The Public Health Safety of Using Human Excreta from Urine Diverting Toilets for Agriculture: The Philippine Experience

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Abstract

To determine the safety of using human excreta in agriculture, an observational study was conducted 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, Philippines for ten (10) months, from August 2007 to May 2008. The study was conducted using seven (7) urine-diverting toilets. Baseline data for parasite ova and pathogenic bacteria were taken and duly recorded. Results show that microorganisms do not pose a public health threat if human excreta from UDDT vaults are used in agriculture. However, helminth eggs, particularly those of *Ascaris lumbricoides*, may still be infective and six months may not be sufficient to dehydrate human faeces and render them safe for agricultural use. Secondary treatment is strongly recommended to render human excreta safe for agricultural use.

Keywords: agriculture, human excreta, urine diverting dry toilets

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 Nina 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 countries (WHO and UNICEF, 2006). 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 aquaculture (Scott, 2002). 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 Philippine 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 monthly observation and the use of standard laboratory techniques, such as bacteria culture and sedimentation, 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 dehydation (UDD) toilets in various locations in Cagayan de Oro City, Philippines. Specifically, the study also determined, on 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, Philippines, involving ten (10) waterless UDD toilets. One of the excreta storage vaults was emptied for use as experimental chamber for faeces collection. A thermometer was installed inside the chamber to record ambient temperatures within the storage chamber. After one week of collecting faeces, 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, while the community residents were able to continue to use their toilet. A standard absorbent material made of a mixture of lime and sawdust was prepared and provided to the different locations during the week that excreta sample was being collected. This was to ensure that absorbent material was 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.

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 faeces 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. Hence, this toilet was also dropped from the study.

Table 1. Microorganisms present with Average Temperature in Various UDD Toilets from Aug 2007 to Dec 2007, Cagayan de Oro City

Toilet	Aug	Sep	September Average Temp °C		Oct	Nov	Dec	December Average Temp °C	
			2nd Sample	3rd Sample				3rd Sample	4th Sample
1.Manresa Farm (Field)	E coli Proteus vulgaris Enterobacter spp	E coli Citrobacter spp	23.27	24.0	Citrobacter spp Enterobacter spp	E coli	Enterobacter spp E coli		25.33
2.Manresa Farm (Demo garden)	Citrobacter spp	Arizona spp Enterobacter spp	26.17	22.23	E coli	Enterobacter spp	E coli		22.33
4.Balulang Elementary (close to Elem)		Enterobacter spp Citrobacter spp	25.9			Enterobacter spp	Enterobacter spp	26.67	

5.FS Catanico (close to compost area)		Enterobacter spp Proteus mirabilis Proteus vulgaris	27.6		Proteus spp Enterobacter spp	Enterobacter spp E coli	Proteus spp	23.67	
7.Macasandig (Tambo)	Enterobacte r spp	Enterobacter spp E coli	24.67	26.33	Citrobacter spp Enterobacter spp E coli	E coli	E coli		24.67
8.Carmen (Independence Farm)	Proteus mirabilis Proteus vulgaris		28.17	26.33					26.67
9.Lapasan	Enterobacte r spp	Enterobacter spp E coli	30.33	25.67		Enterobacter spp	Enterobacter spp		28.33

Table 2. Microorganisms present with Average Temperature in Various UDD Toilets from Jan 2008 to May 2008, Cagayan de Oro City

Toilet	Jan	Feb	February Average Temp °C	Mar	Apr	April Arverage Temp °C	May
1. Manresa Farm (Field)	Enterobacter spp	Enterobacter spp E coli	28.33	Enterobacter spp	Enterobacter spp	28.33	Enterobacter spp
2. Manresa Farm (Demo garden)	Enterobacter spp E coli	Enterobacter spp	27.00	Enterobacter spp	Enterobacter spp	28.33	Enterobacter spp
4. Balulang Elementary (close to Elem)	Enterobacter spp	Enterobacter spp	26.66	Enterobacter spp	Enterobacter spp	27.66	Enterobacter spp
5. FS Catanico (close to compost area)	Enterobacter spp	E coli	27.66	E coli	E coli Enterobacter spp	27.33	E coli Enterobacter spp
7. Macasandig (Tambo)	Enterobacter spp E coli	Enterobacter spp E coli	27.33	E coli	E coli Enterobacter spp	29.00	E coli Enterobacter spp
8. Carmen (Independence Farm)		Enterobacter spp	26.00		Enterobacter spp	30.33	Enterobacter spp
9. Lapasan	Enterobacter spp	E coli Enterobacter spp	29.33	Enterobacter spp	Enterobacter spp	29.66	Enterobacter spp

Table 3. Parasite eggs present with Average Temperature in Various UDD Toilets from August 2007 to October 2007, Cagayan de Oro City

Toilet	Aug	Number per LPF	Sep	Number per LPF	September Average Temp °C		Oct	Number per LPF
					2nd Sample	3rd Sample		
1. Manresa Farm (Field)	Ascaris	5-6	Ascaris ova	1-2	23.27	24.0	Ascaris (irreg)	2-4
	Hookworm	0-1	Trichuris trichura	0-1			Trichuris trichura	0-1
	Hookworm ova	0-1	Hookworm ova (irreg)	0-1				
	Trichuris trichura ova	0-1	Trichuris trichura ova	0-1				
			Ascaris ova (irreg)					
2. Manresa Farm (Demo garden)	Ascaris	0-2	Ascaris ova (irreg)	1-3	25.17	22.23	Ascaris	0-1
	Ascaris ova	1-2	Ascaris ova	0-3			Ascaris (irreg)	2-3
	Enterobius	0-1						

	vermicularis							
	Hookworm ova	0-1						
4. Balulang Elementary (close to Elem)			Ascaris ova (irreg)	1-2	25.90			
5. FS Catanico (close to compost area)			Ascaris ova (irreg)	2-3	27.60		Ascaris ova	2-3
			Trichuris trichura ova	0-2			Ascaris ova (irreg)	3-5
7. Macasandig (Tambo)	Ascaris ova	0-1	Ascaris ova (irreg)	0-3	24.67	26.33	Ascaris ova (irreg)	2-3
			Ascaris ova	0-4				
8. Carmen (Independence Farm)	Ascaris	0-1	Ascaris	0-2	28.17	26.33	Ascaris	0-1
			Hookworm	0-1			Ascaris (irreg)	0-3
9. Lapasan	Ascaris ova	3-4	Ascaris ova (irreg)	2-3	30.33	26.67	Ascaris	
							Ascaris (irreg)	2-4

Table 4. Parasite eggs present with Average Temperature in Various UDD Toilets from November 2007 to January 2008, Cagayan de Oro City

Toilet	Nov	Number per LPF	Dec	Number per LPF	December Average Temp °C		Jan	Number per LPF
					3rd Sample	4th Sample		
1. Manresa Farm (Field)	Ascaris (irreg)	4-5	Ascaris (irreg)	3-5		25.33	Ascaris (irreg)	2-3
2. Manresa Farm (Demo garden)	Ascaris (irreg)	2-3	Ascaris (irreg)	2-5		22.33	Ascaris (irreg)	1-2
4. Balulang Elementary (close to Elem)	Ascaris (irreg)	2-3	Ascaris (irreg)	0-2	26.67		Ascaris (irreg)	1-2
5. FS Catanico (close to compost area)	Ascaris (irreg)	2-3	Ascaris (irreg)	1-2	23.67		Ascaris (irreg)	1-3
			Trichuris trichura	0-1			Trichuris trichura	0-1
7. Macasandig (Tambo)	Ascaris (irreg)	2-4	Ascaris (irreg)	1-2		24.67	Ascaris (irreg)	2-3
8. Carmen (Independence Farm)	Ascaris (irreg)	0-1	Ascaris	1-2		26.67	Ascaris (irreg)	0-1
9. Lapasan	Ascaris (irreg)	2-3	Ascaris (irreg)	3-6		28.33	Ascaris (irreg)	2-3

Table 5. Parasite eggs present with Average Temperature in Various UDD Toilets from February 2008 to May 2008, Cagayan de Oro City

Toilet	Feb	Number per LPF	Feb Average Temp °C	March	Number per LPF	April	April Average Temp °C	Number per LPF	May	Number per LPF
1. Manresa Farm (Field)	Ascaris (irreg)	2-3	28.33	Ascaris (irreg)	2-3	Ascaris (irreg)	28.33	2-3	Ascaris (irreg)	0-2
2. Manresa Farm (Demo garden)	Ascaris (irreg)	2-3	27.00	Ascaris (irreg)	1-3	Ascaris (irreg)	28.33	2-3	Ascaris (irreg)	2-3
4. Balulang Elementary (close to Elem)	Ascaris (irreg)	2-3	26.66	Ascaris (irreg)	2-3	Ascaris (irreg)	27.66	2-3	Ascaris (irreg)	2-3
5. FS Catanico (close to	Ascaris (irreg)	2-3	27.66	Ascaris (irreg)	2-3	Ascaris (irreg)	27.33	2-4	Ascaris (irreg)	1-2

compost area)										
7. Macasandig (Tambo)	Ascaris (irreg)	2-3	27.33	Ascaris (irreg)	2-3	Ascaris (irreg)	29.00	2-3	Ascaris (irreg)	1-2
8. Carmen (Independence Farm)	Ascaris (irreg)	0-1	26.00	Ascaris (irreg)	1-2	Ascaris (irreg)	30.33	2-6	Ascaris (irreg)	2-3
9. Lapasan	Ascaris (irreg)	3-4	29.33	Ascaris (irreg)	2-3	Ascaris (irreg)	29.66	2-3	Ascaris (irreg)	2-4

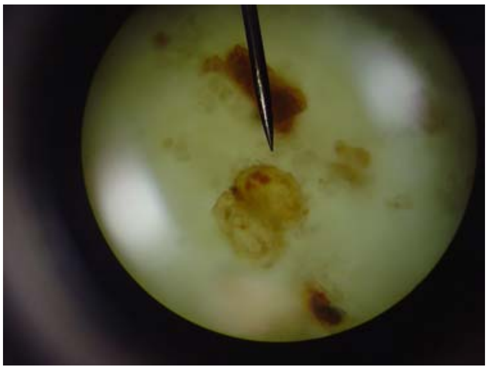

Figure 1. *Ascaris lumbricoides* egg, August 2007 (first month of data collection)

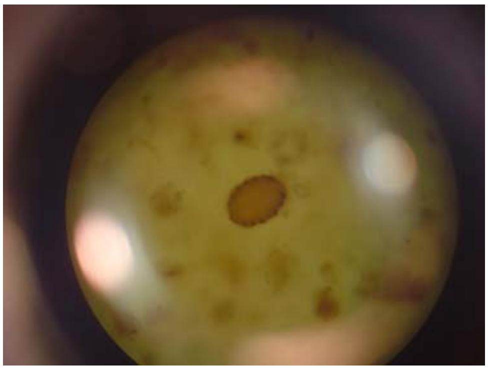

Figure 2. *Ascaris lumbricoides* egg, October 2007 (third month of data collection)

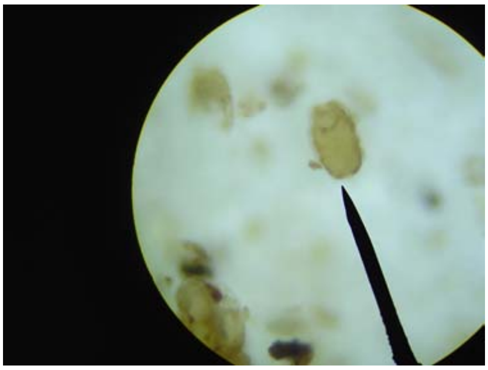

Figure 3. *Ascaris lumbricoides* egg, January 2008 (sixth month of data collection)

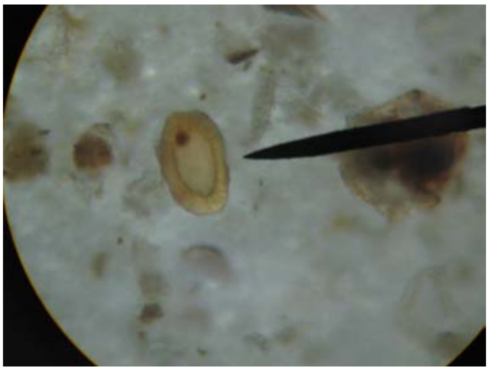

Figure 4. *Ascaris lumbricoides* egg, March 2008 (eighth month of data collection)

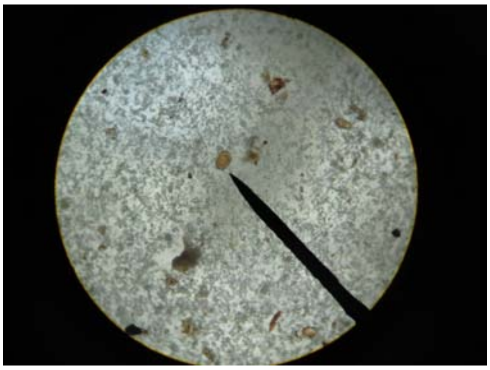

Figure 5. *Ascaris lumbricoides* egg, May 2008 (tenth month of data collection)

Discussion

Microorganisms

Preliminary results of this study show that the most common micro organisms found in fresh human faeces 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 meningitis (Department of Health, Philippines, 2003).

These micro organisms have also been shown to decrease considerably during the six (6) months that data has been collected for this study. Starting from the 6th month of data collection (January 2008), micro organisms found in the faeces samples consist only of *Enterobacter spp* and *E.coli* from the original five (5) enteric organisms which were identified in the first month of data collection (Tables 1 and 2). 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 faeces quickly die outside the human body (Brooks et al, 2004). Earlier studies conducted in other countries indicate that *Salmonella* has a die-off rate in stored faeces of 30-35 days (WHO, 2006) consistent with the results of this study. However, one study found that *Salmonella* may still present in stored faeces after one year (Austin, 2001).

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. The same is true of temperature and parasite eggs (Tables 1-5). 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 3). These are also the most common intestinal parasites in Filipinos (Belizario and Solon, 2000). It has also been shown that *Ascaris* ova, which have thick cell walls 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 (WHO, 2006 and Hewa, 1994). Earlier studies conducted to calculate health risks related to the use of stored, untreated faeces indicate that *Ascaris* posed the highest risk, with a high likelihood of infecting vulnerable persons after accidental ingestion (Schonning et al, 2007).

Most of these microorganisms and parasites belong to the list of 30 known excreta-related infections of public health importance (WHO, 2006). Data shows that micro organisms 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 throughout the ten months that data was gathered for this study. This is particularly true of *Ascaris lumbricoides* ova, which have thick cuticles and hence are very resistant to drying. It can be seen from the photographs that the *Ascaris* ova do not show a great change in morphology especially in the first six months of the study (Figures 1-3). It is further shown in the data that from the sixth to the tenth month of data collection, helminth ova in the faeces samples are predominantly those of *Ascaris lumbricoides* only (Tables 4 and 5). Furthermore, from the sixth to the tenth month of data collection, the *Ascaris* ova were seen to have undergone morphologic changes and were seen to be irregular, broken and greatly shrunken and reduced in size (Figures 4 and 5). This has implications regarding the infectivity of *Ascaris* ova and seems to suggest that they may still be infective up to the sixth month since conditions inside the UDD toilet vaults did not seem to greatly affect their morphology during the study, although determining the infectivity of helminth ova was not within the scope of this research.

Re-use of UDD toilet products has very important economic implications in an agricultural country like the Philippines because it could greatly bring down the cost of crop production. However, bacterial and parasitic infections still cause significant mortality and morbidity in the Philippine population (Department of Health, Philippines, 2003) and major health risks should be considered in the formulation of any recommendation. An earlier study on health risks associated with the use of wastewater for irrigation of crops found that there was an increase in the risk of developing enteric diseases, particularly in young children during the months that wastewater was used for irrigation (Fattal et al., 1986). With the high prevalence of gastrointestinal and parasitic diseases in the Philippines, the same consequence may result without careful investigation and analysis.

Conclusions

After ten months of data collection, three (3) important conclusions can be drawn from the results. These are:

1. Micro organisms do not pose a public health threat if human excreta are used in agriculture. However, *Ascaris* ova may still be infective after six months because this time period may not be adequate to dehydrate human faeces and render them safe for agricultural use. This seems to be especially true in a tropical country like the Philippines where ambient humidity and amount of rainfall is high most months of the year.
2. After six months, *Ascaris* ova were the only helminth ova of significant numbers seen in the faeces samples, giving further evidence to their ability to resist drying and desiccation.
3. To render human excreta safe for agricultural use, secondary treatment is recommended, regardless of the time that human excreta has been kept in the vaults of UDD toilets

Recommendations

It is recommended that secondary treatment methods for human excreta be investigated and compared, as well as studies assessing the health risks of using UDD toilet products must be conducted in order to formulate concrete guidelines for the agricultural use of human excreta in the Philippine setting. Secondary treatment methods should include aerobic composting, vermicomposting, bio gas production as well as other methods of secondary treatment. Health risks should include infections such as infant diarrhea, *Salmonella* infection, and transmission of helminths, in particular, *Ascaris*, Hookworm, and *Trichuris trichiura*. Average humidity inside the UDD toilet vaults should also be measured in future studies, since this factor may be more important than ambient temperature in relation to the survival of pathogenic organisms and parasite ova in human excreta.

References

Austin A. Health aspects of ecological sanitation. In: *Proceedings of the 1st international conference on ecological sanitation 2001*, *Nanning, China, 5-8 November*, pp 104-111.

Belizario VY and Solon JA. *Philippine textbook of medical parasitology.* The Publications Program,
University of the Philippines 2000. pp 85-112.

Brooks GF, Butel JS, Morse SA. *Medical microbiology.* 23rd ed, McGraw Hill International 2004. pp. 248-261.

Department of Health, Republic of the Philippines. *Leading causes of adult morbidity and leading causes of infant mortality 2003*. Health Statistics link at www.doh.gov.ph.

Fattal B, Wax Y, Davies M, Shuval HI. Health risks associated with wastewater irrigation: an epidemiological study. *American Journal of Public Health August 1986, 76 (8): 977-979.*

Hewa S. The hookworm epidemic on the plantations in colonial Sri Lanka. *Medical History, 38: 73-90 (1994).*

Schonning C, Westrell T, Stenstrom TA et al. Microbial risk assessment of local handling and use of human faeces. *Journal of Water and Health, 5 (1): 117-128 (2007).*

Scott, E. Dry sanitation solutions. *Journal of Rural and Remote Environmental Health 1(2): 23-25 (2002).*

World Health Organization. *Guidelines for the safe use of wastewater, excreta and greywater. Volume 4:Excreta and greywater use in agriculture*. Geneva, Switzerland (2006) http://www.who.int/water_sanitation_health/wastewater/gsuweg4/en/index.html.

World Health Organization and UNICEF. *Meeting the MDG drinking water and sanitation target: the urban and rural challenge of the decade.* WHO Press 2006. Geneva, Switzerland.

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