

A Qualitative Study of Decentralized Compost Sanitation in Uganda's West Nile Region

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Abstract

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Decentralized compost sanitation represents a potential sustainable sanitation solution that could limit fecal contamination at the source while also complementing the rural, agricultural lifestyle of rural areas without access to reliable sanitation infrastructure. Papoga, a rural community in Uganda's West Nile Region, is rich in the materials necessary to harness and accelerate this natural process that breaks down pathogens in human waste while creating organic fertilizer.

This qualitative descriptive study seeks to gain insight into the local perceptions of decentralized thermophilic compost sanitation in Papoga and its associated health benefits. Specifically, this paper intends to answer the following questions built upon distinct aims:

1. How has compost sanitation been marketed in Papoga?
2. Is compost sanitation protective of public health in Papoga?
3. What are the drivers and barriers to compost sanitation in Papoga?

This paper suggests that demand for compost sanitation was spread throughout Papoga organically while its inherent benefits acted as their own incentives. Introducing compost sanitation via the

schools provided a semi-controlled environment to introduce compost to the area, while the school children acted as the local messengers bringing word of compost home to parents.

Compost sanitation is associated with better health as evidenced by the reduced STH prevalence in accordance with the timing of compost's launch into the schools. In addition, recorded temperatures of active compost piles suggest that many common pathogens and parasites would not be able to withstand the heat generated during the natural thermophilic process.

As with any community, the drivers of compost sanitation in Papoga vary from person to person and include yielded fertilizer, comfort, and health benefits among other things. The barriers of compost sanitation in Papoga also vary from person to person and are associated more with the accessibility of the tools and information necessary for management of compost rather than with fear or mistrust of the technology.

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1 Introduction

Compost sanitation was first introduced in Papoga, Uganda in April 2016 by International Medical Outreach (IMO), a non-governmental organization with a strong local presence. Since then, primary schools, places of worship, and several hundred homes have decided to adopt compost sanitation in lieu of pit latrines with IMO's guidance and support. IMO and its local Project Management Committee (PMC) initially introduced compost sanitation as one of several early components of its Soil-transmitted Helminthiasis (STH) Control Program that aims to reduce the prevalence of STH in a given catchment area to below 25% within five years.

STH refers to a set of parasitic diseases caused by a group of intestinal worms that are transmitted primarily through soil contaminated with feces. Approximately two billion people worldwide are infected with STH and an additional four billion are at risk.¹ Of these, children are most susceptible to infection due to their frequent exposure to a contaminated environment through playing, eating raw vegetables and fruits, and direct contact with soil and water.² Heavy infections of STH decrease nutritional status, affect school performance, and lower resistance to other infectious diseases while chronic infections lead to malnutrition, stunted growth, and diminished intellectual capacity.³

The World Health Organization recommends bi-annual treatment for intestinal parasites where prevalence exceeds 50% and is below 75%.⁴ In January 2015, stool sample analysis found STH prevalence to be 73.7% among school children in Papoga. Although Papoga's STH prevalence registers within the window for bi-annual mass drug administration, there is no indication of regular governmental distribution of anthelmintic medication. Therefore, based on this baseline STH prevalence, the initial strategy employed by IMO included mass distribution of Albendazole 400mg twice yearly to all pupils enrolled in school, public health education focusing on hand hygiene, and the distribution of shoes to pupils up to eight years old enrolled in school.

Decentralized compost sanitation represents a potential sustainable sanitation solution that could limit fecal contamination at the source while also complementing the rural, agricultural lifestyle of the area. Papoga is rich in the materials necessary to harness and accelerate this natural process that breaks down pathogens in human waste while creating organic fertilizer.

1.1 Research Questions

This qualitative descriptive study seeks to gain insight into the local perceptions of decentralized thermophilic compost sanitation in Papoga and its associated health benefits. Specifically, this paper intends to answer the following questions built upon distinct aims:

4. How has compost sanitation been marketed in Papoga?
 - Explain the founding strategies employed by IMO in introducing and expanding compost sanitation throughout Papoga.
 - Describe the manner in which compost sanitation was marketed and spread throughout Papoga compared to IMO's original strategies.
 - Elucidate the local characteristics that enabled compost to spread organically.
5. Is compost sanitation protective of public health in Papoga?
 - Compare temperature recordings of active compost sites with thermal death points of common pathogens that affect human health.
 - Explore the temporal relationship between the rollout of compost sanitation in schools and the reduction of STH prevalence among school children.
6. What are the drivers and barriers to compost sanitation in Papoga?
 - Describe the local perception of compost sanitation in terms of advantages, disadvantages, hopes, and fears.
 - Compare perceptions of compost sanitation before exposure to insights gained after exposure.

1.2 Literature Review

As of 2015, 2.3 billion people globally lack basic sanitation service with 892 million people still practicing open defecation.⁵ Improved sanitation facilities are those designed to hygienically separate excreta from human contact and include flush or pour-flush toilets to sewerage systems, septic tanks or pit latrines, improved pit latrines and composting toilets while basic sanitation service is the use of improved facilities which are not shared with other households.⁶

World leaders at the 70th Session of the UN General Assembly in 2015 adopted the 2030 Agenda for Sustainable Development comprised of 17 Sustainable Development Goals (SDGs) and 169 targets in order to establish collaborative partnership by all countries and stakeholders. SDG 6.2 sets out to achieve access to adequate and equitable sanitation and hygiene for all and an end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.⁷ UN Water's Integrated Monitoring Initiative for SDG 6 establishes the two-part indicator SDG 6.2.1 to track the percentage of a population using an improved sanitation facility at the household level that is not shared with other households and where excreta are treated and disposed of in situ or transported and treated off-site.⁸

The significance of this global effort articulated by SDG 6 should not be understated. Diseases associated with poor sanitation account for 10% of the global burden of disease.⁹ With more than 200 million tons of human waste going uncontained and untreated around the world each year the health of everyone is at risk.¹⁰ Poor sanitation facilities, open defecation, and contaminated drinking water contribute to the transmission of infectious diseases like diarrhea, cholera, typhoid, and soil transmitted helminthiasis, and can also impact malnutrition. According to a WHO estimate, the deaths of 361,000 children under 5 years old each year could be avoided by addressing water and sanitation risk factors.⁵ Although clean water is often addressed by humanitarian aid groups in advocacy and deed, access to improved sanitation is more frequently associated with reduced stunting risk than access to improved water.¹¹ The 54th World Health Assembly (WHA54.19) calls for improved water and sanitation to reduce transmission of soil-transmitted helminths.¹²

Pit latrines are commonly thought to be an adequate method of waste management; however, many pit latrines, especially those in rural areas of low-income nations, are unable to safely separate humans from fecal contamination. Soil-transmitted helminthiasis and other enteric diseases are spread through fecal material that is left largely uncontained by pit latrines. Just one gram of feces can contain more than 10 million viruses, 1 million bacteria, 1,000 parasite cysts and 100 parasite eggs.¹³ Open defecation contributes to the spread of fecal contamination by depositing pathogenic fecal material directly into soil or water. Pathogens in feces can be transmitted by hands, food, water, soil, animals, flies, and more, all of which lead to the primary route through the mouth. Among children younger than 18 months, exposure to fecal contamination occurs primarily within

the home compound. In the same vein, Lahue et. al. found in 2018 that a limited understanding of disease on low resource communities continues to hamper improvements in health.¹⁴

The 2015 Sanitation Hygiene Infant Nutrition Efficacy (SHINE) trial was motivated by two main premises. First, Environmental Enteric Dysfunction (EED), a disorder of the small intestine that is widespread in people living in low-income settings throughout the world, is a major cause of child stunting and anemia. Secondly, the primary cause of EED is infant ingestion of fecal microbes due to living in conditions of poor quality and quantity of water, sanitation, and hygiene (WASH).¹⁵ The community-based cluster-randomized SHINE trial tested the independent and combined effects of WASH interventions in two rural districts in Zimbabwe. The WASH interventions implemented as part of the SHINE trial included improved pit latrine, hand washing stations, liquid soap, point-of-use water chlorination, and clean play space. These WASH interventions were found to not prevent enteric infections.¹⁵ According to Rogawski et. al., transformative WASH interventions are needed that are more efficacious in interrupting fecal-oral microbial transmission of children living in highly contaminated environments.”¹⁶

Compost sanitation has emerged as one potential “transformative WASH interventions.” SOIL and Sanergy are two groups that have generated substantial success in centralized compost sanitation in urban settings. SOIL is non-profit organization that is in the process of scaling up EkoLakay, its transformative social business providing 1,000 households with a centralized sanitation toilet service in Port-au-Prince, Haiti. EkoLakay’s container-based city-wide sanitation service serves 6,000 users in collecting 10 metric tons of human excreta each week. With the help of its full-time staff of 84 people, these excreta are treated and transformed into agricultural-grade compost that is then sold for 300 USD per metric ton. EkoLakay customers rent a SOIL toilet for a fee of about 3.75 USD per month that includes the rental of an EkoLakay toilet, weekly pick up of waste, and weekly drop off of a fresh supply of carbon cover material used in “dry flushing.” In generating their realized success, SOIL has operated with a climate-resilient design, encouraged inclusive innovation and responsible growth, and engaged the public sector heavily.¹⁷

In Nairobi, Kenya, Sanergy opened the first “Fresh Life Toilet” in Mukuru Kwa Njenga slum in November 2011. Today, there are over 2,500 Fresh Life Toilets spread across Nairobi’s urban slums serving over 103,000 residents each day. These urine-diverting squat-plate toilets collect

waste that is then collected by Sanergy's team. It is then centrally converted into organic fertilizer and insect-based animal feed.

Despite the success realized by SOIL and Sanergy in urban areas, most of the world's 2.3 billion people living without access to adequate sanitation live in rural settings. For many, a centralized compost system would be difficult due to rough terrain, inconsistent funding, and the complexity of a urine-diverting design. Thermophilic compost sanitation presents a potential option for the rural households, schools, places of worship, and other entities that commit to managing their own systems for their own use.

2 Methods

2.1 Study Setting

Papoga is a rural parish comprised of about 1,600 households in the Zou Sub County of Uganda's Zombo District. This collection of villages and trading centers lies along Uganda's border with Democratic Republic of Congo in what is popularly known as the West Nile Region. The forested mountainous area hosts most of the markets and trading centers of the Alur people that populate both sides of the international border. The rural lifestyle is largely agricultural, with wired electricity first making its scattered appearance in September 2015.

There are three government primary schools, one private primary school, and a nursery school with a combined pupil count of several thousand children in Papoga. Like many rural communities across East Africa, these children are expected to be active members of the subsistence-farming lifestyle in addition to maintaining their studies. This includes tending to livestock, collecting water multiple times throughout the day, taking care of younger siblings and family members, aiding in minor building projects, and performing domestic chores like cooking and cleaning. These children represent the target population of IMO's STH Control Program.

2.2 Description of Intervention

Thermophilic compost sanitation is an all-natural process whereby nitrogen-rich feces and urine, together with carbon material like sawdust or rice hulls, are composted into organic fertilizer due

to naturally present thermophilic bacteria. By combining the appropriate amount of nitrogen and carbon in a compost bin that allows oxygen to pass through, the natural process accelerates without the need for any additives such as beetles, worms, electricity, or power.

This system is container-based, which means that feces, urine, and toilet paper is collected in a toilet receptacle. Any excreta deposited into the toilet receptacle must be covered completely by a “dry flush” consisting of any small-particle carbon-based cover material like sawdust or rice hulls. Containing the excreta in the toilet receptacle is the first step in keeping it from contaminating the surrounding environment. This first combination of excreta and cover material begins to balance the carbon-nitrogen ratio necessary for the thermophilic compost process to occur.

Once the toilet receptacle is full, it is deposited into a larger compost bin where the bulk of the decomposition will take place. At the compost bin, the toilet receptacle is emptied into the center of the bin atop a “biological sponge” made of large-particle carbon-based material like dried grass or leaves. The contents of the toilet receptacle are then covered with more large-particle carbon material. If the compost bin is slatted and allows oxygen to pass through, the decomposition process will accelerate without the need to turn or aerate the pile.

2.3 Data Collection

Although there is some overlap by nature, this study consists of four distinct components: interviews and focus group discussions, surveys, observation, and STH prevalence. An Institutional Review Board determination of exempt status covers all but the STH prevalence component, as IMO collected and analyzed all stool samples in accordance with local health departments. There were no criteria for eligibility or exclusion of cases in this study.

2.3.1 *Semi-structured Interviews and Focus Group Discussions*

An IMO roster of households that have shifted to compost sanitation in lieu of pit latrines or are interested in doing so was used as a starting point in recruiting participants for this study. Participants from this roster were first chosen randomly. After visiting the randomly selected households, convenience sampling led to other participants that could provide relevant perceptions

regarding compost sanitation even if they were not on the IMO roster due to compost's widespread dissemination in Papoga.

Almost every interview occurred at the home of the participant where the current method of sanitation could be referred to tangibly. From here, convenience sampling was used to recruit other participants as time allowed. Furthermore, interviews were conducted with the LC1— the highest elected official – of the villages of Amunze, Ambe-Olieko, and Olalo.

The interviews were conducted in English when possible and with a translator when necessary. An interviewed subject would first be asked for consent to undergo a recorded interview. There were no instances where a subject refused to be interviewed or refused recording. The subject would then spell his or her name and the interview would commence with the use of an interview guide. The interviews were semi-structured to allow for each interviewee to offer an unfiltered, unguided perspective. Twenty-one interviews were conducted in May 2017 while nine interviews and two focus group discussions were conducted in September 2018. The focus group discussions were unplanned and consisted of several community members and leaders alike within the community itself.

2.3.2 *Surveys*

The surveys were developed in English before consultation with local IMO staff in order to contextualize questions for the local Alur population. The surveys were then translated into the local Alur language in order to include a larger majority of the local population in the response pool. The written surveys were distributed widely and indiscriminately in several different parts of Papoga parish. Responders were asked to complete the survey within 48 hours. After 48 hours, seventeen surveys were submitted in English and fifty-one were submitted in Alur. Twenty-six surveys were able to be used due to many being incomplete or illegible. After the surveys were returned, local IMO staff translated responses.

The surveys sought a wide variety of information regarding sanitation use and management and focused most notably on its fears, challenges, advantages, and disadvantages.

2.3.3 *Observation*

In addition to the interviews, focus group discussions, and surveys, IMO program notes and reports were used to glean information regarding the strategy and roll out of compost sanitation in Papoga. These sources of information included a log of internal temperatures that were recorded at every active compost bin at every school compost bin in and around Papoga between April and October 2016. Temperatures of active compost piles were recorded weekly in six school compost bins from April to October 2016 and five more compost bins from June to October 2016. These temperatures were then compared with thermal death points of common pathogens and parasites as revealed in published literature.

2.3.4 *STH Prevalence*

The prevalence of STH among school children in Papoga's primary schools was available via IMO's yearly rapid appraisal reports. Starting in 2015, stool analysis has been performed by IMO yearly in Papoga's four primary schools with the help of local health teams with the approval of the Zombo District health department, cooperation of school administrators and staff, and consent of parents and children. Stool analysis for soil-transmitted helminthiasis included 207 children in January 2015, 200 children in October 2016 and 2017, and 196 children in September 2018. Stool analysis was also performed among children not enrolled in school in the villages of Olalo and Ambe-Olieko in September 2018.

Each collection and analysis of stool samples from 2015 to 2018 was completed by IMO independent of this study, although the data was made accessible to the author. Therefore, an IRB determination of exempt status was granted.

IMO employed quota sampling in its stool analyses by which the number of children randomly chosen to participate in the stool analysis correlated with the size of the school's population. The number of children from each school that participated in the stool analysis changed each year according to enrollment numbers. An equal number of boys and girls were included in each the analysis each year.

A fresh fecal specimen, uncontaminated by urine, was collected from each child that participated in the stool analysis in a clean, intact, dry container that was sealed with a lid. The participants were randomly selected from the school population and given instructions on how to deposit the sample into a provided container. The younger children were assisted by older pupils, school staff, or parents.

Microscopic examination of stool specimens follows a strict protocol. The container did not need to be sterile, but it did need to be free from chemicals, antiseptics, disinfectants, or other substance that could disrupt the integrity and validity of the specimen. For the purposes of detecting ova and parasites, the specimen was available for testing within an hour of collection. Each specimen was immediately labeled with the appropriate demographics upon receipt by laboratory personnel. If the specimen was dysenteric or mostly liquid 10 cc was adequate, while if the specimen was formed one gram or half a teaspoon was sufficient. For infection control purposes all specimens were handled with gloves with associated good handwashing technique upon both entry and exit of the laboratory.

Preparation of the specimens differed for dysenteric and unformed specimens as opposed to semi-formed and formed specimens. For dysenteric and unformed specimens, a small amount of specimen was placed on a slide to include any blood or mucus within the specimen. A small drop of prepared iodine was then placed on the other end of the slide. The slide was then covered with a cover-glass, pressing gently with a tissue to make a thin preparation. The slide was then examined immediately using the 10X objective with the condenser partially closed to provide adequate contrast. For semi-formed and formed specimens, about 2mg of specimen was mixed with the iodine/saline suspension and then covered with a cover-glass, pressing gently with a tissue to make a thin preparation. Just as with the dysenteric and unformed specimens, it was examined immediately using the 10X objective with the condenser partially closed to provide adequate contrast.

Specimens that were not formed were examined immediately while specimens that were formed were mixed in a prepared iodine solution, breaking up large particles to create a sufficiently dilute slurry. Iodine was important for better contrast specifically for cysts and eggs. Direct examination of feces was used to detect motile parasites and to identify significant helminth infections.

Concentration techniques were not necessary since the purpose of the examination was not to detect *Schistosoma* larvae, nor to determine adequacy of treatment. Although up to three specimens collected on alternate days would increase sensitivity, only one specimen per child was utilized. Logistically, compliance that is required for multiple specimens collected on alternate days is not realistic in some of the rural settings. Then the specimen was examined with the 40x objective for identification of eggs, cysts, and oocysts. At least ten microscope fields were examined before reporting “no parasites found”.

For the STH prevalence as informed by the stool analyses, the following formula was used to ascertain a 95% confidence interval:

$$CI = p \pm Z_{\alpha/2} * \sqrt{(1/n) * p * (1-p) * (N-n)/(N-1)}$$

where p is the sample proportion, $Z_{\alpha/2}$ is the critical value of the normal distribution at $\alpha/2$, α is 0.05 and the critical value is 1.96, n is the sample size, and N is the population size.¹⁸

2.4 Statistical Methods

After receiving the STH data from IMO, it was analyzed using Microsoft Excel. Raw data from interviews and focus group discussions, questionnaires, and temperature recordings were analyzed both by hand and with the help of Microsoft Word and Microsoft Excel.

3 Results

3.1 How has compost sanitation been marketed in Papoga?

IMO introduced compost sanitation into Papoga on a rolling basis in three separate phases focused primarily on the schools. At the culmination of the third phase in October 2016, 68 of the first 84 compost toilets launched in Papoga were found in schools while only 16 were found in households.

Table 3.1.1 Compost Toilets Launched in Phases 1 – 3

	Phase One (April 2016)	Phase Two (June 2016)	Phase Three (October 2016)	Total
School Toilets	19	19	30	68
Household Toilets	0	8	8	16
Total	19	27	38	84

After the first three phases, expansion of compost sanitation shifted to the households. Over the course of five more phases, 167 households spread across 39 different villages opted to shift to compost sanitation in lieu of pit latrines.

Table 3.1.2 Compost Toilets Launched in Phases 4 – 8

	Households	Villages
Phase Four	32	16
Phase Five	14	9
Phase Six	16	12
Phase Seven	16	10
Phase Eight	89	12
Total	167	39

Table 3.1.3 Where did survey respondents first hear of compost sanitation?

Source	Number	Percentage
Local IMO team members	18	69.2%
Friends, family, and/or neighbors	14	53.8%
Schools	2	7.7%
Government	1	3.8%

3.2 Is compost sanitation protective of public health in Papoga?

Temperatures were taken weekly at each school that adopted compost sanitation from April 2016 to October 2016. These include Bethel Junior, Papoga Primary, Zale Primary, and Zeu Primary from Phase One and Aarii Primary, Ayaka Primary, and Bethel Junior’s second campus that shifted to compost sanitation in Phase Two.

Table 3.2.1 Temperatures of Compost Bins at Phase One Schools (April to October 2016)

	Week 1	Week 3	Week 5	Week 7	Week 9	Week 11	Week 13	Week 15	Week 17	Week 19	Week 21	Week 23	Week 25
BJS1 1	43°	49°	49°	52°	52°	54°	54°	52°	52°	43°	35°	27°	27°
BJS1 2	43°	49°	52°	54°	57°	57°	60°	54°	52°	46°	49°	-	-
Papoga	49°	49°	49°	52°	52°	52°	54°	54°	57°	60°	54°	38°	24°
Zale	27°	27°	27°	27°	27°	27°	27°	27°	27°	21°	21°	21°	-
Zeus	27°	27°	27°	27°	27°	49°	49°	49°	52°	54°	49°	38°	-

Table 3.2.2 Temperatures of Compost Bins at Phase Two Schools (July to October 2016)

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13
Arii	27°	27°	32°	38°	-	38°	46°	49°	43°	43°	-	32°	32°
Ayaka1	43°	54°	60°	66°	-	66°	66°	63°	60°	54°	-	52°	49°
Ayaka2	49°	-	52°	54°	60°	63°	66°	-	66°	60°	54°	-	-
BJS2 1	43°	52°	60°	60°	-	60°	57°	54°	60°	63°	66°	-	66°
BJS2 2	43°	43°	-	43°	52°	54°	54°	60°	-	60°	63°	49°	-

For both Phase One and Phase Two schools, temperatures were recorded weekly starting on the Friday immediately following each school’s launch of compost sanitation. The bolded temperatures in Table 3.2.1 and Table 3.2.2 are those above 50° C. This same data is laid out in Figure 3.2.1 below.

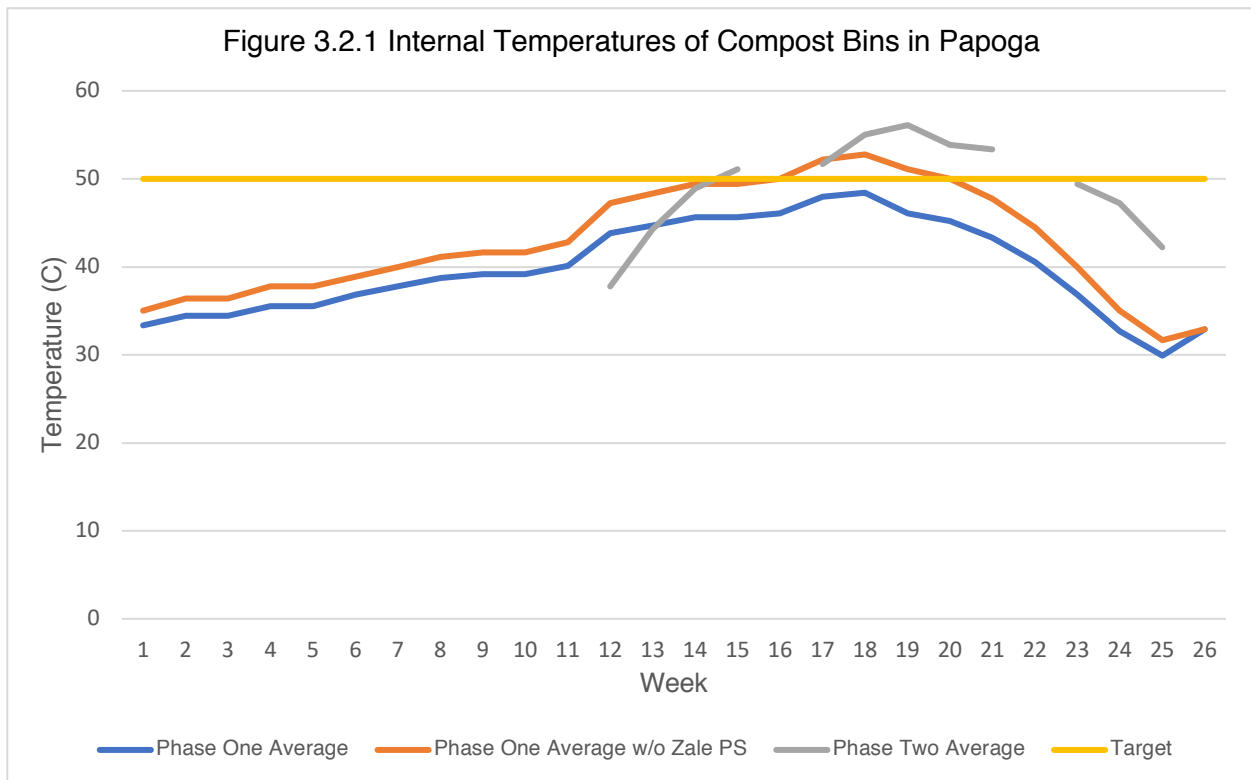


Table 3.2.3 Thermal Death Points for Common Parasites and Pathogens

Pathogen	Thermal Death Point	Time to Death at Death Point
<i>Ascaris lumbricoides</i> ¹⁹	55° C	60 min
<i>Ascaris lumbricoides</i> eggs <small>Error! Bookmark not defined.</small>	50° C	60 min
	55° C	7 min
Bacillus typhosus, Salmonella ²⁰	56° C	10 min
	63° C	4 minutes
Ebola virus	60° C	60 minutes
<i>Entamoeba histolytica</i> cysts ²¹	50° C	5 minutes
Enteric viruses <small>Error! Bookmark not defined.</small>	60° C	Rapidly
<i>Escherichia coli</i> ²²	60° C	105 minutes
Hookworm eggs <small>Error! Bookmark not defined.</small>	45° C	One hours
	50° C	5 minutes
Schistosoma eggs <small>Error! Bookmark not defined.</small>	50° C	60 minutes
Shigella, Dysentery bacilli ²⁰	58-60° C	10 minutes
Taenia eggs <small>Error! Bookmark not defined.</small>	45° C	Four hours
	59° C	10 minutes
<i>Trichinella spiralis</i> larvae <small>Error! Bookmark not defined.</small>	55° C	Quickly
<i>Vibrio cholera</i> ²³	55° C	1 minute

Table 3.2.4 STH Prevalence Among School Children in Papoga

Date	Prevalence	Sample Size	95% CI
January 2015	73.7%	205	68.0 - 79.4
April to October 2016	Compost Sanitation Launched in Primary Schools		
October 2016	50.0%	200	43.4 - 56.6
October 2017	33.0%	200	26.8 - 39.3
September 2018	23.4%	196	17.8 - 29.0

Table 3.2.5 STH Prevalence by Type

Type	January 2015	Apr. to Oct. 2016	September 2018
Hookworm	27.9%	Compost Sanitation Launched in Primary Schools	11.7%
Ascaris	26.5%		10.2%
Pinworm	11.8%		0.5%
Whipworm	9.3%		0.5%
Tapeworm	1.0%		0.0%
Schistosomiasis	0.5%		0.0%
Children infected with > 1 type	3.4%		0.0%

Table 3.2.6 STH Prevalence by School

School	Jan. 2015	Apr. to Oct. 2016	Oct. 2016	Oct. 2017	Sep. 2018
Bethel Junior	61.3%	Compost Sanitation Launched in Primary Schools	51.9%	33.3%	17.9%
Papoga Primary	60.4%		45.0%	30.0%	23.0%
Zale Primary	85.1%		65.0%	37.5%	25.5%
Zeu Primary	80.8%		45.6%	27.3%	21.1%

Table 3.2.7 STH Prevalence Among Children Not in School

Village	Prevalence	Sample size	95% CI
Olalo	95%	20	84.01 - 100
Ambe-Olieko	100%	32	95.73 - 100

3.3 What are the drivers and barriers to compost sanitation in Papoga?

Table 3.3.1 Drivers of Compost Sanitation in Papoga

Driver	Total (56)		Survey (26)		Interviews (30)	
	Percentage	Number	Percentage	Number	Percentage	Number
Fertilizer / Manure	58.9%	33	76.9%	20	43.3%	13
Comfortability / Easy	35.7%	20	30.7%	8	40.0%	12
No smell	25.0%	14	15.4%	4	33.3%	10
Technology / Organized	25.0%	14	15.4%	4	33.3%	10
No flies	23.2%	13	15.4%	4	30.0%	9
Avoid digging pit	21.4%	12	15.4%	4	26.7%	8
Health / Sanitation / Hygiene	21.4%	12	19.2%	5	23.3%	7
Cheaper than pit latrine	14.3%	8	19.2%	5	10.0%	3
Durability / Lasts longer	7.1%	4	3.8%	1	10.0%	3
Portability	5.4%	3	3.8%	1	6.7%	2
Increase income	3.6%	2	7.7%	2	0.0%	0
Example for others	1.8%	1	3.8%	1	0.0%	0
Open defecation free	1.8%	1	3.8%	1	0.0%	0

Over 75% of survey respondents and nearly half of those interviewed cited the potential recovery of fertilizer as the main driver of shifting to compost sanitation in Papoga households. Other significant drivers include compost sanitation being comfortable and easy to use, their associated sense of organization and progressive technology, and their being odor-free and fly-free.

Table 3.3.2 Fears or Barriers of Compost Sanitation in Papoga

Barrier	Total (56)		Survey (26)		Interviews (30)	
	Percentage	Number	Percentage	Number	Percentage	Number
Misuse by children and visitors	25.0%	14	26.9%	7	23.3%	7
Need for cover material	16.1%	9	15.4%	4	16.7%	5
Need for biodegradable soap	14.3%	8	15.4%	4	13.3%	4
Desire for gloves, toilet brushes	10.7%	6	3.8%	1	16.7%	5
Fear of the unknown	8.9%	5	0.0%	0	16.7%	5
Flies / smell when misused	7.1%	4	7.7%	2	6.7%	2
Seems unhealthy	5.4%	3	3.8%	1	6.7%	2
Expensive to replicate	3.6%	2	3.8%	1	3.3%	1
Need to clean consistently	3.6%	2	0.0%	0	6.7%	2
Seems tedious	3.6%	2	3.8%	1	3.3%	1
Tradition / Attitude	3.6%	2	0.0%	0	6.7%	2
Cannot use when renting	1.8%	1	0.0%	0	3.3%	1
Chickens get in	1.8%	1	0.0%	0	3.3%	1
Local government looking for pits	1.8%	1	0.0%	0	3.3%	1
Stolen fertilizer	1.8%	1	0.0%	0	3.3%	1

When asked about fears or barriers to compost sanitation, the most common response stemmed from a fear of misuse by children or visitors. The access of cover material, biodegradable soap and other components for managing compost were significant, but less common barriers.

4 Discussion

4.1 Implications of Findings

A 2016 review of sustainable sanitation systems in Africa concluded that “a winning sanitation management plan should also be appreciated and supported by all stakeholders, which can be achieved through proper communication and integration of local user needs.”²⁴ Decentralized thermophilic compost sanitation fulfills each of these requirements in full. All stakeholders that opt in to compost sanitation appreciate and support the new technology while the compost systems themselves are accessible and marketable primarily through informal communication. Furthermore, compost satisfies many local needs that include limiting pathogenic spread, reducing STH, and providing organic fertilizer. In many ways, compost sanitation represents a “transformative” sanitation intervention called for on the heels of the SHINE trials.¹⁶

The spread of compost sanitation across entire communities and regions would restore the nutrient cycle across the same geographical area. At the same time, fecal contamination could be reduced, thereby limiting spread of enteric diseases, soil-transmitted helminthiasis, and more. The widespread adoption of compost sanitation carries potential benefits in health and well-being as children and adults would no longer be subject to chronic intestinal parasite infection and other enteric disease that are spread through fecal contamination. Instead, pathogens and other harmful material found in human excreta would be contained and transformed by the natural thermophilic compost process into rich, organic fertilizer safe for personal use. The organic production of fertilizer could boost crop yield dramatically without having to purchase chemical fertilizers that introduce a host of problems. Decentralized thermophilic compost sanitation is uniquely suited to those in agricultural, rural communities. Personal and community-wide development and health can be restored through the implementation of compost sanitation as an improved method of waste management.

4.1.1 *How has compost sanitation been marketed in Papoga?*

In 2016, IMO presented the idea of thermophilic compost sanitation to its local Project Management Committee (PMC) as a way to limit fecal contamination at the source. Papoga's four primary schools were used to introduce compost sanitation to the community. By starting small in a controlled environment with school teachers first learning the ins and outs of compost use and management, any challenges or troubleshooting could be better managed. Before and after a school's compost launch, each school maintained constant communication with the local IMO team to insure proper management and use. This included site visits by the IMO team at least weekly. While converting school pit latrines to compost toilets was the strategic starting point, the eventual goal was to migrate compost sanitation into willing households without having to incentivize or coerce.

In April 2016, nineteen pit latrines were converted to compost toilets at four primary schools, one nursery school, and one agricultural institution. In June 2016, twenty-seven more pit latrines were converted to compost toilets at three primary schools and eight homes as part of Phase Two of the planned compost expansion. Each of the households that converted to compost during Phase Two had been associated with the planning and implementing process and opted to convert on their own

volition. The residents were responsible for providing the raw materials with which the compost bins are constructed. In October 2016, thirty-eight pit latrines were converted to compost toilets in two schools and eight households in Papoga as part of Phase Three, bringing the total number of IMO-sanctioned compost toilets in Zombo District to eighty-four (Table 3.1.1).

As was to be expected, conversion to compost sanitation was not perfect, though regular site visits and open-ended communication allowed for troubleshooting to take place quickly. The most common issues involved leaving toilet seats open and not using enough cover material during the dry flush. These both allowed for the presence of both flies and odor in the compost toilets. One school found their first compost bin to emit a fruity-odor that was nullified when more cover material was added to the bin. At another school, four of the eighteen staff members expressed concern about exposure to disease via the toilet seats. These concerns were dismissed after speaking with IMO's chief medical officer and other team members regarding the safety of toilet seats, especially in relation to the danger of fecal contamination via pit latrines and open defecation.

Six months after the first compost toilet was launched, the majority of staff, pupils, and even parents of Papoga's schools quickly realized the appeal of the compost system and grew in proficiency. All but one school in Papoga eagerly converted fully to compost sanitation by October 2016. Pupils, parents, and surrounding community members helped to build the new compost bins and place the new compost toilets into the recently sealed pit latrine stances.

As anticipated by IMO, the fervor over compost grew out from the schools to the homes. After compost sanitation was launched in the schools starting in April 2016, the majority of school staff wanted to bring compost systems home due to its comfortability, sanitary feeling, and the potential of manure for their home gardens. IMO and the PMC together decided to utilize the school staff's eagerness in order to make compost sanitation tangible throughout households in the region. By riding this wave of demand from those already experienced with compost management, compost sanitation moved into villages where the management, benefits, challenges could be seen firsthand. Thus, the 184 households that shifted to compost sanitation up to September 2018 represent 42 villages and an estimated 986 users spread throughout Zombo District's Zeu Sub County (Table 3.1.1 and Table 3.1.2).

Interviews, focus group discussions, and surveys revealed that the schools were the most significant starting point for the idea of compost to reach the homes. Each of the primary schools reported large numbers of parents visiting just to take a look at the compost toilets. Some of these parents took initiative to seek out the local IMO team to be considered for a toilet themselves. One of these parents, Mr. Jeremy, was happy to first hear of compost sanitation from his children, two of which attend Papoga Primary School and one that attends Bethel Junior School. He went to the school, sought out the IMO team, and made the “easy decision” to convert his pit latrine to a compost toilet. After doing so, Mr. Jeremy experienced an influx of interest from his neighbors. One of his brothers had even visited from a different part of the district and, after seeing and using the compost toilet, wanted to bring one home to his village. Although almost 70% of survey respondents credited their first hearing about compost sanitation from the local IMO team, over half of them also credited family, friends, or neighbors with first telling them of compost (Table 3.1.3).

By September 2018, during Phase Eight of IMO’s compost expansion, this trend resulted in relatively large numbers of households in each village shifting to compost at the same time. This marked a turning point in the compost expansion strategy due to the now universal demand for compost in Papoga. A significant phenomenon revealed by interviews and focus group discussions is that of “self-appointed mobilizers”. These people who came to learn of compost through use or proximity and took it upon themselves to spread the word about compost sanitation technology and its feasibility throughout their own village. In the 81-household village of Amunze, for instance, a man living in one of the first households to adopt compost sanitation first heard of it from the schools through his children. After he visited the school, attended an IMO training, and shifted to compost at home, a neighbor saw it for the first time. This neighbor in turn began spreading the word of compost to his neighbors and other people throughout the village. He brought people to the compost bin, showed them how it works, and explained its benefits for the individual house and for the entire community. This phenomenon of self-appointed mobilizers was prevalent in nearly every village in which a household has shifted to compost and seems to be the key local component of widespread compost sanitation demand and adoption after its initial introduction through the schools.

4.1.2 *Is compost sanitation protective of public health in Papoga?*

Naturally present thermophilic bacteria activate in the presence of the optimal ratio of carbon, nitrogen, and oxygen. Given these conditions, the thermophilic bacteria that drives the compost process generates enough heat for a long enough time to kill many common parasites and pathogens. In the schools that adopted compost sanitation from the beginning, the heat steadily rose and maintained temperatures above 50°C for several weeks (Figure 3.2.1). The hottest recorded temperatures were found at Ayaka Primary School most likely due to its large pupil population contributing to a high volume and variability of input. As described above, Zale Primary School initially resisted compost sanitation during the time that the temperature measurements were recorded and, predictably, their compost bins did not generate heat above ambient temperature (Table 3.2.1 and Table 3.2.2).

At the recorded temperatures of the active compost bins, many common parasites and pathogens are killed within hours or even minutes (Table 3.2.3). Pathogen destruction has even been demonstrated at 50°C, producing completely acceptable, hygienic compost.²⁵ Of particular note are the soil-transmitted helminths *Ascaris*, Hookworm, and Schistosomes in addition to enteric viruses, *cholera*, and *E. coli*. Although no temperatures have yet been recorded at households, all observed piles emit radiant heat and have been reported to steam during rainfall.

Each primary school in Papoga experienced substantial reduction in STH prevalence from January 2015 to September 2018 after compost sanitation was launched in between April and October 2016 (Table 3.2.4). Hookworm and ascaris remain the two most common parasites found among Papoga's school children; however, their prevalence dropped by 58.1% and 61.5% respectively (Table 3.2.5). All four primary schools in Papoga has seen a substantial reduction in STH prevalence since compost sanitation was employed. Bethel Junior School maintains the lowest prevalence of Papoga's four primary schools, while Zale Primary experienced the largest reduction (70%) in STH prevalence since shifting to compost sanitation (Table 3.2.6). It should be noted, that since Zale's initial resistance to compost sanitation, it is now fully engaged, and 100% compost based.

Stool analyses taken among children in the villages of Olalo and Ambe-Olieko not enrolled in school and without access to compost sanitation at home revealed STH prevalence to be 95% and 100% respectively (Table 3.2.7). It seems likely that the relatively recent trend of larger clusters of households shifting to compost sanitation at the same time will allow fecal contamination and pathogenic spread to be reduced over larger geographic areas instead of being confined to single household plots.

The January 2015 stool analysis performed by IMO preceded any intervention regarding STH in the schools or community. After this baseline was established, other potential implementation contributing to the STH prevalence reduction include public education focusing on hand hygiene, the distribution of shoes to children up to eight years of age, and mass drug administration administered bi-annually to each of the four primary schools. Each stool analyses, however, was performed just before this mass drug administration. The distribution of shoes ended after 2016; however, mass drug administration and handwashing hygiene continues until now.

4.1.3 *What are the drivers and barriers to compost sanitation in Papoga?*

One older neighbor wanted compost out of fear of going outside at night and the smell-free experience. The absence of smell, according to this neighbor, would allow them to put the toilet inside Mr. Jeremy's interest was piqued especially because of a serious accident his family had years before where a child fell into a pit. In addition to eliminating the chance of a repeat accident with a child, and also because of once dropping a phone into a pit, he felt that the compost could yield manure for his crops in order to add nutrients back into the soil. Once he made the "easy decision" to shift into compost, he received no resistance from the family. Because of his children's previous exposure to compost sanitation at school, it had become natural to them.

The greatest driver of compost in Papoga is the potential for recovering fertilizer for use in home and school gardens with comfortability of use, no smell and no flies, and the avoidance of digging a pit also contributing to compost's spread throughout the parish (Table 3.3.1). Mr. Odongo Manuel, LC1 of Amunze shared that before compost sanitation, some of the people in the Amunze were happy with pit latrines "simply because no new technology has ever been brought to the area. Now that compost has been brought in, many are interested in compost toilet and talking about it." The same interest and desire for compost sanitation exists in the village of Ambe-Olieko where

each of the 56 households have registered to shift to compost sanitation in lieu of a pit latrine. The main motivations for moving away from pit latrines in Ambe-Olieko include cleanliness, ease of use, structural integrity, and cost. One woman in Ambe-Olieko has even sealed a brand-new pit that she just paid to have dug in favor of her new compost toilet.

Although the potential of recovering fertilizer is a main driver of compost sanitation in Ambe-Olieko, the hygienic nature and “sense of cleanliness” is a major draw too. According to one woman, “Pit latrine brings a lot of flies. With the compost toilet there is no single fly; someone could even use it in the house. This gives the sense that there are no diseases.” Everyone surveyed in Ambe-Olieko agrees that there is an abundance of diarrhea and intestinal parasites in the village, and everyone also believes that the compost will help to reduce them. According to one man, “The issue of diarrhea will be history now that compost is here. Because diarrhea is caused by flies that visit pit latrines and then visit the food that we eat. With compost, there are no flies.”

Mr. Odongo went on to say, “Compost is part of hygiene practice and is definitely going to help.” In Amunze, nearly every household has expressed interest in shifting to compost by attending a training session with some having already built their compost bin. Inadequately maintained pit latrines quickly become breeding grounds for disease-carrying flies and become major routes of transmission for hookworm and other intestinal parasites. Improper placement of a pit can leech pathogenic fecal material into ground water or into arable land. Consequently, pit latrines create more opportunities for both direct and indirect fecal contamination instead of safely, effectively, and hygienically managing human excreta.

Not only does the compost provide relief from fecal contamination, it transforms what was once termed “waste” into a valuable resource. Mr. Odongo’s wife chimed in with her excitement over the fertilizer that they will soon recover. “The way I see the compost bin, we will recover manure to apply to our crop and increase the yield.” Throughout Amunze, there is no fear in using manure from the compost. The people of Amunze recognize the prevalence of diarrhea and intestinal parasites in their village and believe that proper sanitation through compost can, according to Mr. Odongo, “fight it off.”

Another driver of compost throughout Papoga is in its comfort and ease of use. Elderly and disabled people who previously struggled to use a pit latrine without aid are now finding relief in the compost toilet's seat. One older woman described how compost has helped her because her husband is weak and cannot walk. She previously had to hold him when he visited the pit latrine. Now with compost, he can go by himself, relieving her of a tasking duty in helping the husband when he visits the toilet. Having to rely on support from spouses, partners, and children is a common practice in Papoga for those that have no strength to squat over a pit latrine.

The emergence of compost sanitation has even removed the threat of fines and imprisonment levied on those without toilets or pit latrines by the district's health team. Those without the money or ability to have any method of sanitation would previously go into hiding when the health teams would visit. One woman testified that "compost has now rescued" her. Under the public health act, the penalty for not having toilet or pit latrine is one- or two-weeks imprisonment or a fine for threatening public health through the spread of disease and infection.

Although this public health act is based on solid evidence, many people are unable to dig a pit due to recurring associated costs and their inherent unsustainability. Though simple in theory, the construction of a new pit latrine requires digging a sufficiently-sized hole or pit, constructing a structurally-sound floor over that pit, and constructing a structure atop it. Whether done by hand or by employ, these requirements necessitate precious costs of time, energy, and money that are often prohibitive. Furthermore, once filled with human excreta, a pit latrine is deemed decommissioned, sealed, and replaced. The structure atop the pit is razed while a new pit is sunk, and a new structure is built in another spot. It is not uncommon for a family to fill, seal, raze, and build a new pit latrine every several years. A primary school could see this latrine turnover happen even faster. It is not hard to imagine a cluster of razed structures sitting atop full pits littering a homestead or schoolyard, leaving prized land permanently unworkable. In addition to being fundamentally unsustainable, too many school and personal pit latrines are hastily built and poorly maintained, leading to more than just an unpleasant experience during use.

Herein lies the major advantage with compost according to Mr. Odongo: compost sanitation is very cheap and lasts longer than pit latrine. Most of the people in the village normally hire people to sink a pit because most do not have the proper tools, the required strength, or the necessary skill

in digging pit latrines for themselves. In Amunze, it costs 80,000 Ugandan schillings, about \$21, to sink a pit with additional costs incurred in raising the wall, sealing it, installing a roof. For many, this price far exceeds their means.

In the neighboring village of Ambe-Olieko, a woman added, “When you are sick and weak, compost is easier to use than pit latrine. It is the best answer for those who are too sick or weak to sink a pit latrine.” Just as in Amunze, most people in Ambe-Olieko hire someone else to sink a pit with very few doing it themselves. Costs in Ambe-Olieko are about 4,000 UGX, or one US dollar, per foot depending on the length. Some cut costs by opting for a narrower pit for about 2,500 UGX, or about 67 cents. According to Ambe-Olieko’s LC1, even this cheaper rate per foot comes to more than 50,000 UGX just to sink the pit. Sealing the pit and building a structure pushes the cost up to 100,000 UGX. Angelo, a 70-year-old village elder added, “These compost toilets have saved us from a lot of illnesses, especially by cutting off flies. Flies are a vector of disease. Cutting off the smell cuts off the flies. You have also saved us from spending money and time on sinking pit latrines. So, by giving compost toilets, it’s like you are giving money. Using compost is a better situation than pit latrines. This is now a learning area.”

Treating compost as a learning area may be the correct approach, as the most common fear associated with compost is that of misuse by children or visitors (Table 3.3.2). It is common practice in Papoga for people to relieve themselves in open pit latrines when necessary. This common courtesy now opens the door for misuse for those uninformed of how to properly use a compost toilet.

Another potential barrier to compost use is the need for cover material and biodegradable soap and the desire for gloves and toilet brushes. Many people had started to visit lumber sites to collect the sawdust at no charge. However, some of these sites have started to charge for sawdust due to the new demand. There are other options in addition to saw dust that is available in Papoga, though the new requirement of having to collect something is daunting for some. IMO has provided hosted several soap-making workshops that are free to the public in Papoga. Still, these new demands associated with compost sanitation might give pause to some thinking about shifting away from pit latrines.

Very few people suggested that attitude or tradition would be a barrier to the widespread adoption of compost in Papoga. The overarching barriers and disadvantages tend to hover around the fear of being able to acquire the necessary components to manage the compost system rather than a fear of the compost process itself.

Even some obstacles have eventually led a deeper appreciation for compost sanitation. For example, after the completion of one Phase Two female-led family's new compost sanitation system, a person falsely led the family to believe that their bin was not ready for use because the walls were not lined with wire mesh as they had been done at the schools. Since the family believed the bin to be incomplete, they began using the bin as a pigpen. When this was learned, IMO's local staff quickly corrected the misinformation. The family enthusiastically began to use their compost system properly. In May 2017, it was found that all members of the household had adapted to the compost system. While the youngest children still need supervision, the older children help guide their young siblings. When asked if the family had any regret about the shift to compost, the household head replied, "Compost is much better. There is no smell, and most importantly I will get fertilizer. I have no idea about pit latrine anymore!"

4.2 Strengths and Limitations

This study was well informed by an intimate knowledge of the history and context of compost sanitation in Papoga that allowed for a rich qualitative dive into local perceptions. The combination of interviews and focus group discussions, surveys, observation, and STH prevalence enabled compost sanitation to be seen from several different angles despite its occupying the same space. However, the qualitative, observational nature of the study does not provide a direct impact of compost sanitation on individual and community-wide health. Although the data uncovered through interviews, surveys, temperature recordings, and stool analyses suggest a link between compost sanitation and health, it does not prove one. Field challenges prevented further qualitative analysis.

4.3 Future Research

This paper serves as a foundation for further research into the potential nutritional benefits of compost sanitation via to resource recovery, a cost-benefit analysis comparing compost sanitation

and pit latrines, and a deeper quantitative look into the health effects of compost sanitation compared to other sanitation practices. A soil analysis directly testing for soil-transmitted helminths and their ova would be prudent.

In May 2019, four compost samples from Papoga, three household compost bins and one school compost bin underwent Nematodes in Soil Analysis, Complete Compost/Manure Analysis, and Complete Compost-Manure Pathology Screening at Crop Nutrition Laboratory Services Ltd. in Kiambu, Kenya. Results of these analyses were not returned before the submission of this paper.

5 Conclusion

This paper suggests that demand for compost sanitation was spread throughout Papoga organically while IMO allowed the inherent benefits to act as their own incentives. Introducing compost sanitation via the schools provided a semi-controlled environment to introduce compost to the area, while the school children acted as the local messengers bringing word of compost home to parents.

Compost sanitation is associated with better health as evidenced by the reduced STH prevalence in accordance with the timing of compost's launch into the schools. In addition, recorded temperatures of active compost piles suggest that many common pathogens and parasites would not be able to withstand the heat generated during the natural thermophilic process.

As with any community, the drivers of compost sanitation in Papoga vary from person to person and include yielded fertilizer, comfort, and health benefits among other things. The barriers of compost sanitation in Papoga also vary from person to person and are associated more with the accessibility of the tools and information necessary for management of compost rather than with fear or mistrust of the technology.

Appendix A: Household Interview Guide

- What village is this?
- How long have you lived in this village?
- How many people live in your household?

- How do you manage your human waste?
- Are you happy with your current method of waste management?
- Do you know of compost-based sanitation?
- How have you come to hear of compost-based sanitation? Please tell me from the first time you heard, to everything that you've learned up to now.

- Are you interested in adopting compost-based sanitation?
 - Why are you interested?
- What advantages of compost-based sanitation do you anticipate?
- What fears do you have of using compost?
- Do you anticipate any disadvantages?

- What is your perception of the incidence of diseases like intestinal worms or diarrhea in your village?
- Do you believe that compost-based sanitation will have an effect on the incidence of these diseases?

- Do you use compost-based sanitation at your home?
 - When did you turn to compost-based sanitation?
 - What benefits have you seen from compost-based sanitation?
 - What struggles have you seen from compost-based sanitation?
 - Have you recovered fertilizer from your compost?
 - Have you used it on your crops at home?
 - Have you seen a difference in crop yield due to the fertilizer?
 - How long did it take to fill your first compost bin?
 - How many people use the compost toilet in your household?

- Do you have any other thoughts or comments regarding anything that we have discussed or not discussed?

Appendix B: Survey, Households Not Using Compost

Demographics

Where is the household? (List village, parish, and subcounty)

How many people in the household? (Write the total number first, then list ages and genders of each person. For example, write "M65" for a 65-year-old man and "F14" for a 14-year-old female.)

Who is the head of the household? (Write name, age, and gender. If you prefer to remain anonymous, please write age and gender just as above.)

Which of the children attend school? (List ages and genders of each child attending school, just as above.)

Water, Income, and Crops

What is the household's source of water? List all sources by type and by name if a name exists.

Who retrieves water, how often, and how long does it take?

What is the household's source of income? Please list all.

What is the household's average income each month? (UGX)

What crops are grown at the household? Please list all.

Sanitation Methods and Perceptions

Which of these do you feel is the most important? (Circle one.)

Clean water

Sanitation

Personal hygiene

How does the household manage human waste? (Circle all that apply)

Pit latrine

Open defecation

Other (describe)

How many times per week do those in the household above 13 years practice open defecation near the household?

How many times per week do those in the household above 13 years practice open defecation away from the household?

How do you feel about the current method of human waste management? (Circle one.)

Very happy ☺ Happy ☹ Neutral ☹ Unhappy Very unhappy

Does the household share its method of managing human waste with other households? If yes, with how many?

If using pit latrine, how long does it take for the pit to fill?

If using pit latrine, do you sink the pit and build a structure yourself or do you pay someone to do it?

If using pit latrine, how much time and/or money (in UGX) does it cost to sink a new pit and build a new structure?

Have you heard of compost-based sanitation? If so, from where did you hear of it? (Circle all that apply)

Have not heard of compost sanitation Yes, I heard from family / friends / neighbors Yes, I heard from IMO team members Other (describe)

If you have heard of compost-based sanitation, have you attended an IMO compost training session?

If you have attended an IMO compost training session, have you built your compost bin?

Would you like to adopt compost-based sanitation?

What fears (if any) do you have regarding using compost-based sanitation?

If you are interested in adopting compost-based sanitation, why would you like to? (List all reasons)

What advantages (if any) do you think compost-based sanitation will have? (List all)

What disadvantages (if any) do you think compost-based sanitation will have? (List all)

What do you think would prohibit the spread of compost-based sanitation throughout your village?

What do you think would prohibit the spread of compost-based sanitation throughout your parish?

What do you think would prohibit the spread of compost-based sanitation throughout your sub-county?

What do you think would prohibit the spread of compost-based sanitation throughout Uganda?

Appendix C: Survey, Households Using Compost

Demographics

Where is the household? (List village, parish, and subcounty)

How many people in the household? (Write the total number first, then list ages and genders of each person. For example, write "M65" for a 65-year-old man and "F14" for a 14-year-old female.)

Who is the head of the household? (Write name, age, and gender. If you prefer to remain anonymous, please write age and gender just as above.)

Which of the children attend school? (List ages and genders of each child attending school, just as above.)

Water, Income, and Crops

What is the household's source of water? List all sources by type (spring, borehole, river, etc.) and by name.

Who retrieves water, how often, and how long does it take?

What is the household's source of income? Please list all.

What is the household's average income each month? (UGX)

What crops are grown at the household? Please list all.

Sanitation Methods and Perceptions

Which of these do you feel is the most important? (Circle one.)

Clean water

Sanitation

Personal hygiene

How do you feel about the current method of human waste management? (Circle one.)

Very happy

☺ Happy

☹ Neutral

☹ Unhappy

Very unhappy

Does the household share its method of managing human waste with other households? If yes, with how many?

How did you hear of compost-based sanitation? (Circle all that apply)

Yes, I heard from
family / friends / neighbors

Yes, I heard from
IMO team members

Other
(describe)

What material did you use to build your compost bin?

How many times per week do those in the household above 13 years practice open defecation near the household?

How many times per week do those in the household above 13 years practice open defecation away from the household?

What is easier to manage, a compost system or a pit latrine?

When did you adopt compost-based sanitation? (Write the month and year of adoption)

Why did you choose to adopt to compost-based sanitation? (List all)

What advantages (if any) have you noticed since adopting compost-based sanitation? (List all)

What disadvantages (if any) have you noticed since adopting compost-based sanitation? (List all)

Did you have any fears about compost before adopting? What were they? Do you still have them?

Have you recovered "humus" (fertilizer) from your compost pile?

If you have recovered "humus" (fertilizer) from the pile, what date (approximately) did you do so? Have you seen a difference in crop yield?

What do you think would prohibit the spread of compost-based sanitation throughout your village?

What do you think would prohibit the spread of compost-based sanitation throughout your parish?

What do you think would prohibit the spread of compost-based sanitation throughout your sub-county?

What do you think would prohibit the spread of compost-based sanitation throughout Uganda?

Thank you for completing this survey! You are very much appreciated.

Appendix D: Survey, Households New to Using Compost

Demographics

Where is the household? (List village, parish, and subcounty)

How many people in the household? (Write the total number first, then list ages and genders of each person. For example, write "M65" for a 65-year-old man and "F14" for a 14-year-old female.)

Who is the head of the household? (Write name, age, and gender. If you prefer to remain anonymous, please write age and gender just as above.)

Which of the children attend school? (List ages and genders of each child attending school, just as above.)

Water, Income, and Crops

What is the household's source of water? List all sources by type (spring, borehole, river, etc.) and by name.

Who retrieves water, how often, and how long does it take?

What is the household's source of income? Please list all.

What is the household's average income each month? (UGX)

What crops are grown at the household? Please list all.

Sanitation Methods and Perceptions

Which of these do you feel is the most important? (Circle one.)

Clean water Sanitation Personal hygiene

How do you feel about moving to compost based sanitation? (Circle one.)

Very happy ☺ Happy ☹ Neutral ☹ Unhappy Very unhappy

Will the household share it's method of managing human waste with other households? If yes, with how many?

How did you hear of compost-based sanitation? (Circle all that apply)

Yes, I heard from
family / friends / neighbors

Yes, I heard from
IMO team members

Other
(describe)

What material did you use to build your compost bin?

How many times per week do those in the household above 13 years practice open defecation near the household?

How many times per week do those in the household above 13 years practice open defecation away from the household?

What do you think will be easier to manage, a compost system or a pit latrine?

When did you adopt compost-based sanitation? (Write the month and year of adoption)

Why did you choose to adopt to compost-based sanitation? (List all)

What advantages (if any) do you anticipate after adopting compost-based sanitation? (List all)

What disadvantages (if any) do you anticipate after adopting compost-based sanitation? (List all)

Do you have any fears about compost? What are they? Do you still have them?

What do you think would prohibit the spread of compost-based sanitation throughout your village?


What do you think would prohibit the spread of compost-based sanitation throughout your parish?

What do you think would prohibit the spread of compost-based sanitation throughout your sub-county?

What do you think would prohibit the spread of compost-based sanitation throughout Uganda?

Thank you for completing this survey! You are very much appreciated.

Appendix E: Soil Analyses

<p>Client: International Medical Outreach</p> <p>Farm: Ayaka Primary School</p> <p>Reference No: 8200136</p> <p>Date: 29-May-2019</p> <p><i>Thank you for the sample(s) received by our laboratory. Your sample(s) will be analyzed according to this schedule. Your lab results will be submitted under client and farm name.</i></p>	<p>Contacts List:</p> <p>Laboratory results will be emailed to:</p> <p>1) Price, Sue - sue@imoutreach.com</p>	
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SCHEDULE OF ANALYSIS

CN-SH-08, rev. no 2, effective date: 03/04/2019

Manure Compost Analysis		
Field	Analysis	Reporting time (working days)
	Complete Compost/Manure Analysis <i>Boron, C/N ratio, Calcium, Carbon, Copper, Dry matter, EC (Salts), Iron, Magnesium, Manganese, pH, Phosphorus, Potassium, Sodium, Sulphur, Total Nitrogen, Zinc</i>	7

Nematodes Analysis			
Field	Crop Name	Analysis	Reporting time (working days)
Compost Bin		Nematodes in Compost/Manure <i>Aphelenchoides, Aphelenchus, Criconema, Ditylenchus, Helicotylenchus, Hemicyclophora, Heterodera, Hirschimienella, Hoplolaimus, Longidorus, Meloidogyne, Paratylenchus, Pratylenchus, Radopholus, Rotylenchus, Saprofagic, Scutellonema, Trichodorous, Tylenchorhynchus, Tylenchulus, Tylenchus, Xiphinema</i>	5

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Website: www.cropnuts.com

Manure Compost Analysis Report

Complete Compost/Manure Analysis



Report Ref#: CN-06888

Customer:	International Medical Outreach	Fertilizer:	Manure	Date Received:	29-May-19
Address:	sue@imoutreach.com	Crop Stage:		Analysis Date:	6-Jun-19
Farm Name:	Ayaka Primary School	Comments:		Report Date:	6-Jun-19
Contact Person:	Sue Price	Condition:		Sample ID:	CI106CM0001

Field: Compost Bin

History (Last 3 analysis)

Parameter	Unit	Result	Guide Low	Guide High	Low	Optimum	High	Symbol	Current	Method
pH		7.06	6.00	8.50				pH	7.06	Photometric
EC (Salts)	mS/cm	0.94	0.75	1.20				EC(S)	0.94	Photometric
Dry matter	%	47.2						DM	47.2	Gravimetric
Carbon	%	25.8	13.0	60.0				C	25.8	Ignita
Total Nitrogen	%	1.40	0.80	1.50				N	1.40	Colorimetric
Phosphorus	%	0.33	0.20	0.75				P	0.33	Spectroscopy
Potassium	%	0.69	0.40	2.00				K	0.69	Spectroscopy
Calcium	%	0.56	0.60	1.50				Ca	0.56	Spectroscopy
Magnesium	%	0.31	0.20	0.80				Mg	0.31	Spectroscopy
Sulphur	%	0.18	0.20	0.50				S	0.18	Spectroscopy
Manganese	ppm	766	200	800				Mn	766	Spectroscopy
Iron	ppm	23700						Fe	23700	Spectroscopy
Zinc	ppm	206	40.0	300				Zn	206	Spectroscopy
Copper	ppm	41.4	8.00	400				Cu	41.4	Spectroscopy
Boron	ppm	26.1	20.0	140				B	26.1	Spectroscopy
Sodium	ppm	1930		< 3000				Na	1930	Spectroscopy
C/N ratio		18.5	10.0	20.0				C:N	18.5	Calculated

NUTRIENT CONTRIBUTION PER TON

N	P	K	Ca	S	Mg
kg/Ha	kg/Ha	kg/Ha	kg/Ha	kg/Ha	kg/Ha
1.98	0.47	0.98	0.79	0.25	0.44

NOTES:

Nutrient Contribution & Fertilizer Deductions

These figures estimate the quantity of nutrients supplied per 1000 kg (1 ton) of this manure/compost applied each hectare of land. The calculation takes into account the material dry matter %, the nutrient content % result above, and an estimated nutrient release of 30% to the first crop.

Jo Gakobo Lab Manager		Cordingley Jeremy Managing Director		Approval Date: 06/06/2019
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Email: laboratory@croppnuts.com

Nematodes Analysis Report

Nematodes in Compost/Manure



Report Ref#: CN-06636

Customer: International Medical Outreach	Crop: No crop	Date Received: 29-May-19
Address: sue@imoutreach.com	Crop Stage:	Analysis Date: 29-May-19
Farm Name: Ayaka Primary School	Comments:	Report Date: 3-Jun-19
Contact Person: Sue Price	Condition:	Sample ID: CI106NEM0001

Field: Compost Bin

To maintain the correct history ensure that the next sample sent from this Field is labelled: Compost Bin

History (Last 3 analysis)

Parameter	Unit	Result	Guide Low	Guide High	Low	Optimum	High	Symbol	Current	Method
Saprophagic	100 ml	40100		> 1000				Sap	40100	
Meloidogyne	100 ml	ND		< 30.0				Mel	ND	
Pratylenchus	100 ml	ND		< 50.0				Pra	ND	
Radopholus	100 ml	ND		< 50.0				Rad	ND	
Tylenchus	100 ml	ND		< 100				Tyl	ND	
Tylenchulus	100 ml	ND		< 100				Ty	ND	
Tylenchorhynchus	100 ml	ND		< 50.0				Tyle	ND	
Helicotylenchus	100 ml	ND		< 50.0				Hel	ND	
Scutellonema	100 ml	ND		< 100				Scu	ND	
Ditylenchus	100 ml	ND		< 10.0				Dts	ND	
Aphelenchus	100 ml	ND		< 100				Aps	ND	
Aphelenchoides	100 ml	ND		< 100				Aph	ND	
Xiphinema	100 ml	ND		< 200				Xip	ND	
Longidorus	100 ml	ND		< 40.0				Lo	ND	
Paratylenchus	100 ml	ND		< 70.0				Par	ND	
Hoplolaimus	100 ml	ND		< 50.0				Hop	ND	
Criconema	100 ml	ND		< 100				Crā	ND	
Hirschimieniella	100 ml	ND		< 100				Hi	ND	
Rotylenchus	100 ml	ND		< 100				Rot	ND	
Hemicyclophora	100 ml	ND		< 100				Hem	ND	
Heterodera	100 ml	ND		< 500				Het	ND	
Trichodorous	100 ml	ND		< 100				Ted	ND	

ND = Not Detected

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Jo Gakobo Lab Manager		Cordingley Jeremy Managing Director		Approval Date: 03/06/2019
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Mobile: +254 (0) 736 839933 / (0) 720 639933
Email: laboratory@croppnuts.com

Client: International Medical Outreach
Farm: Olama Philips Compost Bin
Reference No: 2019276
Date: 29-May-2019

Contacts List:

Laboratory results will be emailed to:
 1) Price, Sue - sue@imoutreach.com



Thank you for the sample(s) received by our laboratory. Your sample(s) will be analyzed according to this schedule. Your lab results will be submitted under client and farm name.

SCHEDULE OF ANALYSIS

CN-SH-08, rev. no 2, effective date: 03/04/2019

Manure Compost Analysis		
Field	Analysis	Reporting time (working days)
	Complete Compost/Manure Analysis Boron, C/N ratio, Calcium, Carbon, Copper, Dry matter, EC (Salts), Iron, Magnesium, Manganese, pH, Phosphorus, Potassium, Sodium, Sulphur, Total Nitrogen, Zinc	7

Nematodes Analysis			
Field	Crop Name	Analysis	Reporting time (working days)
Compost Bin		Nematodes in Compost/Manure Aphelenchoides, Aphelenchus, Criconema, Ditylenchus, Helicotylenchus, Hemicyclophora, Heterodera, Hirschimieniella, Hoplolaimus, Longidorus, Meloidogyne, Paratylenchus, Pratylenchus, Radopholus, Rotylenchus, Saprofagic, Scutellonema, Trichodoros, Tylenchorhynchus, Tylenchulus, Tylenchus, Xiphinema	5

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Website: www.croppnuts.com

Manure Compost Analysis Report

Complete Compost/Manure Analysis



Report Ref#: CN-06889

Customer:	International Medical Outreach	Fertilizer:	Manure	Date Received:	29-May-19
Address:	sue@imoutreach.com	Crop Stage:		Analysis Date:	6-Jun-19
Farm Name:	Olama Philips Compost Bin	Comments:		Report Date:	6-Jun-19
Contact Person:	Sue Price	Condition:		Sample ID:	CI106CM0002

Field: Compost Bin

History (Last 3 analysis)

Parameter	Unit	Result	Guide Low	Guide High	Low	Optimum	High	Symbol	Current	Method
pH		6.41	6.00	8.50				pH	6.41	Photometric
EC (Salts)	mS/cm	1.15	0.75	1.20				EC(S)	1.15	Photometric
Dry matter	%	93.3						DM	93.3	Gravimetric
Carbon	%	21.1	13.0	60.0				C	21.1	Ignitio
Total Nitrogen	%	1.17	0.80	1.50				N	1.17	Colorimetric
Phosphorus	%	0.30	0.20	0.75				P	0.30	Spectroscopy
Potassium	%	0.23	0.40	2.00				K	0.23	Spectroscopy
Calcium	%	0.86	0.60	1.50				Ca	0.86	Spectroscopy
Magnesium	%	0.35	0.20	0.80				Mg	0.35	Spectroscopy
Sulphur	%	0.15	0.20	0.50				S	0.15	Spectroscopy
Manganese	ppm	1200	200	800				Mn	1200	Spectroscopy
Iron	ppm	57900						Fe	57900	Spectroscopy
Zinc	ppm	147	40.0	300				Zn	147	Spectroscopy
Copper	ppm	85.4	8.00	400				Cu	85.4	Spectroscopy
Boron	ppm	44.1	20.0	140				B	44.1	Spectroscopy
Sodium	ppm	263		< 3000				Na	263	Spectroscopy
C/N ratio		18.0	10.0	20.0				C:N	18.0	Calculated

NUTRIENT CONTRIBUTION PER TON

N	P	K	Ca	S	Mg
kg/Ha	kg/Ha	kg/Ha	kg/Ha	kg/Ha	kg/Ha
3.27	0.84	0.64	2.41	0.42	0.98

NOTES:

Nutrient Contribution & Fertilizer Deductions

These figures estimate the quantity of nutrients supplied per 1000 kg (1 ton) of this manure/compost applied each hectare of land. The calculation takes into account the material dry matter %, the nutrient content % result above, and an estimated nutrient release of 30% to the first crop.

Jo Gakobo Lab Manager		Cordingley Jeremy Managing Director		Approval Date: 06/06/2019
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 Email: laboratory@croppnuts.com

Nematodes Analysis Report

Nematodes in Compost/Manure



Report Ref#: CN-06637

Customer: International Medical Outreach	Crop: No crop	Date Received: 29-May-19
Address: sue@imoutreach.com	Crop Stage:	Analysis Date: 29-May-19
Farm Name: Olama Philips Compost Bin	Comments:	Report Date: 3-Jun-19
Contact Person: Sue Price	Condition:	Sample ID: CI106NEM0002

Field: Compost Bin

To maintain the correct history ensure that the next sample sent from this Field is labelled: Compost Bin

History (Last 3 analysis)

Parameter	Unit	Result	Guide Low	Guide High	Low	Optimum	High	Symbol	Current	Method
Saprofagic	100 ml	280		> 1000				Sap	280	
Meloidogyne	100 ml	ND		< 30.0				Mel	ND	
Pratylenchus	100 ml	ND		< 50.0				Pra	ND	
Radopholus	100 ml	ND		< 50.0				Rad	ND	
Tylenchus	100 ml	ND		< 100				Tyl	ND	
Tylenchulus	100 ml	ND		< 100				Ty	ND	
Tylenchorhynchus	100 ml	ND		< 50.0				Tyle	ND	
Helicotylenchus	100 ml	ND		< 50.0				Hel	ND	
Scutellonema	100 ml	ND		< 100				Scu	ND	
Ditylenchus	100 ml	ND		< 10.0				Dts	ND	
Aphelenchus	100 ml	ND		< 100				Aps	ND	
Aphelenchoides	100 ml	ND		< 100				Aph	ND	
Xiphinema	100 ml	ND		< 200				Xip	ND	
Longidorus	100 ml	ND		< 40.0				Lo	ND	
Paratylenchus	100 ml	ND		< 70.0				Par	ND	
Hoplolaimus	100 ml	ND		< 50.0				Hop	ND	
Criconema	100 ml	ND		< 100				Crā	ND	
Hirschimieniella	100 ml	ND		< 100				Hi	ND	
Rotylenchus	100 ml	ND		< 100				Rot	ND	
Hemicyclophora	100 ml	ND		< 100				Hem	ND	
Heterodera	100 ml	ND		< 500				Het	ND	
Trichodorous	100 ml	ND		< 100				Ted	ND	

ND = Not Detected

COMMENTS #

Saprofagics play an important role nutrient cycling, enhanced decomposition and check populations of plant feeding nematodes. These beneficial nematodes can be boosted by addition of organic amendments such as compost and manure.


RECOMMENDATIONS #

> Saprofagics - Enhance beneficial nematodes by incorporation of organic amendments such as animal manures, food wastes, yard wastes, sewage sludge and composts including vermicompost ; Organic rich soils harbour predatory mites, springtails, tardigrades and earthworms that are important controllers of harmful nematodes. Restricted application of chemical nematicides conserves these beneficial nematodes.

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Jo Gakobo Lab Manager		Cordingley Jeremy Managing Director		Approval Date: 03/06/2019
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Mobile: +254 (0) 736 839933 / (0) 720 639933
Email: laboratory@croppnuts.com

Client: International Medical Outreach Farm: Owech Patrick Compost Bin Reference No: 5023225 Date: 29-May-2019	Contacts List: Laboratory results will be emailed to: 1) Price, Sue - sue@imoutreach.com	
<p><i>Thank you for the sample(s) received by our laboratory. Your sample(s) will be analyzed according to this schedule. Your lab results will be submitted under client and farm name.</i></p>		

SCHEDULE OF ANALYSIS

CN-SH-08, rev. no 2, effective date: 03/04/2019

Manure Compost Analysis		
Field	Analysis	Reporting time (working days)
	Complete Compost/Manure Analysis Boron, C/N ratio, Calcium, Carbon, Copper, Dry matter, EC (Salts), Iron, Magnesium, Manganese, pH, Phosphorus, Potassium, Sodium, Sulphur, Total Nitrogen, Zinc	7

Nematodes Analysis			
Field	Crop Name	Analysis	Reporting time (working days)
Compost Bin		Nematodes in Compost/Manure <i>Aphelenchoides, Aphelenchus, Criconema, Ditylenchus, Helicotylenchus, Hemicyclophora, Heterodera, Hirschimieniella, Hoplolaimus, Longidorus, Meloidogyne, Paratylenchus, Pratylenchus, Radopholus, Rotylenchus, Saprofagic, Scutellonema, Trichodoros, Tylenchorhynchus, Tylenchulus, Tylenchus, Xiphinema</i>	5

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Nematodes Analysis Report

Nematodes in Compost/Manure



Report Ref#: CN-06638

Customer: International Medical Outreach	Crop: No crop	Date Received: 29-May-19
Address: sue@imoutreach.com	Crop Stage:	Analysis Date: 29-May-19
Farm Name: Owech Patrick Compost Bin	Comments:	Report Date: 3-Jun-19
Contact Person: Sue Price	Condition:	Sample ID: CI106NEM0003

Field: Compost Bin

To maintain the correct history ensure that the next sample sent from this Field is labelled: Compost Bin

History (Last 3 analysis)

Parameter	Unit	Result	Guide Low	Guide High	Low	Optimum	High	Symbol	Current	Method
Saprofagic	100 ml	3200		> 1000				Sap	3200	
Meloidogyne	100 ml	ND		< 30.0				Mel	ND	
Pratylenchus	100 ml	ND		< 50.0				Pra	ND	
Radopholus	100 ml	ND		< 50.0				Rad	ND	
Tylenchus	100 ml	ND		< 100				Tyl	ND	
Tylenchulus	100 ml	ND		< 100				Ty	ND	
Tylenchorhynchus	100 ml	ND		< 50.0				Tyle	ND	
Helicotylenchus	100 ml	ND		< 50.0				Hel	ND	
Scutellonema	100 ml	ND		< 100				Scu	ND	
Ditylenchus	100 ml	ND		< 10.0				Dts	ND	
Aphelenchus	100 ml	ND		< 100				Aps	ND	
Aphelenchoides	100 ml	ND		< 100				Aph	ND	
Xiphinema	100 ml	ND		< 200				Xip	ND	
Longidorus	100 ml	ND		< 40.0				Lo	ND	
Paratylenchus	100 ml	ND		< 70.0				Par	ND	
Hoplolaimus	100 ml	ND		< 50.0				Hop	ND	
Criconema	100 ml	ND		< 100				Crā	ND	
Hirschimieniella	100 ml	ND		< 100				Hi	ND	
Rotylenchus	100 ml	ND		< 100				Rot	ND	
Hemicylophora	100 ml	ND		< 100				Hem	ND	
Heterodera	100 ml	ND		< 500				Het	ND	
Trichodorus	100 ml	ND		< 100				Ted	ND	

ND = Not Detected

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Jo Gakobo Lab Manager		Cordingley Jeremy Managing Director		Approval Date: 03/06/2019
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Crop Nutrition Laboratory Services Ltd, Limuru, Kenya
Mobile: +254 (0) 736 839933 / (0) 720 639933
Email: laboratory@croppnuts.com

Client: International Medical Outreach
Farm: Wanadi Richard-Compost Bin
Reference No: 4949608
Date: 29-May-2019

Thank you for the sample(s) received by our laboratory. Your sample(s) will be analyzed according to this schedule. Your lab results will be submitted under client and farm name.

Contacts List:

Laboratory results will be emailed to:
 1) Price, Sue - sue@imoutreach.com



SCHEDULE OF ANALYSIS

CN-SH-08, rev. no 2, effective date: 03/04/2019

Manure Compost Analysis		
Field	Analysis	Reporting time (working days)
	Complete Compost/Manure Analysis Boron, C/N ratio, Calcium, Carbon, Copper, Dry matter, EC (Salts), Iron, Magnesium, Manganese, pH, Phosphorus, Potassium, Sodium, Sulphur, Total Nitrogen, Zinc	7

Nematodes Analysis			
Field	Crop Name	Analysis	Reporting time (working days)
Compost Bin		Nematodes in Compost/Manure Aphelenchoides, Aphelenchus, Criconema, Ditylenchus, Helicotylenchus, Hemicyclophora, Heterodera, Hirschimieniella, Hoplolaimus, Longidorus, Meloidogyne, Paratylenchus, Pratylenchus, Radopholus, Rotylenchus, Saprofagic, Scutellonema, Trichodoros, Tylenchorhynchus, Tylenchulus, Tylenchus, Xiphinema	5

Crop Nutrition Laboratory Services Ltd.

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Manure Compost Analysis Report

Complete Compost/Manure Analysis



Report Ref#: CN-06891

Customer:	International Medical Outreach	Fertilizer:	Manure	Date Received:	29-May-19
Address:	sue@imoutreach.com	Crop Stage:		Analysis Date:	6-Jun-19
Farm Name:	Wanadi Richard-Compost Bin	Comments:		Report Date:	6-Jun-19
Contact Person:	Sue Price	Condition:		Sample ID:	CI106CM0004

Field: Compost Bin

History (Last 3 analysis)

Parameter	Unit	Result	Guide Low	Guide High	Low	Optimum	High	Symbol	Current	Method
pH		6.25	6.00	8.50				pH	6.25	Photometric
EC (Salts)	mS/cm	0.94	0.75	1.20				EC(S)	0.94	Photometric
Dry matter	%	93.5						DM	93.5	Gravimetric
Carbon	%	20.1	13.0	60.0				C	20.1	Ignitio
Total Nitrogen	%	1.15	0.80	1.50				N	1.15	Colorimetric
Phosphorus	%	0.29	0.20	0.75				P	0.29	Spectroscopy
Potassium	%	0.21	0.40	2.00				K	0.21	Spectroscopy
Calcium	%	0.84	0.60	1.50				Ca	0.84	Spectroscopy
Magnesium	%	0.35	0.20	0.80				Mg	0.35	Spectroscopy
Sulphur	%	0.14	0.20	0.50				S	0.14	Spectroscopy
Manganese	ppm	1200	200	800				Mn	1200	Spectroscopy
Iron	ppm	59300						Fe	59300	Spectroscopy
Zinc	ppm	148	40.0	300				Zn	148	Spectroscopy
Copper	ppm	85.4	8.00	400				Cu	85.4	Spectroscopy
Boron	ppm	44.8	20.0	140				B	44.8	Spectroscopy
Sodium	ppm	251		< 3000				Na	251	Spectroscopy
C/N ratio		17.4	10.0	20.0				C:N	17.4	Calculated

NUTRIENT CONTRIBUTION PER TON

N	P	K	Ca	S	Mg
kg/Ha	kg/Ha	kg/Ha	kg/Ha	kg/Ha	kg/Ha
3.23	0.81	0.59	2.36	0.39	0.98

NOTES:

Nutrient Contribution & Fertilizer Deductions

These figures estimate the quantity of nutrients supplied per 1000 kg (1 ton) of this manure/compost applied each hectare of land. The calculation takes into account the material dry matter %, the nutrient content % result above, and an estimated nutrient release of 30% to the first crop.

Jo Gakobo Lab Manager		Cordingley Jeremy Managing Director		Approval Date: 06/06/2019
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Nematodes Analysis Report

Nematodes in Compost/Manure



Report Ref#: CN-06634

Customer: International Medical Outreach	Crop: No crop	Date Received: 29-May-19
Address: sue@imoutreach.com	Crop Stage:	Analysis Date: 29-May-19
Farm Name: Wanadi Richard-Compost Bin	Comments:	Report Date: 3-Jun-19
Contact Person: Sue Price	Condition:	Sample ID: CI106NEM0004

Field: Compost Bin

To maintain the correct history ensure that the next sample sent from this Field is labelled: Compost Bin

History (Last 3 analysis)

Parameter	Unit	Result	Guide Low	Guide High	Low	Optimum	High	Symbol	Current	Method
Saprophagic	100 ml	160		> 1000				Sap	160	
Meloidogyne	100 ml	ND		< 30.0				Mel	ND	
Pratylenchus	100 ml	ND		< 50.0				Pra	ND	
Radopholus	100 ml	ND		< 50.0				Rad	ND	
Tylenchus	100 ml	ND		< 100				Tyl	ND	
Tylenchulus	100 ml	ND		< 100				Ty	ND	
Tylenchorhynchus	100 ml	ND		< 50.0				Tyle	ND	
Helicotylenchus	100 ml	ND		< 50.0				Hel	ND	
Scutellonema	100 ml	ND		< 100				Scu	ND	
Ditylenchus	100 ml	ND		< 10.0				Dts	ND	
Aphelenchus	100 ml	ND		< 100				Aps	ND	
Aphelenchoides	100 ml	ND		< 100				Aph	ND	
Xiphinema	100 ml	ND		< 200				Xip	ND	
Longidorus	100 ml	ND		< 40.0				Lo	ND	
Paratylenchus	100 ml	ND		< 70.0				Par	ND	
Hoplolaimus	100 ml	ND		< 50.0				Hop	ND	
Criconema	100 ml	ND		< 100				Crā	ND	
Hirschimieniella	100 ml	ND		< 100				Hi	ND	
Rotylenchus	100 ml	ND		< 100				Rot	ND	
Hemicyclophora	100 ml	ND		< 100				Hem	ND	
Heterodera	100 ml	ND		< 500				Het	ND	
Trichodorous	100 ml	ND		< 100				Ted	ND	

ND = Not Detected

COMMENTS #

Saprophagics play an important role nutrient cycling, enhanced decomposition and check populations of plant feeding nematodes. These beneficial nematodes can be boosted by addition of organic amendments such as compost and manure.

RECOMMENDATIONS #

> Saprophagics - Enhance beneficial nematodes by incorporation of organic amendments such as animal manures, food wastes, yard wastes, sewage sludge and composts including vermicompost ; Organic rich soils harbour predatory mites, springtails, tardigrades and earthworms that are important controllers of harmful nematodes. Restricted application of chemical nematicides conserves these beneficial nematodes.

**NEED HELP UNDERSTANDING THIS REPORT? Visit our [Help Desk](#)
FIND NEMATODE CONTROL PRODUCTS on our [Farm Inputs Directory](#)**

Jo Gakobo Lab Manager		Cordingley Jeremy Managing Director		Approval Date: 03/06/2019
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