to conclude that they understood the purpose of the pilot study, and were taking personal ownership of its success.

5.4 Otji Toilet Waste Management

We recommend that composting be used to manage the human waste output from the Otji toilets. Due to the amount of human waste that residents will empty over the course of the next year, it is important that there is a standardized method developed for its disposal. Lab results from the pathogen analysis of the fecal matter show that composting is a safe solution for managing the human waste from the Otji toilets so long as the methods outlined in Code of Practice: Volume 10 are closely followed (Code 2011).

We recommend that the DRFN conduct household interviews and community meetings focusing on the benefits of composting, as well as the dangers of the improper disposal of human waste, before the implementation of a composting system. The results of our pathogen analysis testing could be used in these meetings and interviews as a definitive way to show the community that the waste is safe for use on gardens so long as it is managed correctly.

We recommend that the DRFN construct a composting structure similar to the one seen in Appendix X at least fifty meters away from the collection center in Gründorn South at a site agreed upon by the community members. Due to the nature of thermophilic composting, and the volume of human waste being produced, we recommend that each household switches and/or empties their waste buckets every six months, starting on the same day. This will help to hold people accountable and will also help to standardize the amount of time that the waste pile needs to sit before it can be safely used. From our research, we have found that waste needs to sit for a minimum of one year before it can

be used as compost in gardens (Jenkins 2005). Residents can then bring their waste from the Otji toilets to this site once every six months, on days specified in advance during community meetings.

We recommend that the community manage the compost site as follows:

1. Waste from the first two, six-month rotation periods would be dumped into the first bin
2. The middle bin would be used for any extra organic matter that does not fit into the first compost bin
3. Waste from the next two, six-month rotation periods would be dumped into the third bin while the waste in the first bin is allowed to decompose for that year
4. After the one year waiting period, waste from the first bin can be used on gardens, while the third bin is allowed to sit for one year
5. After another six-month rotation period, any compost left in the first bin would be transferred to the second bin for use at a later time so that the first bin can be filled again

These steps, which we developed in part from the Humanure Handbook and Code of Practice: Volume 10, would need to be adapted based on the perceptions and input of the local community members. Due to the fact that several community members expressed concern with the idea of using human waste as compost, education would be the key component to the success of this project. In conclusion, our results show that composting is a safe and viable option for the management of human waste in these arid communities, and that further research needs to be completed in order to devise systems specific to Gründorn South and Nico Noord.

5.5 Future Projects

Composting

We recommend that a project involving composting be considered by the DRFN for further research. We have established, through our Polytechnic of Namibia lab results, that composting is a safe and viable solution for the disposal of Otji toilet waste. However, there are regulations and guidelines within the Code of Practice: Volume 10, which researchers need to analyze and follow to assure the proper use of human waste as composting material (Code 2011). Additional information on the nutrient content of the fecal matter and soil would be beneficial to community gardening practices, as well. Although there has been background research done by our team to ensure that the project is feasible and safe, there is enough work to be completed in research, education, and implementation to warrant its own project.

We recommend that the DRFN consider researching the reuse of urine from the urine diversion toilets in accordance with Code of Practice: Volume 10 (Code 2011). With the newer design of the Urine Diversion System for the Otji toilets, the possibility of collecting urine for gardening purposes and nutrient enrichment is possible. This would necessitate further thought and consideration, as well as an assessment of its feasibility.

Improper Waste Management

We recommend that the DRFN research the economic ramifications of improper waste management. From our research, we have concluded that improper waste management, from the standpoint of community members, is a financial hazard. Proving the necessity of enhanced waste management with concrete statistics, and a financial analysis regarding the loss of small stock and working ability from ingestion of contaminants, would allow for a substantial argument in favor of funds allocation and energy devotion to such a venture. We recommend that rural and urban populations be analyzed.

Biogas

We recommend that the DRFN conduct research on a project involving biogas for the communities of Gründorn South and Nico Noord. Biogas is another solution to human waste

management that can stand to supplement solar panels and other means of electricity in rural communities. Due to the fact that we did not extensively research this topic while in the field, more analysis will need to be completed into the feasibility of such a project. However, Sarah Bock, a community member in Nico Noord, currently has a biogas digester, showing that the implementation of such a system is possible for rural communities. This also provides a starting point for research in order to analyze the feasibility of implementing other biogas digesting systems. There is enough work to be completed in research, education, and implementation of biogas digesters to warrant its own project.

5.6 Recommendations for Future Researchers

We recommend that all capacity-building projects make use of participatory approaches whenever physical infrastructure or monitoring systems are being introduced. Throughout the course of our research and fieldwork, we used community participation and input to guide both the collection system that was put into place, and the recommendations that were made regarding future research and projects. Were it not for their suggestions and their help during the construction phase, the center would not have been completed, and its future success would have been compromised. The use of participatory approaches will help to ensure that the solutions which are being put into place will work for that specific community, and that the community will take ownership of the project. From our Otji toilet evaluation interviews, we were able to conclude that the community felt a sense of ownership of the toilets not from monetary input, but from the time and labor that they contributed.

We recommend that the implementation of all community-based projects include hands-on training as a group in order to increase accountability, reduce instances of miscommunication, and ensure that everyone involved with the project has the same vision for its future uses and success. From our results, we have found that adequate training is necessary in order for a community to participate in and carry on a project. In our case, we held a training session during the construction phase of the collection center, just before it was finished. The timing of this meeting was most effective because it allowed people to see part of the physical infrastructure first so that they would have a better understanding of how it would work. It also allowed us to stress the importance of community participation until the construction was complete, which brought a large number of community members to the site. The most important parts of the session were our discussion on the current conditions within the community, as well as allowing the community members that were present to evaluate and provide input on the monitoring system that we were proposing for the collection center.

5.7 Summary

In conclusion, our results show that the improper management of solid waste within Gründorn South and Nico Noord poses a danger to the community members and their small stock. In order to improve the current conditions, we have constructed a centralized waste collection and sorting system, and recommend that:

1. Waste be sorted at the household level then brought to the centralized collection site
2. Monthly monitoring of the collection site be performed by the DRFN
3. Otji toilets be constructed for all households in Gründorn South and Nico Noord
4. Structural updates to the Otji toilet occur
5. The DWSSC increases education on sanitation
6. Composting be used for the management of human waste
7. Participatory approaches and educational training be utilized for the design and implementation of future projects

Overall, the completion of these recommendations will help to alleviate issues with solid and human waste management within the Odendaal farms of southern Namibia. We presented these recommendations to the communities as well as the DRFN in the hope that they will continue to work together in order to make improvements in these areas in the future.

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7. Appendices

Appendix A. Community Perception Interview Questions

Preamble: The purpose of this survey is to establish community perceptions of waste from the source, at waste generation, to disposal. The questions will be asked by the team from Worcester Polytechnic Institute in the United States. Responses are anonymous and will be reviewed to understand collective, majority thoughts, as well as individual concerns in regards to waste management.

- How do you define solid waste/trash?
- What do you do with your waste/trash?
- Does the trash have an impact on your home or community?
- How and where do you store your trash before disposing of it?
- What concerns do you have about present trash disposal methods (e.g. safety, health, environment, cost, etc.)?
- Have trash disposal methods changed in recent years, and if so, why?
- Would you like to change anything about your waste disposal methods, and if so, how?
- What do you know of recycling or reuse methods?

Appendix B. Waste Audit Interview Questions

Preamble: The purpose of these interview questions is to examine motivation and processes associated with waste generation and disposal. The questions will be asked by the team from Worcester Polytechnic Institute in the United States. Responses are anonymous and will be reviewed to better understand present practices and logic to enable consideration of viable solid waste management solutions.

*Name:*_____
*Age and Gender:*_____
*Community:*_____
*Date:*_____
*Occupation (formal or informal):*_____
Monthly income (outside sources too): 100-200|200-300|300-400|400-500|500-600|600-700|700+
*Number of people in household:*_____

- Where do you purchase most of your goods (from outside and inside the community)?
- How and by whom were the products used?
- What types of things do you throw away and why?
- Were any products saved (reused or recycled), and if so, which ones?
- How do you make use of your waste?

Appendix C. Evaluation of the Otji Toilet Survey Questions for Individuals

Preamble: The purpose of these survey questions is to evaluate the effectiveness of the Otji toilets, in the opinion of the community members who own such toilets. The questions will be asked by a team of engineering students from Worcester Polytechnic Institute in the United States. Responses are anonymous and will be reviewed to better understand the use and implementation of the Otji toilets for further analysis to make suggestions for improvement.

*Name:*_____
*Age and Gender:*_____
*Community:*_____
*Date:*_____
*Occupation (formal or informal):*_____
Monthly income (outside sources too): 100-200|200-300|300-400|400-500|500-600|600-700|700+
*Number of people in household:*_____

- Do you use the toilets on a regular basis?
- Who is using the toilets (including how many people)?
  Select: Family Guests Both Neither/Abandoned
- What maintenance do you perform on the toilet and who does it (if it needs maintenance)?
  Select as applicable: Cleaning of: bowl | ventilation system | waste collection chamber
  Repairs to: structure | bowl | ventilation system
- How often do you empty and/or shift your Otji toilet waste bucket?
- How do you dispose of the waste from the Otji toilets?
  Select: Dispose in the surrounding environment Burn Bury
- Do you feel that you have received adequate training on the use and maintenance of your Otji toilet?
  Y/N
- Have you had any issues with bugs, snakes, or other wildlife getting into the toilet or collection chamber?
  Y/N
- Do you feel there still a demand for the toilets from other people living in your community?
  Y/N
- Have you experienced any challenges with the Otji toilets and do you have any recommendations?
- If offered a toilet, would you be willing and/or able to pay?
- Is it OK for us to examine your Otji toilet?

Criteria for Otji Toilet Evaluation:

	[Excellent]		[Neutral]		[Poor]
Ease of Maintenance:	5	4	3	2	1
Eliminating Odor Emission:	5	4	3	2	1
Structural Integrity:	5	4	3	2	1
Overall view of Toilet:	5	4	3	2	1

Appendix D. Otji Toilet Evaluation Information and Criteria Data Tables

Information	**Respondent 1**	**Respondent 2**	**Majority Answer**	**% Majority**
Demand for toilets				
Adequate training				
Able to pay				

Criteria	**Respondent 1**	**Respondent 2**	**Respondent 3**	**Average**
Ease of Maintenance				
Eliminating Odor Emission				
Structural Integrity				
Issues With Wildlife				
Totals				

Appendix E. Interview Questions for City of Windhoek Solid Waste Management Division

Preamble: The purpose of this interview is to gain a better understanding of waste from the point of generation to final disposal. Participation-enhancing campaigns will also be analyzed. The questions will be asked by the team from Worcester Polytechnic Institute in the United States. Responses will be reviewed to understand waste management from the level of a municipality organization.

- At what scale did you start collecting waste and on what scale is waste collected now?
- What kind of data goes into a collection fleet assessment to ensure that the current fleet meets requirements?
- What kind of programs do you have regarding education and awareness?
    - How do your educational programs differ between community and school programs?
- What kind of programs do you have to encourage community participation?
- Do you have any suggestions for programs on education and community participation in rural communities?
- What criteria do you have regarding site surveying for a landfill?
- Do you have any suggestions on how to create a feasible landfill in rural communities?
    - Size, location, etc…
- What sorts of challenges does a landfill in this sort of environment face?
- What factors need to be address regarding hazardous and general waste separation and disposal?
    - For instance, how are the liners different?
- What are the costs associated with landfill maintenance and construction?
- Do you think it would be feasible to have pick-ups of any kind for rural communities?
- Do you have suggestions of how to create a feasible recycling/solid waste pick-up in rural communities?
- By what means would one go through to seek approval for such an endeavor?
- Do you know of any rural waste and recycling collection systems in place presently?
- Do you know of any other organizations that you think would be helpful to contact for our project?

Appendix F. Interview Questions for Rent-A-Drum CC

Preamble: The purpose of this interview is to gain a better understanding of recycling practices. The questions will be asked by the team from Worcester Polytechnic Institute in the United States. Responses will be reviewed to understand recycling and reuse management from the level of a municipality-wide, private organization.

- How was the company founded on collecting recyclables?
- Where did the blue bag collection commence?
- How many cities or communities do you currently pick up bags from?
- How often do you pick up the recycling bags/ how many bags do you usually pick up at a time?
- What volumes of unsorted then sorted recyclables are you collecting?
- Where do the compacted recyclables go after they are prepared for transport?
- Did it prove beneficial to supply an instruction manual when you first gave the bags to the households?
- Before you started this recycling campaign, were the people in these cities recycling anything at all?
- Are most households using the bags and recycling or do a lot of people still just throw everything away?
- What are the costs associated with recycling collection and transport?
- What makes these operations cost effective?
- Do you know of any rural collection services?
- Do you know of any other companies that you think would be beneficial to talk to for our project?
- Is it possible if we could take some plastic bags when we go into the field ourselves and collect waste?

Appendix G. Official Letter of Request for the Life Sciences Laboratories at Polytechnic of Namibia

Dear Mr. Nowaseb,

As students from Worcester Polytechnic Institute (WPI) in Worcester, Massachusetts, we are given the opportunity to complete project work off campus through our Interdisciplinary and Global Studies Division. This work helps to prepare students to use the knowledge that they have gained in the classroom in order to develop solutions to problems relating to technology and society. By working in a team of four, advised by two faculty members, students are able to gain valuable experience in teamwork, public speaking, report writing, and problem solving.

More specifically, as third year students, we are currently in Namibia working towards the completion of our Interactive Qualifying Project. This unique, interdisciplinary requirement brings students from different fields of study together to research and address challenges that affect people, communities, and institutions around the globe.

The Desert Research Foundation of Namibia (DRFN) has hosted students from WPI for the past seven years. This year, two groups of students are working on projects in the sectors of water and energy. The water group will be completing a project in the Hardap region entitled *Support to Rural Communities for Improved Solid Waste Management*, and the energy group will be completing a project entitled *Evaluation of the Tsumkwe Energy Project*.

As members of the group working with the water desk of the DRFN, we will be focusing our project on the improvement of sanitation in regards to the use of natural fertilizers in the rural communities of Gründorn South and Nico Noord. In order to accomplish this goal, we hope to use an assessment of the pathogens present in the fecal matter, of which we have collected ten samples. We thank you in advance for taking the time to complete such an analysis and for helping to ensure the safety and well-being of the members of the aforementioned communities.

Sincerely,

Fransiska Nghitila
DRFN Researcher
With Elyssa Dorenfeld, Patrick Ford, Livia Motz, and John Petitpas

Appendix H. Community Member Interview Data

Sample table:

Community	Gender	Age	
Occupation	Income	Size of household	
Where products are purchased:		What is purchased	
What is thrown away		What is reused	
How is waste disposed of		Sample information if applicable	
Otji toilet use	Who uses the toilet	Maintenance	State of buckets
How do/would you dispose of the ecosan?		Have you received adequate training?	
Problems with wildlife		Is there a demand for more Otji toilets?	
Challenges with Otji toilet		UDS/not UDS	
Would you purchase a toilet?		Criteria: X,X,X,X (See Appendix C)	
Comments:			

Interview Data:

Gründorn South	Male	30	
Farmer	N$ 400/month	Household of 7	
Products purchased from Anzel Gründoring Winkel			
Throws away plastic bags, empty containers, and spray cans		Reuses containers	
Burns waste twice a month 30-35 yards from house		Sample #1 filled half a bag in 4 days (.75kg)	
Uses Otji toilet daily	Used by family and guests	Cleaned daily	Bucket not full
Would place ecosan into a hole then burn and cover it		Has received adequate training on Otji toilet	
Has seen geckos in the drying chamber		There is still a demand for Otji toilets	
Smells sometimes when it is windy		Not UDS	
Would buy a toilet if he could pay in installments		Criteria: 5,5,5,5	
Comments: Does not separate waste before it is burned, added plate on roof tiles for support, washes hands in his house, does not have a good understanding of ecosan reuse, uses toilet paper and newspaper			

Gründorn South	Female	Declined to give her age
Farmer	Grant of N$ 550/month	Household of 2
Products purchased from Anzel Gründoring Winkel: maize meal, flour, rice, cooking oil, tea, sugar, coffee		
N/A	Reuses plastic/paper bags	

Burns waste in a gully in her yard (.75kg)	Sample #2 filled 2/3 of a bag in 4 days
Uses the bush	Wants an Otji toilet for herself but could not afford one
Comments: She was given the opportunity to share with neighbors but does not	

Gründorn South	Female		Declined to give her age
Farmer	Grant of N$ 550/month		Household of 4
Products purchased from Anzel Gründoring Winkel or Mariental			
Throws away plastic bags, paper, tins		Reuses containers	
Burns waste 20 meters from house		Sample #3 filled ¾ of a bag in 4 days (1.5kg)	
Uses Otji toilet daily	Used by family	Cleaning	One bucket rotated
Would burn ecosan or store it for gardening		Has received adequate training on Otji toilets	
Has seen geckos and one snake		There is still a demand for Otji toilets	
Wants to add tiles and mat for aesthetics		UDS	
Wants an Otji toilet but could not afford one		Criteria: 5,5,5,5	
Comments: Rainy season lessens waste pile			

Gründorn South	Male		72
N/A	Grant of N$ 550/month		Household of 1
Products purchased from Anzel Gründoring Winkel			
Throws away bottles, cans, and plastics		Reuses coffee cans	
Burns his waste behind neighbors house		Sample #4 filled 1/8 of a bag in 4 days (.5kg)	
Uses Otji toilet often	Three houses share the toilet	Cleaning	Bucket not full
Would burn ecosan or store it for gardening		Has received adequate training on Otji toilets	
None		There is still a demand for Otji toilets	
None			
Could not afford		Criteria: 4,5,5,5	
Comments: Drying plate broken			

Gründorn South	Male		70
Farmer	Grant of N$ 550/month		Household of 3
Products purchased from Keetmanshoop			
Throws away paper plastic bags, tins		Reuses cans, bottles, and wire	
Burns waste in a drum in the yard		Sample #5 filled 1/3 of a bag in 4 days (.5kg)	
Uses Otji toilet daily	Family and guests use toilet	Cleaning	Bucket not full
Would dump ecosan in the bush		Has received adequate training on Otji toilets	

Bee's nest	There is still a demand for Otji toilets
None	N/A
Would buy a toilet	Criteria: 5,4,5,5
Comments: Community toilet for churchyard would be helpful, drying plate broken	

Gründorn South	Male		51
Farmer	Sells small stock		Household of 1
Products purchased from Anzel Gründoring Winkel or Mariental: maize meal, coffee, tea, and basics			
Throws away boxes, papers, plastic bags, and containers		Reuses containers	
Burns waste at site 2 houses away		Sample #6 filled 1/3 of a bag in 4 days (1kg)	
Uses Otji toilet daily	Three house and during church	Cleaning	Bucket not full
Would bury the ecosan		Has received adequate training on Otji toilets	
None		There is still a demand for Otji toilets	
Toilet is a bit narrow; when it is hot it smells		N/A	
Could not afford a toilet		Criteria: 5,3,2,5	
Comments: Burns plastics and rubber, would not use ecosan in his garden, does not use ash			

Gründorn South	Male		49
Farmer	N$ 800/month		Household of 10-12
Products purchased from Mariental or Keetmanshoop: cloths, cosmetics, food			
Throws away old cloths, packages		Reuses tins	
Burns waste in hole near his yard		Sample #7 filled 2/3 of a bag in 4 days (1.5kg)	
Uses Otji toilet often	Family and guests use toilet	Cleaning	Bucket not full
Would dig a hole a burn the ecosan		Has received adequate training on Otji toilets	
Bee's nest		There is still a demand for Otji toilets	
None		UDS	
Would buy a toilet		Criteria: 4,4,5,5	
Comments: It is difficult to dig a deep hole because of rocky soil and shallow bedrock, bumped toilet with a donkey cart, wants centralized disposal site, skeptical about using ecosan in his garden			

Gründorn South	Female		71
N/A	Grant of N$ 550/month		Household of 2
Products purchased from Anzel Gründoring Winkel or Gibeon: maize meal, flour, and meat			
Throws away tins and containers		Reuses containers	
Burns waste away from her house twice/week		Sample #8 filled 2 bags in 4 days (18.5kg)	
Uses Otji toilet often	Family and guests use toilet	Cleaning	One bucket rotated

Would bury the ecosan	Has received adequate training on Otji toilets
Has seen geckos but they are not a problem	There is still a demand for Otji toilets
The toilet is a bit narrow	N/A
Could not afford a toilet	Criteria: 5,5,5,5
Comments: Sample could not be used because majority of items in the bags were visibly old scrap metal	

Gründorn South	Male	54	
Farmer	Tends small stock	Household of 2	
Products purchased from Anzel Gründoring Winkel: maize meal, flour, coffee, tea, sugar, and cooking oil			
Throws away paper, plastics, and tins		Reuses containers	
Burns waste every 2 weeks in a drum 5 meters from house		Sample #9 filled 1 bag in 4 days (3kg)	
Uses Otji toilet often	Family and guest use toilet	Cleaning	One bucket rotated
Would bury ecosan or keep it for gardening		Has received adequate training on Otji toilets	
Has seen one snake		There is still a demand for Otji toilets	
None		N/A	
Could not afford a toilet		Criteria: 5,3,4,5	
Comments:			

Gründorn South	Female	35
Shop Assistant	N$ 350-450 /month	Household of 3
Products purchased from Anzel Gründoring Winkel or Mariental		
Throws away cans and plastic bags	Reuses bottles and buckets	
Burns waste behind her house		
Uses the bush	Wants an Otji toilet but could not afford one	
Comments:		

Gründorn South	Female	Declined to give her age	
Unemployed	none	Household of 5	
Products purchased from Anzel Gründoring Winkel			
Throws away plastics, paper bags, cans, and tins		Reuses paper and plastic bags	
Burns waste in a bin in her yard			
Uses Otji toilet often	Family uses the toilet	Cleaning	Not full
Would dump the ecosan in the bush		Has received adequate training on Otji toilets	
None		N/A	
The toilet door swings open		UDS	
N/A		Criteria: 5,5,5,5	

Comments: Fixed door brackets, would not use ecosan in garden			

Gründorn South	Female		38
Shop Keeper	N$ 2,800/month		Household of 9
Products purchased from Rehoboth for household and shop			
Throws away all used products		N/A	
Burns waste in a bin behind house whenever the bins fills up			
Does not use daily	Family, guests, and customers	Cleaning	Not full
Would use ecosan in her garden		Has received adequate training on Otji toilets	
None		There is still a demand for Otji toilets	
None		UDS	
Has toilet for customers		Criteria: 5,5,5,4	
Comments: Have flush toilets			

Nico Noord	Female		51
Farmer/community activist	N$ 3,000 /month and sells small stock		Household of 6
Products purchased from Mariental: food, fresh vegetables, and cleaning products			
Throws away plastics, paper bags, tins		Reuses plastic bottles	
Burns waste in a hole twice a month			
Uses Otji toilet often	Family, guests, workers	Cleaning	Not full
Would use ecosan in her orchard		Has received adequate training on Otji toilets	
None		There is still a demand for Otji toilets	
Would move toilet closer to her house		N/A	
Would buy a toilet		Criteria: 5,4,5,5	
Comments: Have a flush toilet and uses whichever toilet is closer			

Nico Noord	Male		51
Farmer	N$ 667/month		Household of 2
Products purchased from Gibeon or Mariental and also buys for neighbors			
Throws away bottles, tins, paper, and plastic		Reuses containers	
Burns waste on the side of his house once or twice a month			
Uses Otji toilet often	Two houses share	Cleaning	Rotated bucket in December
Would use ecosan in his garden		Has received adequate training on Otji toilets	
None		There is still a demand for Otji toilets	
Should have a protective fence		N/A	
Would buy a toilet		Criteria: 5,5,4,4	

Comments: Uses bucket at night because it is closer, only smells when it is very humid

Nico Noord	Female		43
Shop Owner	N$ 1,500-3,000/month		Household of 2
Products purchased from Mariental: coffee, tea, and sugar			
Throws away plastics and tins		Reuses mayonnaise bottles and tins	
Burns waste behind her house once or twice a month			
Uses Otji toilet often	Family and guests use toilet	Cleaning	Not full
Would burn ecosan or use in her garden		Has received adequate training on Otji toilets	
Geckos, a scorpion, and a birds nest		There is **not** still a demand for Otji toilets	
Should have rainwater collection for hand washing		N/A	
Would buy a toilet depending on the price		Criteria: 5,3,2,4	
Comments: Concerned about the spreading glass and tins, roof blew off			

Nico Noord	Female		53
Farmer	N/A		Household of 1
Products purchased in Gibeon or Mariental			
Throws away plastic bags and tins		Does not reuse anything	
Burns waste in a hole weekly			
Uses Otji toilet daily	herself	Cleaning	Not full
Would use ecosan in her garden		Has received adequate training on Otji toilets	
Bee's and bird's nests		There is still a demand for Otji toilets	
Could add window for ventilation		UDS	
Would buy a toilet		Criteria: 5,4,5,5	
Comments: Also wants a hand washing facility			

Nico Noord	Female		28
Farmer/sells meat in Gibeon	N$ 19,000/month		Household of 4
Products purchased in Mariental or Keetmanshoop			
Throws away bottles and cans		Reuses glass bottles	
Burns waste behind her house			
Have Flush toilets		There is still a demand doe Otji toilets	
Would buy an Otji toilet for workers at a subsidized price			
Comments: Thinks Otji toilet is clearly better than a pit latrine			
Nico Noord	Female		85
N/A	Grant of 550 N$/month		Household of 1

Products purchased in Gibeon: cooking oil, coffee, and tea			
Throws away plastics, bottles, paper		Reuses plastic bottles	
Burns waste in hole behind her house			
Has a flush toilet			
Comments: Hole is getting full, Otji toilet seems the same as a flush toilet to her			

Nico Noord	Male		54
Farmer	Grant of N$ 550/month		Household of 2
Products purchased out of town			
Throws away paper bags, plastics, and bottles		Reuses containers	
Burns waste behind house			
Uses a bucket toilet	Wants an Otji toilet but could not afford one		
Comments: Dislikes waste being blown around, visited by extended family for holidays, older woman currently needs to empty the bucket toilet daily			

Nico Noord	Male		Declined to give his age
Farmer	N$ 2,000/month		Household of 2-4
Products purchased in Mariental			
Throws away bottles, cans, batteries, and plastic bags		Reuses coffee cans	
Burns waste in his yard 40 meters from his house			
Uses Otji toilet daily	Family and guests use the toilet	Cleaning	Changed and emptied
Dumps the ecosan in the bush (it is to rocky to garden)	Has received adequate training on Otji toilets		
None	There is still a demand for Otji toilets		
Would put a fence around it	N/A		
Would buy a toilet	Criteria: 3,4,4,5		
Comments: Small stock is eating blown waste, did not wait for buckets to fill, not built with normal plans			

Nico Noord	Female		36
N/A	Grant of N$ 550/month		Household of 7
Products purchased in Gibeon: food, toiletries, cleaning supplies			
Throws away papers, bottles, plastic bags		Reuses bottles	
Burns waste away from her home three or four times a month			
Uses Otji toilet daily	Family and guests use the toilet	Cleaning	Not full
Comments: Her family uses the Otji toilet daily but she uses the bucket still			

Nico Noord	Male		49
Farmer	N$ 2,000/month		Household of 2
Products purchase in Mariental: food, toiletries, medicine for small stock			
Throws away cans and plastics		Does not reuse anything	
Burns waste in drum once a month			
Uses Otji toilet often	Family and guests use the toilet	Cleaning	Changes every 6 months
Burns the ecosan		Has received adequate training on Otji toilets	
None		There is still a demand for Otji toilets	
Added adjacent shower/hand washing facility		Not UDS	
Would buy a toilet		Criteria: 5,4,5,5	
Comments: Smells when it gets hot but ash takes care of that			

Nico Noord	Male		28
Farmer	N$ 200-500/month		Household of 4
Products purchased in Gibeon			
Throws away papers, can, and plastic containers		Reuses tins	
Burns waste behind his house			
Uses Otji toilet often	Family and guests use the toilet	Cleaning	One bucket rotated
Would dig a hole and work the ecosan into the soil		Has received adequate training on Otji toilets	
Small insects and geckos		There is still a demand for Otji toilets	
Should have cover for the ventilation pipe		UDS	
Would buy a toilet		Criteria: 5,4,5,4	
Comments: Door frame is weak			

Nico Noord	Female		67
Unemployed	N$ 550/month		Household of 3
Products purchased in Mariental: basic needs, sugar, pasta, and flour			
Throws away bottles, plastics, and tins		Reuses bottles and containers	
Burns waste behind her house			
Uses a bucket toilet	Could not afford an Otji toilet but wants one		
Comments: Bucket attracts flies and needs to be emptied weekly			
Nico Noord	Male		63
Unemployed	Grant of 550 N$/month		Household of 2
Products are brought from Windhoek by his brother			
Throws away paper, plastic, and tins		Does not reuse anything	
Burns waste ten meters from his house in a stone enclosure			

Uses the bush	Wants an Otji toilet for safety and privacy
Comments: Would not reuse ecosan	

Appendix I. Construction Materials for Waste Collection Center

The receipt shown below lists the exact materials used for the completion of the construction center, including the total price.

10/04/2012
MARIENTAL AGRIHARK
S/mnt: 04/2012 Page : 1

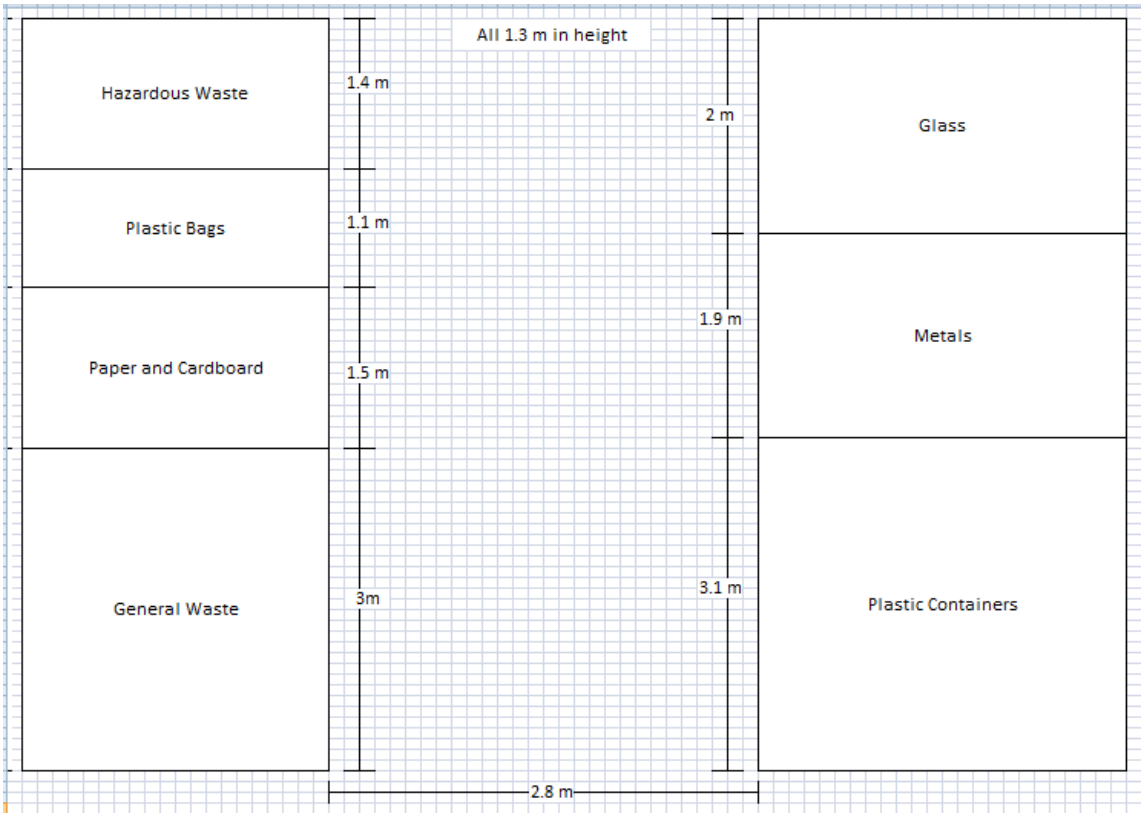
Quantity:Item number	: Description	: Price/Unit:	VAT %:	VAT:	Total
24.000 37311	POLE GUM CREO RND 1.8MX 75-100MM	34.310	15	123.52	946.96
20.000 33766	STANDARDS Y-SECTION 1850MM	44.830	15	134.49	1.031.09
20.000 75525	DROPPERS CREO 1.4MX32-50MM	6.340	15	19.02	145.82
10.000 61603	DROPPERS T SECTION 1850MM	10.780	15	16.17	123.97
2.000 10266	GATE FARM 2400X1200MM	398.140	15	119.44	915.72
1.000 20591	WIRE NETTING 1200X90X1.8MMX50M 34.3KG	600.990	15	90.15	691.14
50.000 11401	WIRE NETTING 1800X13MM P/N BIRD	47.160	15	353.70	2,711.70
1.000 9994545	STEEL WIRE OVAL 2X2.6MMX1500M L/GALV	571.790	15	85.77	657.56
2.000 53961	WIRE SMALL COILS 5KG 14-2.00MM SABS	76.780	15	23.03	176.59

10/04/2012
MARIENTAL AGRIHARK
S/mnt: 04/2012 Page : 2

Quantity:Item number	: Description	: Price/Unit:	VAT %:	VAT:	Total

VIL 2 KLEIN ROLLETJIES HE
u80063 TIEKIE MANS
Your VAT-nr: K 965.29 7.400.55
Your Order nr:

Appendix J. Final Design for Waste Collection Center



The bins for general waste, paper and cardboard, and plastic bags all have lids made from the fencing material.

After analysis of the waste audit data we were able to calculate the estimated monthly output of waste in these categories in both mass and volume. The general waste bin was designed so that the waste could be burned once the bin fills up. The hazardous waste we collected during our waste audit was very minimal, and only consisted of a few batteries and aerosol cans. Therefore we allowed for the hazardous waste bin to fill much more slowly than the rest of the bins so that it would not be an issue in the near future.

Hazardous waste to fill in about 83 months
Plastic Bags to fill in about 19 months
Paper and Cardboard to fill in about 17 months
Glass to fill in about 30 months
Metals to fill in about 50 months
Plastic containers to fill in about 21 months

We chose these bin sizes in order to maximize the area and materials while taking into account the material output. The plastic bag and the paper and cardboard bins were left deliberately smaller because these materials can be easily compressed, eliminating a large percentage of the volume. The metals bin was designed to fill up slower than the other bins in case community members want to move some of the larger scrap metal that we saw in their yards into the bin.

Appendix K. Fecal Matter Pathogen Analysis Results From Polytechnic of Namibia Lab

A laboratory technologist, Mr. Murwina, conducted the following ten pathogen analyses at the Polytechnic of Namibia in order to determine the safety of "ecosan" reuse as compost for gardening practices in the communities of Nico Noord and Gründorn South.

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STOOL ANALYSIS REPORT

Date of analysis -11/04/12

SPECIMEN NUMBER -01

MACROSCOPY -: *Colour--brown*
Constistancy-formed

MICROSCOPY-: *Leucocytes-none*
Red cells-none
Parasites-not observed

CULTURE-:*XLD media-negative*
DCA media-negative
Mac+CV media-negative

RESULTS-*NO PATHOGENS ISOLATED*

Analysis done at Polytecnic of Namibia Microbiology department-by **Mr E Murwira** (lab technologist)

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STOOL ANALYSIS REPORT

Date of analysis -11/04/12

SPECIMEN NUMBER -02

MACROSCOPY -: *Colour--brown*
Constistancy-unformed

MICROSCOPY-: *Leucocytes-few*
Red cells-none
Parasites-not observed
yeasts observed

CULTURE-:*XLD media-positive*
SINGERS-positive
DCA media-negative
Mac+CV media-negative

SEROLOGY-*:negative*

RESULTS-*NO PATHOGENS ISOLATED*

Analysis done at Polytecnic of Namibia Microbiology department-by **Mr E Murwira** (lab technologist)

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STOOL ANALYSIS REPORT

Date of analysis -11/04/12

SPECIMEN NUMBER -03

MACROSCOPY -: *Colour--brown*
Constistancy-unformed

MICROSCOPY-: *Leucocytes-few*
Red cells-none
Parasites-not observed
yeasts observed

CULTURE-:*XLD media-positive*
SINGERS-positive
DCA media-negative
Mac+CV media-negative

SEROLOGY-*:negative*

RESULTS-*NO PATHOGENS ISOLATED*

Analysis done at Polytecnic of Namibia Microbiology department-by **Mr E Murwira** (lab technologist)

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STOOL ANALYSIS REPORT

Date of analysis -11/04/12

SPECIMEN NUMBER -04

MACROSCOPY -: *Colour--brown*
Constistancy-formed

MICROSCOPY-: *Leucocytes-none*
Red cells-none
Parasites-not observed

CULTURE-:*XLD media-positive*
DCA media-positive
Singers-negative
Mac+CV media-negative

RESULTS-*NO PATHOGENS ISOLATED*

Analysis done at Polytecnic of Namibia Microbiology department-by **Mr E Murwira** (lab technologist)

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STOOL ANALYSIS REPORT

Date of analysis -11/04/12

SPECIMEN NUMBER -05

MACROSCOPY -: *Colour--brown*
Constistancy-formed

MICROSCOPY-: *Leucocytes-none*
Red cells-none
Parasites-not observed

CULTURE-:*XLD media-negative*
DCA media-negative
Mac+CV media-negative

RESULTS-*NO PATHOGENS ISOLATED*

Analysis done at Polytecnic of Namibia Microbiology department-by **Mr E Murwira** (lab technologist)

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STOOL ANALYSIS REPORT

Date of analysis -11/04/12

SPECIMEN NUMBER -06

MACROSCOPY -: *Colour--brown*
Constistancy-formed

MICROSCOPY-: *Leucocytes-none*
Red cells-none
Parasites-not observed

CULTURE-:*XLD media-negative*
DCA media-negative
Mac+CV media-negative

RESULTS-*NO PATHOGENS ISOLATED*

Analysis done at Polytecnic of Namibia Microbiology department-by **Mr E Murwira** (lab technologist)

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STOOL ANALYSIS REPORT

Date of analysis -11/04/12

SPECIMEN NUMBER -08

MACROSCOPY -: *Colour--brown*
Constistancy-formed

MICROSCOPY-: *Leucocytes-none*
Red cells-none
Parasites-not observed
yeast cells observed

CULTURE-:*XLD media-negative*
DCA media-negative
Mac+CV media-negative

RESULTS-*NO PATHOGENS ISOLATED*

Analysis done at Polytecnic of Namibia Microbiology department-by **Mr E Murwira** (lab technologist)

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STOOL ANALYSIS REPORT

Date of analysis -11/04/12

SPECIMEN NUMBER -09

MACROSCOPY -: *Colour--brown*
Constistancy-formed

MICROSCOPY-: *Leucocytes-none*
Red cells-none
Parasites-not observed

CULTURE-:*XLD media-negative*
DCA media-negative
Mac+CV media-negative

RESULTS-*NO PATHOGENS ISOLATED*

Analysis done at Polytecnic of Namibia Microbiology department-by **Mr E Murwira** (lab technologist)

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STOOL ANALYSIS REPORT

Date of analysis -11/04/12

SPECIMEN NUMBER -10

MACROSCOPY -: *Colour--brown*
Constistancy-formed

MICROSCOPY-: *Leucocytes-none*
Red cells-none
Parasites-not observed

CULTURE-:*XLD media-negative*
DCA media-negative
Mac+CV media-negative

RESULTS-*NO PATHOGENS ISOLATED*

Analysis done at Polytecnic of Namibia Microbiology department-by **Mr E Murwira** (lab technologist)

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STOOL ANALYSIS REPORT

Date of analysis -11/04/12

SPECIMEN NUMBER -11

MACROSCOPY -: *Colour--brown*
Constistancy-formed

MICROSCOPY-: *Leucocytes-none*
Red cells-none
Parasites-not observed

CULTURE-:*XLD media-negative*
DCA media-negative
Mac+CV media-negative

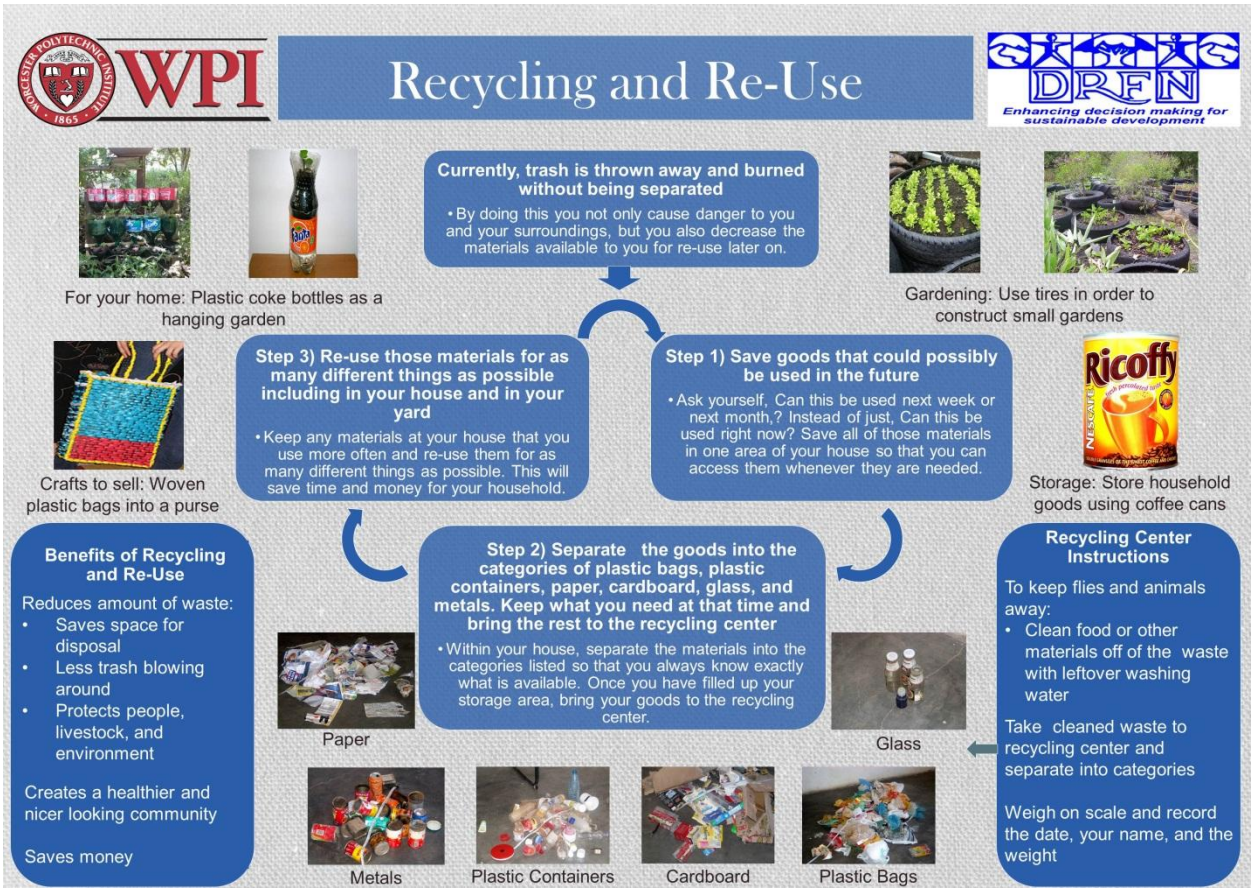
RESULTS-*NO PATHOGENS ISOLATED*

Analysis done at Polytecnic of Namibia Microbiology department-by **Mr E Murwira** (lab technologist)

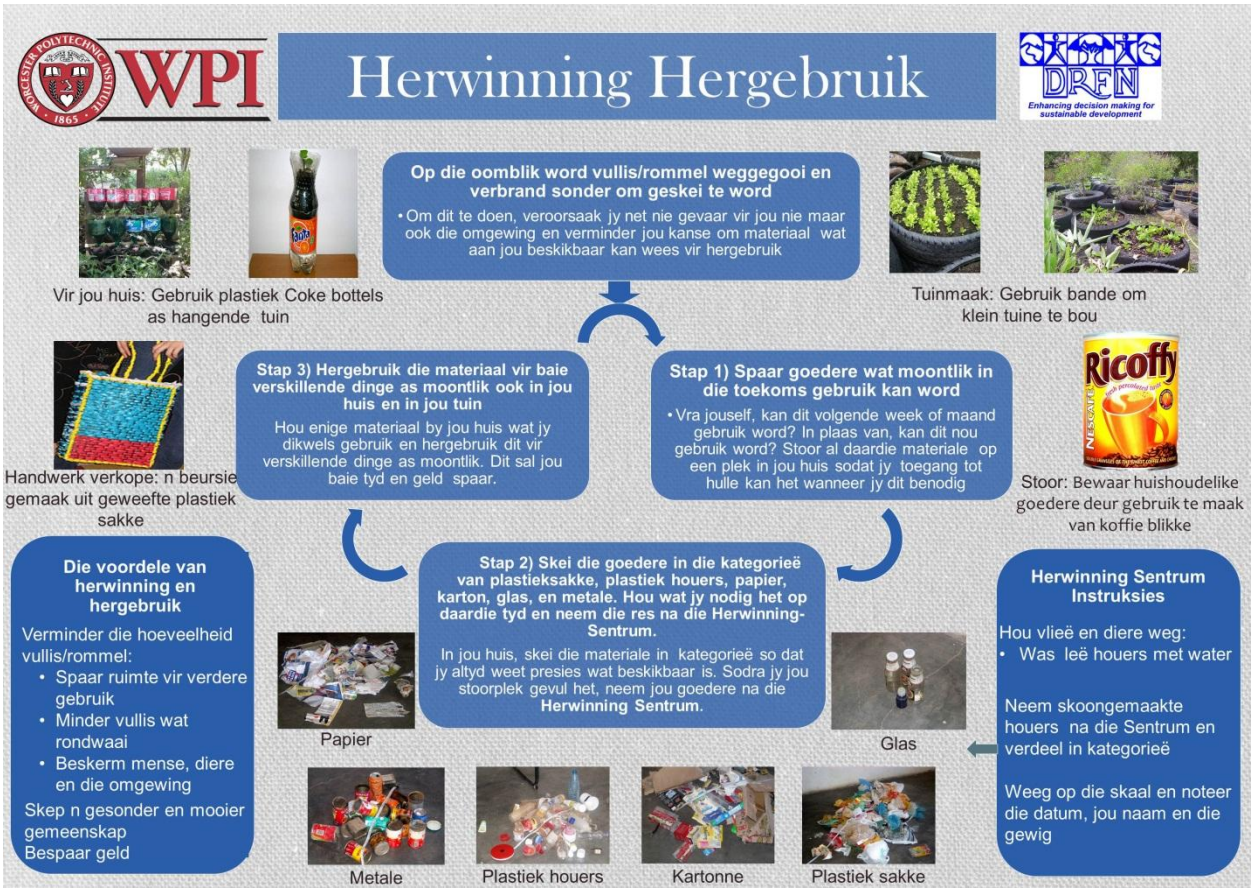
Appendix L. Danger of Waste Poster - English

Appendix M. Danger of Waste Poster - Afrikaans

Appendix N. Recycling and Re-Use Poster - English



Appendix O. Recycling and Re-Use Poster - Afrikaans



Appendix P. Otji Toilet Daily Monitoring System - English

Daily Use Monitoring		Negative Circumstances			
Date	# Uses	High heat? (time)	Insects/animals? (time)	Smell? (time)	Comments
1-Apr					
2-Apr					
3-Apr					
4-Apr					
5-Apr					
6-Apr					
7-Apr					
8-Apr					
9-Apr					
10-Apr					
11-Apr					
12-Apr					
13-Apr					
14-Apr					
15-Apr					
16-Apr					
17-Apr					
18-Apr					
19-Apr					
20-Apr					
21-Apr					
22-Apr					
23-Apr					
24-Apr					
25-Apr					
26-Apr					
27-Apr					
28-Apr					
29-Apr					
30-Apr					

Appendix Q. Otji Toilet Daily Monitoring System - Afrikaans

Daaglikse gebruik monitering		**Negatiewe Omstaandighede**			
Datum	# Gebruikers	Hoëhitte? (tyd)	Insekte/diere? (tyd)	Reuk? (tyd)	Kommentaar
1-Apr					
2-Apr					
3-Apr					
4-Apr					
5-Apr					
6-Apr					
7-Apr					
8-Apr					
9-Apr					
10-Apr					
11-Apr					
12-Apr					
13-Apr					
14-Apr					
15-Apr					
16-Apr					
17-Apr					
18-Apr					
19-Apr					
20-Apr					
21-Apr					
22-Apr					
23-Apr					
24-Apr					
25-Apr					
26-Apr					
27-Apr					
28-Apr					
29-Apr					
30-Apr					

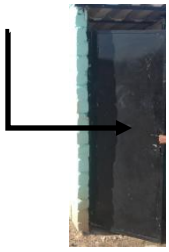
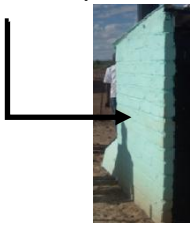
Appendix R. Otji Toilet Monthly Monitoring System - English

LONG-TERM OTJI TOILET MONITORING

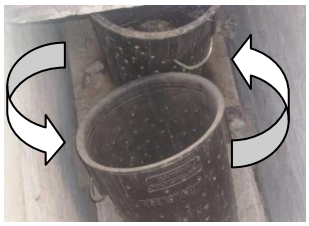
The purpose of this survey is to be able to evaluate the Otji toilets consistently over a long period of time. The survey is to help the Desert Research Foundation of Namibia to assess the toilets at certain periods of time to see if there are any problems that must be taken care of. The responses to these surveys are not anonymous. Thank you for your time in advance.

NAME: _____ AGE: _____ GENDER: _____
COMMUNITY: _____ OCCUPATION: _____
OF PEOPLE IN HOUSEHOLD: _____ DATE: _____
MONTHLY INCOME: _____

PLEASE CHECK☑ GOOD, OKAY, OR BAD FOR EACH QUESTION. IF YOU HAVE ANYTHING TO ADD PLEASE WRITE IT IN THE COMMENTS OR SUGGESTIONS SECTION BELOW.

	GOOD 	OKAY 	BAD 
TOILET BOWL 			
DOOR 			
BRICKS/ STRUCTURE 			

	GOOD 	OKAY 	BAD 
ROOF 			
GETS RID OF ODOR? 			
FLOOR 			
NO GECKOS 			
NO BEES NEST 			



OF TIMES YOU SWITCHED THE BUCKET? _____

REPAIRS NEEDED? _____

COMMENTS OR SUGGESTIONS?

_____

_____

_____

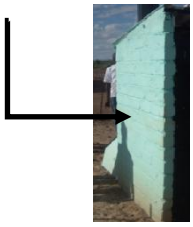
Appendix S. Otji Toilet Monthly Monitoring System - Afrikaans

LANG TERMYN OTJI TOILET MONITERING

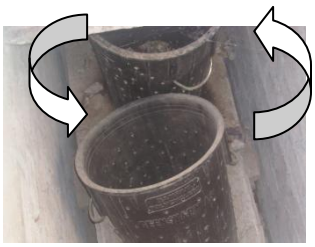
Die doel van hierdie opname is om in staat te wees om gereeld die Otji-toilette oor n lang tydperk te evalueer . Die opname is om die Desert Research Foundation of Namibia te help om die toilette te evaluer oor sekere tye om te sien of daar enige probleme is wat opgeneem moet word. Die antwoorde op hierdie opname is nie anonym nie. Dankie vir jou tyd.

NAAM: _____OUDERDOM: _____ GESLAG: _____
GEMEENSKAAP: _____ BEROEP: _____
AANTALE MENSE IN DIE HUISHOUD: _____ DATUM:_____
MANDELIKESE INKOMSTE: _____

MERK☑ GOED, OKAY, OF SLEG VIR ELKE VRAAG. AS JY IETS HET OM BY TE VOEG, SKRYF DIT IN DIE KOMMENTAAR OF VOOSTEEL AFDELING HIERONDER.

	GOED	OKAY	SLEG
TOILET POT 			
DEUR 			
STENE/ STRUKTUUR 			

	GOED	OKAY	SLEG
DAK 			
ONSLAE RAAK VAN REUKE? 			
FLOER 			
GEEN GOGAS 			
GEEN BY NEST 			



AANTAL KERE WAT JY DIE EMMER OORSKAKEL _____

BENODIG REPERASIES?

_____

KOMMENTAAR of VOORSTELLE?

_____

_____

_____

Appendix T. Waste Collection Center Monitoring System - English

Waste Collection Center

Plastic Bottles

½ BUCKET

1 BUCKET

		# OF BUCKETS				
NAME	**DATE**	**1/2**	**1**	**1 ½**	**2**	**OTHER**

Waste Collection Center

Metal

½ BUCKET

1 BUCKET

		# OF BUCKETS				
NAME	**DATE**	**1/2**	**1**	**1 ½**	**2**	**OTHER**

Waste Collection Center

Glass

½ BUCKET

1 BUCKET

		# OF BUCKETS				
NAME	**DATE**	**1/2**	**1**	**1 ½**	**2**	**OTHER**

Waste Collection Center

General Waste

½ BUCKET

1 BUCKET

		# OF BUCKETS				
NAME	**DATE**	**1/2**	**1**	**1 ½**	**2**	**OTHER**

Waste Collection Center

Paper/Cardboard

½ BUCKET

1 BUCKET

		# OF BUCKETS				
NAME	**DATE**	**1/2**	**1**	**1 ½**	**2**	**OTHER**

Waste Collection Center

Hazardous Waste

½ BUCKET

1 BUCKET

		# OF BUCKETS				
NAME	**DATE**	**1/2**	**1**	**1 ½**	**2**	**OTHER**

Waste Collection Center

Plastic Bags

		# OF BUCKETS				
NAME	**DATE**	**1/2**	**1**	**1 ½**	**2**	**OTHER**

Appendix U. Waste Collection Center Monitoring System - Afrikaans

Hergebruik

Plastic Houers

½ DROM

1 DROM

		# OF DROMS				
NAAM	**DATUM**	**1/2**	**1**	**1 ½**	**2**	**ANDER**

Hergebruik

Metal

½ DROM

1 DROM

		# OF DROMS				
NAAM	**DATUM**	**1/2**	**1**	**1 ½**	**2**	**ANDER**

Hergebruik

Glas

½ DROM

1 DROM

		# OF DROMS				
NAAM	**DATUM**	**1/2**	**1**	**1 ½**	**2**	**ANDER**

Hergebruik

Gewone Rommels

½ DROM

1 DROM

		# OF DROMS				
NAAM	**DATUM**	**1/2**	**1**	**1 ½**	**2**	**ANDER**

Hergebruik

Papier/Karton

½ DROM

1 DROM

		# OF DROMS				
NAAM	**DATUM**	**1/2**	**1**	**1 ½**	**2**	**ANDER**

Hergebruik

Gevaarlike Vullis

½ DROM

1 DROM

		# OF DROMS				
NAAM	**DATUM**	**1/2**	**1**	**1 ½**	**2**	**ANDER**

Hergebruik

Plastiek Sakke

½ DROM

1 DROM

		# OF DROMS				
NAAM	**DATUM**	**1/2**	**1**	**1 ½**	**2**	**ANDER**

Appendix V. Collection Center Contract – English

Collection Center Contract

After attending the meeting on recycling, I understand what is expected of me. All waste must be brought to the collection center and sorted into the seven categories available. These categories are: paper/cardboard, metals, glass, plastic bags, plastic bottles, hazardous waste, and general waste. After I sort out my waste into these categories, I will find the volume of each group and will fill out the information needed in the notebook. Then I will put each group into its respective bin. I also understand that the community members are in charge of the maintenance of the structure. By signing this I understand and will follow these above rules.

NAME	SIGNATURE	DATE

Appendix W. Collection Center Contract – Afrikaans

HERBRUIKERS KONTRAK

Na die bywoning van die gemeenskaps-vergadering betreffende die hergebruik van Rommel, verstaan ek alles wat van af verwag word. Al die herbruikbare material moet na die herbruibruik sentrum geneem word en in die 6 verskillende katogoriee in gedeel word soos beskikbaar.

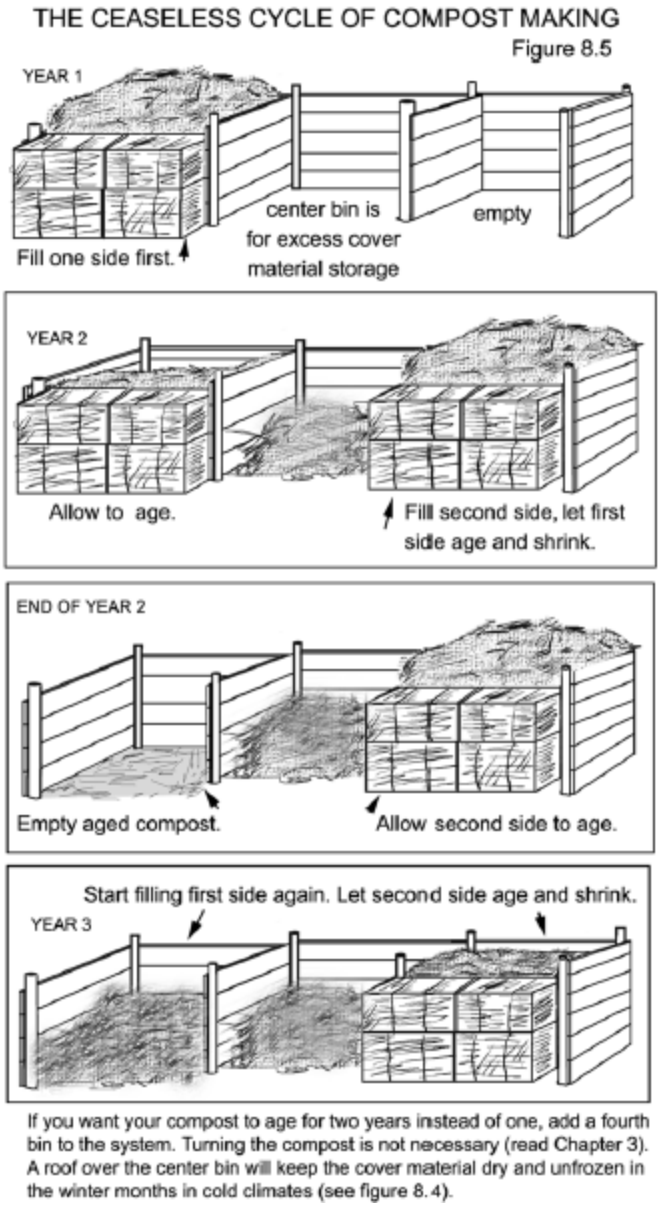
Die katogoriee is soos volg: papier, karton, metal, glas, plastiek sake en plastiek bottles. Na ek klaar die hergebruikbare Rommel uitgesorteer het in die veskillende katogoriee, sale k die verskillende herbruikbare Rommel vir elke katogorie weeg en die aantal gewig neer skryf op die skryf blok wat verskaf is.

Hiermee bevestig ek dat die gemeenskap verantwoordelik is ver die ,onderhoud en instand houding van die infrastruktuur van die herbruik sentrum. Deur die ondertekening van hierdie kontrak bevestig ek dat ek dit verstaan en die reels sal nakom.

Naam	Handtekening	Datum

Appendix X. Composting Cycle (Jenkins 2005)

This diagram portrays one possible method for composting within communities. It should be adapted in order to fit the specific needs of Gründorn South and Nico Noord if it is implemented.



If you want your compost to age for two years instead of one, add a fourth bin to the system. Turning the compost is not necessary (read Chapter 3). A roof over the center bin will keep the cover material dry and unfrozen in the winter months in cold climates (see figure 8.4).

Appendix Y. Pathogen Survival by Composting and Thermal Death Points for Common Parasites and Pathogens (Jenkins Humanure Sanitation)

These tables provide data regarding the length of time and temperature needed in order to eliminate parasites and pathogens from human waste. Even though our lab results came back negative for the presence of pathogens, we recommend that these guidelines be followed in order to ensure the safety of all residents.

Table 7.14

PATHOGEN SURVIVAL BY COMPOSTING OR SOIL APPLICATION

Pathogen	Soil Application	Unheated Anaerobic Digestion	Composting Toilet (Three mo. min. retention time)	Thermophilic Composting
Enteric viruses	May survive 5 mo	Over 3 mo.	Probably elim.	Killed rapidly at 60C
Salmonellae	3 mo. to 1 yr.	Several wks.	Few may surv.	Dead in 20 hrs. at 60C
Shigellae	Up to 3 mo.	A few days	Prob. elim.	Killed in 1 hr. at 55C or in 10 days at 40C
E. coli	Several mo.	Several wks.	Prob. elim.	Killed rapidly above 60C
Cholera vibrio	1 wk. or less	1 or 2 wks.	Prob. elim.	Killed rapidly above 55C
Leptospires	Up to 15 days	2 days or less	Eliminated	Killed in 10 min. at 55C
Entamoeba histolytica cysts	1 wk. or less	3 wks or less	Eliminated	Killed in 5 min. at 50C or 1 day at 40° C
Hookworm eggs	20 weeks	Will survive	May survive	Killed in 5 min. at 50C or 1 hr. at 45C
Roundworm (*Ascaris*) eggs	Several yrs.	Many mo.	Survive well	Killed in 2 hrs. at 55C, 20 hrs. at 50C, 200 hrs. at 45°C
Schistosome eggs	One mo.	One mo.	Eliminated	Killed in 1 hr. at 50°C
Taenia eggs	Over 1 year	A few mo.	May survive	Killed in 10 min. at 59°C, over 4 hrs. at 45°C

Source: Feachem et al., 1980

Table 7.15

THERMAL DEATH POINTS FOR COMMON PARASITES AND PATHOGENS

PATHOGEN	THERMAL DEATH
Ascaris lumbricoides eggs	Within 1 hour at temps over 50°C
Brucella abortus or *B. suis*	Within 1 hour at 55°C
Corynebacterium diptheriae	Within 45 minutes at 55°C
Entamoeba histolytica cysts	Within a few minutes at 45°C
Escherichia coli	One hr at 55°C or 15-20 min. at 60°C
Micrococcus pyogenes var. *aureus*	Within 10 minutes at 50°C
Mycobacterium tuberculosis var. *hominis*	Within 15 to 20 minutes at 66°C
Necator americanus	Within 50 minutes at 45°C
Salmonella spp.	Within 1 hr at 55C; 15-20 min. at 60°C
Salmonella typhosa	No growth past 46C; death in 30 min. 55C
Shigella spp.	Within one hour at 55°C
Streptococcus pyogenes	Within 10 minutes at 54°C
Taenia saginata	Within a few minutes at 55°C
Trichinella spiralis larvae	Quickly killed at 55°C

Source: Gotaas, Harold B. (1956). Composting - Sanitary Disposal and Reclamation of Organic Wastes. p.61. World Health Organization, Monograph Series Number 31. Geneva.

Appendix Z. Otji Toilet Self Builder Manual (Arndt, Simon and Shilongo)

The Otji-Toilet self builder manual

The Clay House Project
Otjiwarongo

The Otji-Toilet self builder set

Your self builder set consists of following material

1 Lid box with following parts
  a) frame
  b) lid with bolts
1 ventilation pipe
1 door
1 door frame with following parts
  a) 1 angle iron 40 x 40 x 3 mm with hinges
  b) 1 angle iron 25 x 25 x 3 mm without hinges
1 welded steel roof structure
1 foundation steel ring (4 round steel— 2 long, 2 short parts)
2 perforated 90 l plastic container
1 Toilet Pot
2 concrete side plates
2 concrete dry plates (700x700)
1 concrete floor plate (850x750)
15 roof tiles (cool tiles)
1 silicon, wire, 2 long 2 short screws
- 4 nuts, 2 angle iron pieces

Congratulation — you decided to build your Otji-Toilet by yourself. A good solution as well for you and for the environment, because the Otji-Toilet is an environment friendly ecosan toilet.
This brochure will help to finish the building job successfully.

The CHP-Team wishes you many success and always fresh air in your self built Otji-Toilet.

How to build your Otji-Toilet

For a builder it is not difficult to build an Otji-Toilet. All you need is the construction plan, the Otji-Toilet self builder set you bought at the Clay House Project and following additional materials:

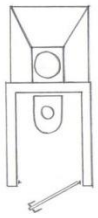
480 super bricks
3 bags cement
0,6 m³ sieved sand
5 litre paint of your choice

and the usual building tools like digging spate, tape measure, brick trowel, plastering trowel, hammer, wheel barrow, screw driver, fencing plier, straight edge, block brush and last but not least a spirit level.
If no super bricks are available, you can use any other cement bricks, but make sure that all measurements are being kept.

And you have to know how to face the lid box of your toilet exactly to the North.

Without facing the lid box to the north your Otji-Toilet will not work properly. For a well functioning Otji-Toilet it is essential to find the right direction. Furthermore the place for the lid box must be shadowless to get the whole day full sun. Only under these conditions you will have an odourless functioning Otji-Toilet.

Before you start to dig the hole for the toilet, please make sure that all the toilet parts you have received are complete and the additional material is available as well.



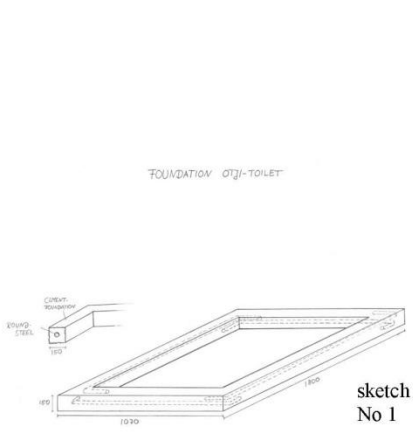
The following pages show each single step which is necessary to build a proper functioning and long lasting Otji-Toilet. Please don't change the construction because every single step has its own importance and is approved through our long experience.

lid box strictly north

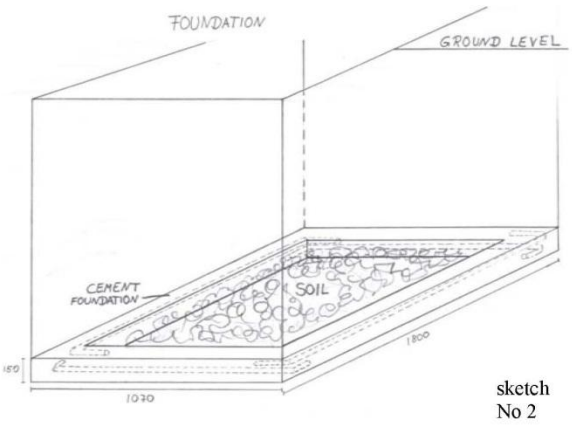
1. In the beginning is a hole

The hole what you dig is 1.100 mm deep, 1.070 mm wide and 1.800 mm long. If your underground is too rocky, the depth of the hole can be reduced. In that case the toilet floor should be raised just as much above ground level in order to get enough depth.

2. Laying the foundation



sketch No 1



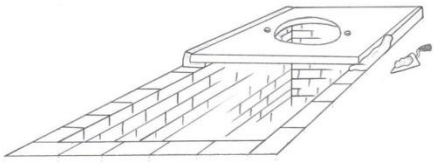
sketch No 2

The concrete foundation will be reinforced with the round steel you received together with the Otji-Toilet self builder set. This reinforced foundation has to carry the whole weight of the toilet house and will prevent the walls from cracks. It is important to level the foundation exactly to get a straight toilet house.
As a preparation for the concrete foundation dig a square channel of 150 mm depth and 150 mm wide on the ground of the hole.

3. Building the tank

The walls of the underground tank can be build out of super bricks or any other bricks which are available. Just make sure that you keep the inside measurements shown in the construction plan. The walls must reach one brick over ground level.

4. Setting the floor-plate



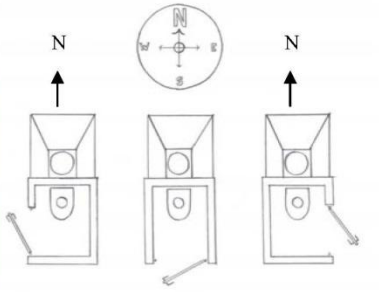
sketch No 3

After building the tank, the floor-plate must be set in cement. Put mortar undern-eeth and add mortar to the side of the plate.

5. Building the toilet house

The building of the toilet house starts at the back side of the floor plate and goes than in direction to the front of the house. The wall of the toilet house is being built on the floor plate, but exeeds to the front plate (south).This side wall has outside a length of 1.200 mm and is extended over the floor plate. Therefore a small foundation should be laid in front. Normally the toilet door opens to the south, but you can change the design if needed.

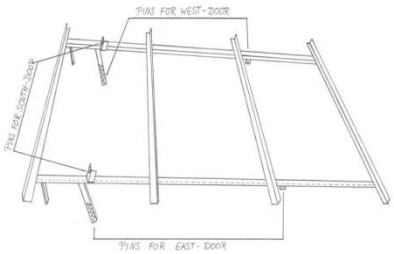
add foundation



sketch No 4

6. Installing the roof structure

As soon as the toilet house is finished, the roof structure is laid on the walls and fixed with mortar. The roof structure provides pins for doors in any direction. The following sketch shows what pin has to be used for what direction of door (to the south, to the east, to the west).
Once the tiles are fixed with wire at the roof structure the gap between roof and wall can be filled with mortar. By that way the roof gets its stability as well.



sketch
No 5

7. Fixing the cool tiles

The cool tiles are being laid starting from the north lid box side—left hand. Each tile has a pin which you hang at the angle iron. The wire fixed to each concrete pin must be tied to the angle iron.

8. Installing the door frame

The door frame contents of two angle iron which must be connected to the pins of the roof structure. See on sketch 3 which pins should be used depending on the direction the door faces.
Each frame has to be concreted into the bottom.

south door
floor

south door
roof

9. Add cement slap

As the floor plate does not cover the whole inside space, add a 100 mm cement slap.

addede cement slap

10. Building the lid box

When the toilet house is completely finished the lid box is being installed.
At first hold the steel frame without the lid at the backside of the toilet house. Put the side plates straight on the tank wall and lean them to the box (you need two people). The box has on each side two pins which prevent the side plates to fall down into the tank, an other two pins are at the upper side of the box. Mark where the upper pins touch the wall, remove the lid box and the side plates and knock a small slit into the wall, where the upper pins of the lid box can enter.
Now bring the box with the pins into the slit and lean at the same time the side plates to the box. Fix the side plates with cement mortar. After that you have to fill the gap between lid box and the tank with bricks and mortar.

11. Installing the ventilation pipe

Put the ventilation pipe over the hole on the top of the lid box. Fix it with wire at the roof structure and use the silicon to seal it on the lid box to make it air– and waterproof. Seal as well small gaps between lid box and side plates to prevent any air circulation at the box. Big gaps you have closed with mortar.

12. Fixing the door

Hang the door into the hinges. Through the special formed hinges the door closes automatically.

13. Fixing the toilet pot

The toilet pot has to be fixed on the floor plate with two screws and the nuts belonging to it. Do it with two people, one on the top and one inside the tank. You have received two short pieces of a iron which can be used as washer..

14. Putting the drying plates into the tank

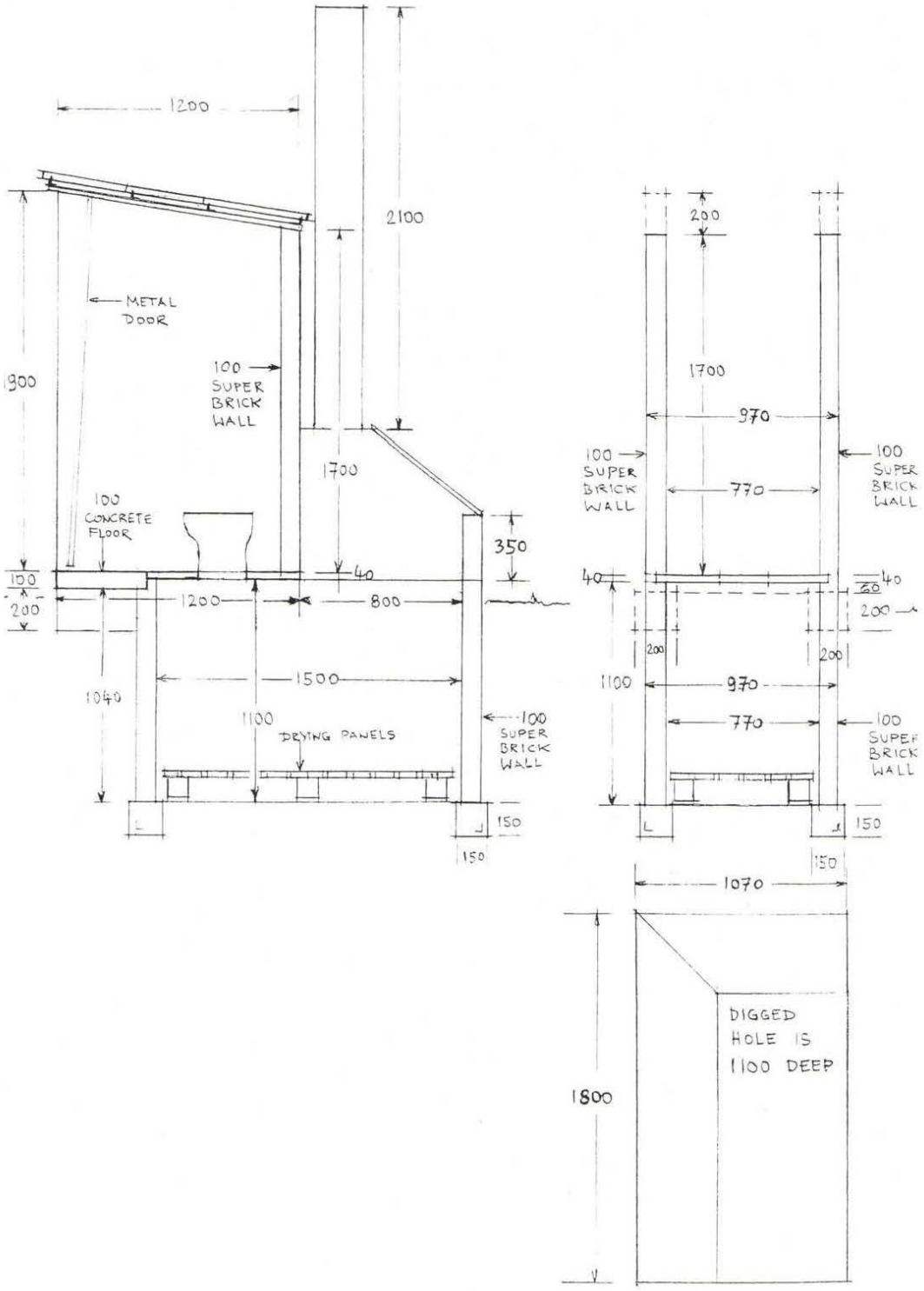
Before you put the drying panels into the tank, the bottom of the tank has to be cleaned from mortar which has fallen down during the building process. This is important to ensure good infiltration once functioning. Now put some bricks as sockets for the drying plates at the ground of the tank.
Place the plates on the bricks and as last step put the plastic containers onto the drying plates (don't throw the containers down on the plates because the plates could brake).

15. Sit down and enjoy

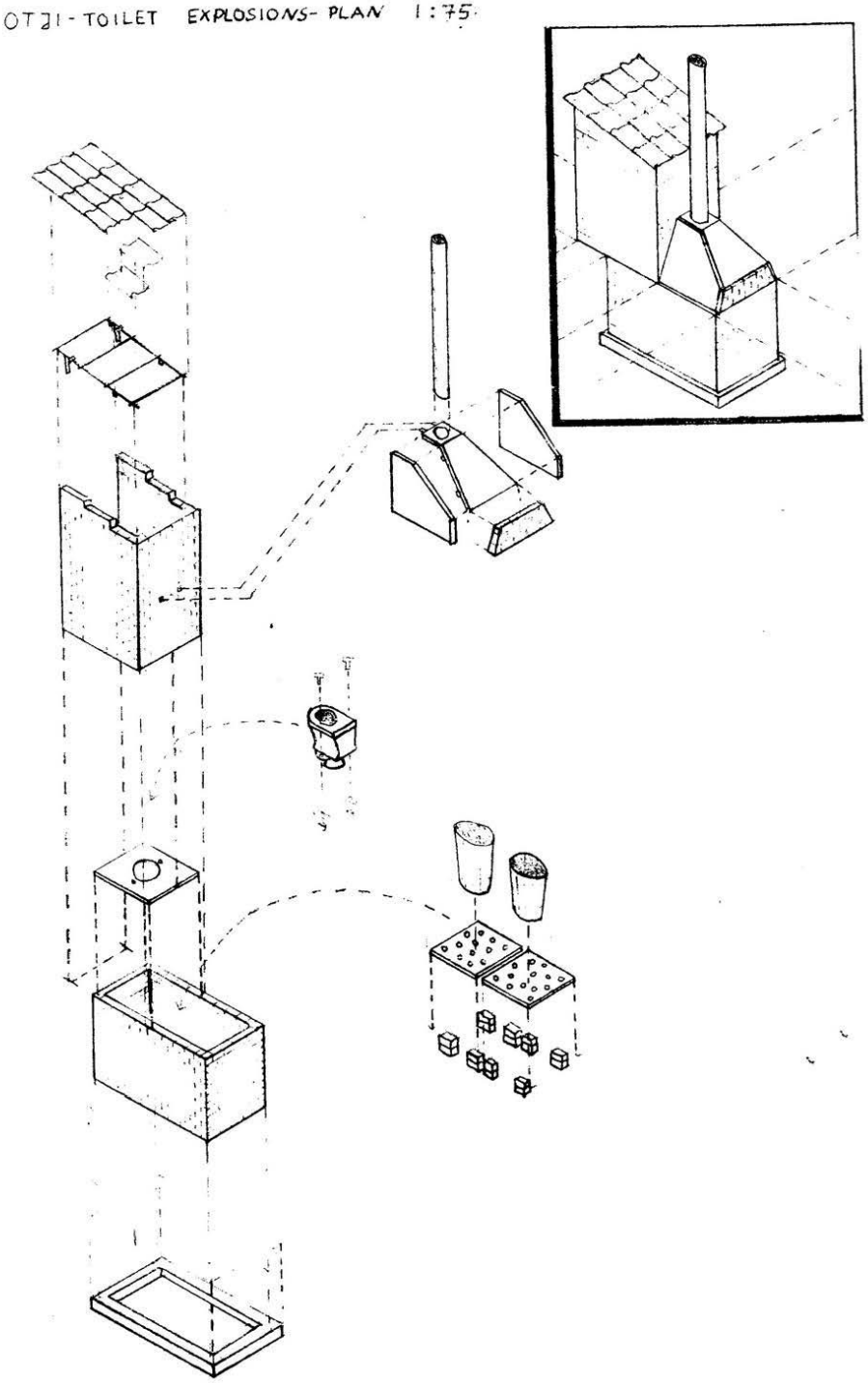
16. How to maintain the Otji-Toilet

Usually the Otji-Toilet needs maintenance only twice a year. If you have more then 10 people using the toilet, please check every 4 month whether the container for the droppings is full or not. Move the full container with a steel hook to the back side of the tank, where the droppings can dry for half a year. Replace the full container with the empty container. Once the second container is full you have to remove the first container with the dried droppings and to empty it, than you exchange the both containers again.
The toilet pot has to be cleaned occasionally with a brush and a little bit of water. That's all.

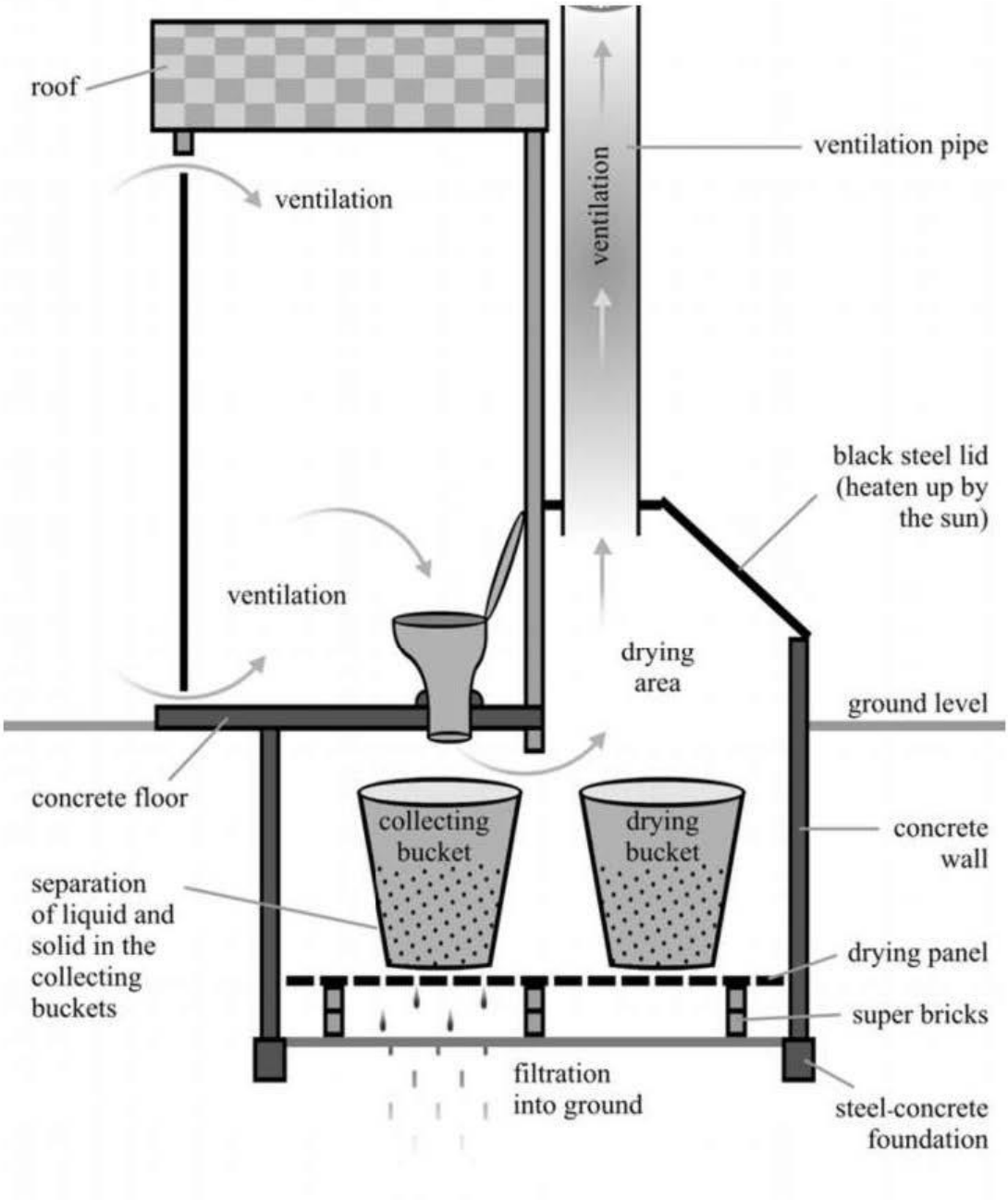
CONSTRUCTION PLAN M 1:25
UPDATE: 19/09/05



OTJI - TOILET EXPLOSIONS- PLAN 1:75



Otji-Toilet function plan



The CHP is a namibian non-profit organisation with a Trust board. The „NAMIBIAN CLAY HOUSE DEVELOPMENT PROJECT TRUST" is registered since 1991, with Nr. T6/92

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