

human feces and render them safe for agricultural use. This seems to be especially true in a tropical country like the Philippines where ambient humidity is high most months of the year.

2. To render human excreta safe for agricultural use, some kind of secondary treatment is necessary.

RECOMMENDATIONS

Based on this preliminary report, it is recommended that the study be continued for another six months in order to fully achieve the objectives. It is further recommended that secondary treatment methods for human excreta be investigated and compared in order to formulate concrete guidelines for the agricultural use of human excreta in the Philippine setting. These should include aerobic composting, vermicomposting, bio gas production as well as other less popular methods of secondary treatment. Average humidity inside the UDD toilet vaults should also be measured in future studies, since this factor may be more important than ambient temperatures in relation to the survival of pathogenic organisms and parasite ova in human excreta.

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An Observational Study to Determine the Length of Time Necessary to Eradicate Parasitic Ova and Pathogenic Bacteria in Human Excreta Kept in the Storage Vaults of Urine-Diverting Dehydration Toilets in Cagayan de Oro City: 2007-2008: A Preliminary Report

Gina S Itchon, Robert J Holmer & Ma Luisa B Tan

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Kinaadman Research Center
Xavier University-Ateneo de Cagayan
Cagayan de Oro City, 9000 Philippines
E-mail : kinaadman@xu.edu.ph



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This **series**, made possible by research grants from Xavier University, covers the entire range of inquiry/research in the various disciplines.

Category I infections are caused by excreted viruses and protozoa and the helminths *Enterobius vermicularis* (pinworm or threadworm) and *Hymenolepis nana* (dwarf tapeworm). These pathogens are infective immediately on excretion and have a low median effective dose.

Category II infections are the excreted bacteria. Like the causative agents of Category I infections, they are infective immediately on excretion. They are moderately persistent and can multiply outside their host, for example in food or in milk.

Category III infections are caused by soil-transmitted intestinal nematodes that require no intermediate host. The most important of these are the human roundworm (*Ascaris lumbricoides*), the hookworms (*Ancylostoma duodenale* and *Necator americanus*) and the human whipworm (*Trichuris trichura*). They are all readily transmitted by the agricultural use of raw or insufficiently prepared excreta and wastewater. Infections in this category cause the greatest public health concern in agricultural use schemes.

Category IV infections are caused by the cow and pig tapeworms, *Taenia saginata* and *T. solium*, respectively. For their successful transmission viable eggs must be ingested by a cow or a pig.

Category V are all water-based helminthic infections. The pathogens require one or two intermediate aquatic hosts, the first of which is a snail, in which asexual multiplication of the pathogen occurs, and the second (if there is one) either a fish or an aquatic macrophyte. Many of these helminthes have a limited geographical distribution. Their transmission is promoted by the aquaculture use of raw or insufficiently treated excreta and wastewater, together with the practice of eating raw or inadequately cooked fish and aquatic vegetables.

Data shows that microorganisms and helminth eggs which have been identified from the samples in this study belong to Categories I to III. *Ascaris lumbricoides*, hookworms, and *Trichuris trichura*, which all belong to Category III pose the greatest public health concern when used in agricultural settings.

Although the number of parasite eggs found in the excreta samples did not decrease considerably in some toilets, the quality of the eggs have noticeably changed. This is particularly true of *Ascaris lumbricoides* ova, which have thick cuticles and hence are very resistant to drying (Figure 1 - 3).

PRELIMINARY CONCLUSION

After six months of data collection, two (2) important conclusions can be drawn from the results. These are:

1. Microorganisms do not pose a public health threat if human excreta are used in agriculture. However, helminth eggs may still be infective and hence, six months is not adequate to dehydrate

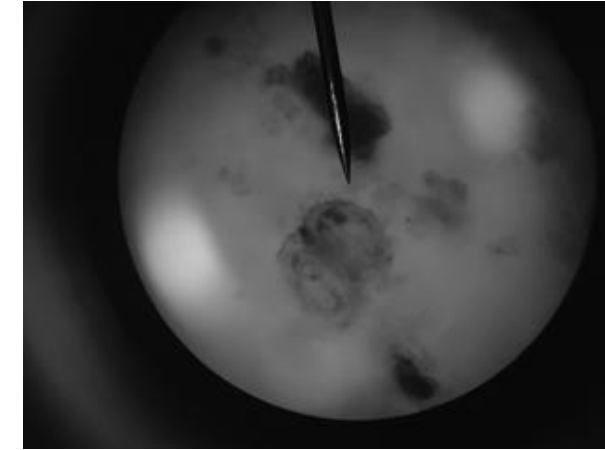


Figure 1 *Ascaris lumbricoides* egg, August 2007 (first month of data collection)

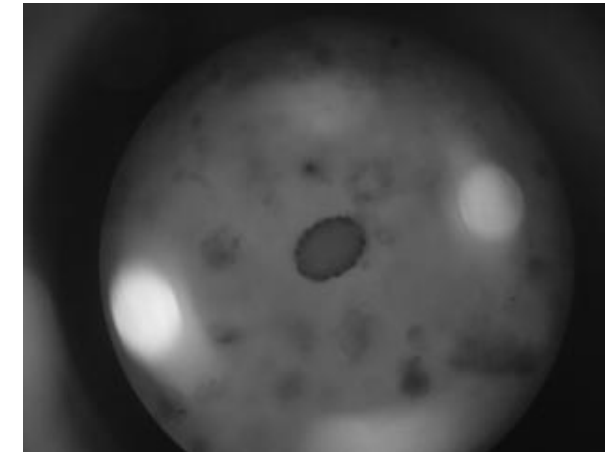


Figure 2 *Ascaris lumbricoides* egg, October 2007 (third month of data collection)

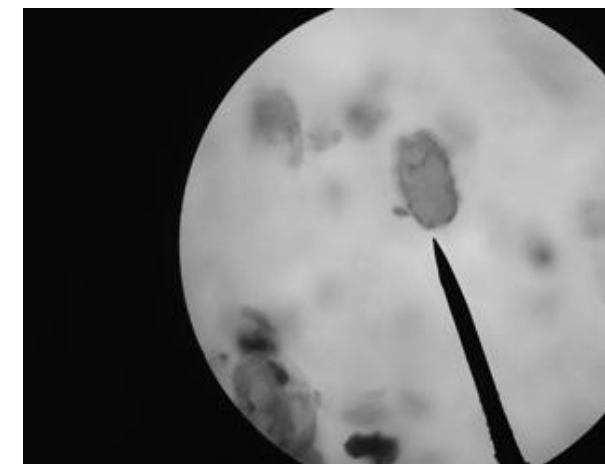


Figure 3 *Ascaris lumbricoides* egg, January 2008 (sixth month of data collection) Discussion

transferred to the adjacent vault in order not to contaminate the excreta sample for the study, while the residents will be able to continue to use their toilet. A standard absorbent material made of a mixture of lime and sawdust to cover the feces was prepared in Manresa and provided to the different locations during the week that excreta sample is being collected. This is to ensure that absorbent material is standardized in all locations. Furthermore, the absorbent material was kept in a pail with cover to prevent contamination.

At the end of the first week of collection, excreta samples were taken from the experimental vaults from each toilet. Baseline data for parasite ova and pathogenic bacteria were taken and duly recorded. Sedimentation technique was used for the identification of parasite ova. Stool culture for human Enterobacteria was performed using the following culture media: Triple Sugar Iron Agar (TSI Agar), Lysine Iron Agar, SIM Medium, Simmons Citrate Agar. In addition, average ambient temperatures within the experimental toilet vaults were recorded on a regular basis.

At monthly intervals thereafter, monitoring of the excreta samples were done using the same laboratory techniques in order to assess for types and quantity of parasitic ova and pathogenic bacteria. Data were duly recorded. As of the present time, data has been taken and recorded for six (6) months, from August 2007 to January 2008. The study is at its midpoint and six (6) months more of data collection is expected.

RESULTS

Of the ten (10) UDD toilets initially planned for data collection in this study, only seven (7) have complete data. These toilets are: Manresa Farm (field), Manresa Farm (Demo garden), Balulang Elementary School (close to the elementary school), FS Catanico Elementary School (close to the compost area), Macasandig, Carmen, and Lapasan. Two (2) toilets were excluded from the start due to insufficient amount of feces sample during the preparatory period. These are the toilets located in Balulang Elementary School (close to the High School Bldg) and FS Catanico Elementary School (close to the elementary rooms). One toilet, located in Kauswagan, was flooded in September and November 2007 and January 2008. Therefore, no excreta samples were taken from the toilet vault during these months.

Microorganisms

Preliminary results of this study show that the most common microorganisms found in fresh human feces are the following: *E. coli*, *Proteus vulgaris*, *Proteus mirabilis*, *Citrobacter spp.* and *Enterobacter spp.* (Table 1). These organisms are part of the normal human flora and all have a potential to cause disease in humans, especially *Proteus spp.*, *E. coli*, and *Citrobacter spp.* *Proteus spp.* cause cases of urinary tract infections, *E. coli* can cause diarrhea and dysentery, and *Citrobacter spp.*, although a

rare cause of disease in humans, has been known to cause urinary tract infections and meningitis³.

These microorganisms have also been shown to decrease considerably during the six (6) months that data has been collected for this study. On the 6th month of data collection (January 2008), microorganisms found in the feces samples consist of *Enterobacter spp.* and *E. coli* from the original five (5) enteric organisms which were identified in the first month of data collection (refer to Table 1). This result is expected since bacteria require specific conditions such as temperature and humidity. Bacteria found in the human gastrointestinal tract such as the ones in human feces quickly die outside the human body⁴. *Enterobacter spp.* are microorganisms found in soil and it is expected that only this bacteria will be found in feces samples which will be analyzed from the 7th to the 12th months.

Preliminary results also indicate that there seems to be no association between average temperature in the respective toilet vaults and the amount and type of bacteria found. That is, the toilet vault with the coolest ambient temperature did not necessarily contain the most species of pathogenic microorganisms and the toilet with the hottest ambient temperature did not contain the least number of species of microorganisms. The same is true of temperature and parasite eggs. (refer to Table 3 and 4). In a tropical country like the Philippines where the average monthly humidity varies from 71 to 85%, this factor may be more important than average ambient temperatures in relation to the survival of pathogenic bacteria and parasite ova. However, humidity was not measured in this study and its measurement is a very important recommendation for future studies.

Parasite Eggs

Data from the first sample analysis in August 2007 showed the most common intestinal parasites in this study. They are: *Ascaris lumbricoides*, Hookworm, *Trichuris trichura* (whip worm), and *Enterobius vermicularis* (pin worm) (Table 2). These are also the most common intestinal parasites in Filipinos⁵. It has also been shown that *Ascaris* ova, which have a thick cell wall are the most resistant. Although it is not within the scope of this study to determine if these *Ascaris* eggs are still viable, the fact that their cell walls are still intact makes their viability and hence infectiveness, a very distinct possibility. Literature also suggests there is enough evidence that parasite ova, especially of *Ascaris*, hookworm, and whipworm, may survive in dehydrated human excreta for up to a year.^{6,7}

Most of these microorganisms and parasites belong to the list of 30 known excreta-related infections of public health importance. These are grouped into five categories⁸:

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Gina S Itchon, Robert J Holmer and Ma Luisa B Tan

Abstract

To determine the safety of using human excreta in agriculture, an observational study was conducted primarily to determine the length of time necessary to eradicate parasitic ova and pathogenic bacteria in human excreta kept in the storage vaults of urine-diverting dehydration toilets in Cagayan de Oro City from August 2007 to January 2008.

The study was conducted using seven (7) urine-diverting toilets in Cagayan de Oro City. One of the excreta storage vaults was emptied for use as experimental chamber for the feces collection. A thermometer was installed inside the chamber to record ambient temperatures within the storage chamber. After one week of collecting feces, the experimental vault was sealed and the toilet bowl transferred to the adjacent vault in order not to contaminate the excreta sample for the study. A standard absorbent material made of a mixture of lime and sawdust to cover the feces was prepared and provided to the different locations during the week that excreta sample was being collected.

At the end of the first week of collection, excreta samples were taken from the experimental vaults from each toilet. Baseline data for parasite ova and pathogenic bacteria were taken and duly recorded using sedimentation and stool culture for identifying and estimating quantities of parasitic ova and pathogenic bacteria, respectively. Ambient temperature within the experimental toilet vaults was read and recorded twice daily (6:00 am and 2:00 pm) during the duration of the study. At monthly intervals thereafter, monitoring of the excreta samples was done using the same techniques to assess for types and quantity of parasitic ova and pathogenic bacteria. Data were duly recorded.

Preliminary results of this study show that the most common microorganisms found in fresh human feces are the following: *E. coli*, *Proteus vulgaris*, *Proteus mirabilis*, *Citrobacter spp.* and *Enterobacter spp.* These microorganisms have also been shown to decrease considerably during the six (6) months that data has been collected for this study. The most common intestinal parasite ova in this study are: *Ascaris lumbricoides*, Hookworm, *Trichuris trichura* (whip worm), and *Enterobius vermicularis* (pin worm). These are also the most common intestinal parasites in Filipinos. Furthermore, it has also been shown that *Ascaris* ova, which have a thick cell wall, are the most resistant to drying and dessication, making their infectivity a distinct possibility.

Two (2) important conclusions can be drawn from the results. First, that microorganisms do not pose a public health threat if human excreta are used in agriculture. However, helminth eggs may still be infective and hence, six months is not adequate to dehydrate human feces and render them safe for agricultural use. This seems to be especially true in a tropical country like the Philippines where ambient humidity is high most months of the year. Second, to render human excreta safe for agricultural use, secondary treatment is necessary.

Keywords: urine diverting dry toilets, human excreta, agriculture

INTRODUCTION

Safe drinking water, basic sanitation, and good hygiene are fundamental to health, survival, growth and development. In the last two decades mankind has received constant and often devastating reminders that water is not an infinite resource. Repeated occurrences of the El Niño and the La Niña phenomena, floods, droughts, and famine in many areas of the world attest to this. It is therefore imperative that water is conserved to ensure that this basic natural resource does not run out and becomes accessible to more people.

Safe drinking water and basic sanitation facilities are inexorably linked to each other. However, the common water-borne sanitation system in current use in most

countries of the world, and which has been accepted as a standard for sanitation, is also a system which is apt to deplete water. Chronic shortage of water, the expensive capital cost of putting up such a sanitation system, and its high cost of maintenance, make water-borne sanitation systems an unrealistic option for many developing countries¹. In less developed areas of the world, waterless toilets have emerged as a more practical option for basic sanitation because of the following reasons: 1) it does not require water for flushing but for hand washing only, 2) it is relatively less expensive to install and maintain, and 3) both urine and excreta can be collected and treated for use as fertilizer in agriculture and aquaculture². Although human urine and excreta have been used extensively in

many parts of the world for agriculture, there is a dearth of studies on its public health implications, particularly in the local setting.

The intention of this study is to address knowledge gaps about the public health risks of using human excreta for agriculture. In particular, the authors determined by observation, the appropriate length of time necessary for the eradication of parasitic ova and pathogenic bacteria in human excreta kept in the storage vaults of waterless urine-diverting dehydration (UDD) toilets in various locations in Cagayan de Oro City. Specifically, the study also determined, at a monthly basis, the presence of common parasitic ova and pathogenic bacteria in human excreta kept in the vaults of these waterless UDD toilets and whether ambient temperatures inside the storage vaults of the

waterless toilet systems have any effect on the eradication of parasitic ova and pathogenic bacteria in human excreta.

MATERIALS AND METHODS

The study was conducted in different school and allotment gardens of Cagayan de Oro City, involving ten (10) waterless UDD toilets which are distributed as follows:

One of the excreta storage vaults was emptied for use as experimental chamber for the feces collection. A thermometer was installed inside the chamber to record ambient temperatures within the storage chamber. After one week of collecting feces, the experimental vault was sealed and the toilet bowl

LOCATION	DESCRIPTION OF USERS	NO. OF UDD TOILETS
Manresa Farm	Staff and field workers of PUVeP	2
Balulang Elementary School	Grade 6 students: 6 gardening families	2
FS Catanico Elementary School	Grade 6 students: 6 gardening families	2
Macasandig (Tambo)	8 gardening families	1
Carmen (Independence Farm)	11 gardening families	1
Lapasan	8 gardening families	1
Kauswagan	12 gardening families	1
Total		10

Table 1. Microorganisms Present in Excreta Samples per Month, Various UDD Toilets Cagayan de Oro City

Aug	Sep	Oct	Nov	Dec	Jan
Citrobacter spp	Arizona spp	Citrobacter spp	E coli	E coli	E coli
E coli	Citrobacter spp	E coli	Enterobacter spp	Enterobacter spp	Enterobacter spp
Enterobacter spp	E coli	Enterobacter spp		Proteus spp	
Proteus mirabilis	Enterobacter spp	Proteus spp			
Proteus Vulgaris	Proteus mirabilis				
	Proteus vulgaris				

Table 4. Parasite eggs present with Average Ambient Temperature in Various UDD Toilets from Aug 2007 - Jan 2008, Cagayan de Oro City

TOILET	PARASITE	Number per LPF			Number per LPF			Number per LPF			Average Temp °C	Number per LPF			Number per LPF			Average Temp °C								
		Aug	Samp1	Samp2	Samp3	Sep	Samp1	Samp2	Samp3	Oct		Samp1	Samp2	Samp3	Nov	Samp1	Samp2		Samp3	Dec	Samp1	Samp2	Samp3	Jan	Samp1	Samp2
1 Manresa Farm (Field)	Ascaris Hookworm Hookworm ova Trichuris Trichuria ova	0-1	5-6 0-1 0-1	2-3	Ascaris ova Trichuris Trichuria Hookworm ova (irreg) Trichuris Trichuria ova Ascaris ova (irreg)	1-2 0-1 0-1		1-2	Ascaris ova (irreg) Trichuris Trichuria	1-3 0-1	2-4 2-3	2-3	23.63	Ascaris (irreg)	4-5	2-3	4-5	Ascaris (irreg)	2-5	1-3	3-5	Ascaris (irreg)	1-3	2-3	1-3	25.33
2 Manresa Farm (Demo garden)	Ascaris Ascaris Ova Enterobius Veumi Celaris Hookworm ova	0-2	1-2 0-1	0-1	Ascaris ova (irreg) Ascaris ova	1-2 0-3	1-3	0-3	Ascaris Ascaris (irreg)	0-1 2-3	0-1 1-2	0-1 2-3	23.27	Ascaris (irreg)	1-2	1-2	2-3	Ascaris (irreg)	1-3	2-5	1-3	Ascaris (irreg)	1-2	0-2	0-2	22.33
3 Balulang Elementary (close to HS)									Ascaris ova (irreg)	0-2	1-2	1-2														
4 Balulang Elementary (close to Elem)					Ascaris ova (irreg)	0-2	0-2	1-2					25.9	Ascaris (irreg)	0-2	0-2	2-3	Ascaris (irreg)	0-1	0-1	0-2	Ascaris (irreg)	1-2	0-2	0-2	26.67
5 FS Catanico (close to compost area)					Ascaris ova (irreg) Trichuris Trichuria ova	2-3 0-2	2-3 0-2	2-3 0-1	Ascaris ova Ascaris ova (irreg)	3-5	1-2	2-3	27.8	Ascaris (irreg)	2-3	1-2	2-3	Ascaris (irreg) Trichuris Trichuria	0-2	0-1	1-2 0-1	Ascaris (irreg) Trichuris Trichuria	1-3	1-2	0-2 0-1	23.67
6 FS Catanico (close to elem rooms)																										
7 Macasandig (Tambo)	Ascaris ova			0-1	Ascaris ova (irreg) Ascaris ova	0-3	0-4	0-2	Ascaris ova (irreg)	2-3	1-3	2-3	25.50	Ascaris (irreg)	2-3	2-3	2-4	Ascaris (irreg)	0-2	0-3	1-2	Ascaris (irreg)	0-3	1-2	2-3	24.67
8 Carmen (Independence farm)	Ascaris	0-1	0-1	0-1	Ascaris Hookworm	0-2 0-1	0-1	0-1	Ascaris Ascaris (irreg)	0-1 0-3	0-1 0-3	0-1 0-2	27.23	Ascaris (irreg)	0-1	0-1	0-1	Ascaris	0-2	1-2	1-2	Ascaris (irreg)	0-1	0-1	0-1	26.67
9 Lapasan	Ascaris ova	3-4	0-2	0-3	Ascaris ova (irreg) Ascaris (irreg)	0-1 1-3	2-3 2-4	0-3	Ascaris				28.00	Ascaris (irreg)	1-3	0-1	2-3	Ascaris (irreg)	2-4	3-6	1-3	Ascaris (irreg)	1-3	1-3	2-3	28.33
10 Kauswagan	Ascaris Hookworm larva Tricuris Trichuria Hookworm	2-5 Plenty 0-1 2-5	0-3 0-1 Plenty	1-3					Ascaris ova Ascaris ova (irreg) Trichuris Trichuria	0-1	1-2	2-3 0-1	26.00					Ascaris (irreg)	2-3	1-2	Damaged Specimen					25.33

Table 2. Parasite Ova Present in Excreta Samples per Month, Various UDD Toilets Cagayan de Oro City

Aug	Sep	Oct	Nov	Dec	Jan
Ascaris	Ascaris	Ascaris	Ascaris (irreg)	Ascaris	Ascaris (irreg)
Enterobius Vemicularis	Hookworm	Trichuris Trichuria		Trichuris Trichuria	Trichuris Trichuria
Hookworm	Trichuris Trichuria				
Tricuris Trichuria					

Table 3. Microorganisms present with Average Ambient Temperature in Various UDD Toilets from Aug 2007 - Jan 2008, Cagayan de Oro City

TOILET	MICROORGANISMS			September Ave Temp °C	Nov	Dec	Jan
	Aug	Sep	Oct				
1. Manresa Farm (Field)	E coli Proteus Vulgaris Enterobacter spp	E coli Citrobacter spp	Citrobacter spp Enterobacter spp	23.63	E coli	Enterobacter spp E coli	Enterobacter spp
2. Manresa Farm (Demo garden)	Citrobacter spp	Arizona spp Enterobacter spp	E coli	23.27	Enterobacter spp	E coli	Enterobacter spp E coli
3. Balulang Elementary (close to HS)			Citrobacter spp Proteus spp				
4. Balulang Elementary (close to Elem)		Enterobacter spp Citrobacter spp		25.90	Enterobacter spp	Enterobacter spp	Enterobacter spp
5. FS Catanico (close to compost area)		Etherobacter spp Proteus mirabilis Proteus vulgaris	Proteus spp Enterobacter spp	27.60	Enterobacter spp	Proteus spp	Enterobacter spp
6. FS Catanico (close to elem rooms)							
7. Macasandig (Tambo)	Etherobacter spp	Enterobacter spp E coli	Citrobacter spp Enterobacter spp E coli	25.50	E coli	E coli	Enterobacter spp E coli
8. Carmen (Independence farm)	Proteus mirabilis Proteus vulgaris			27.25			
9. Lapasan	Enterobacter spp	Enterobacter spp E coli Arizona spp		26.00	Enterobacter spp	Enterobacter spp	Enterobacter spp
10. Kauswagan	Proteus mirabilis Enterobacter spp		Proteus spp Enterobacter spp	26.00		Enterobacter spp	