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Original Article

Pathogenic Potential of Composted and Sundried Human Excreta from Eco-toilets in Bangladesh

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Abstract

Background **:** The concept of eco-toilets in Bangladesh was promoted by an NGO (Practical Action, Bangladesh). The ecotoilets are especially built to collect human excreta for using them as manure on the fields after appropriate treatment for 12 months. ***Objectives*****:** This study was designed to see the physical properties appropriate for fields and pathogenic potential to ensure the treated human excreta are safe for cultivator's handling. ***Methodology*****:** The study was carried out in three phases during 2010 to 2014. A total of 210 composted faecal excreta were examined for physical properties like colour, odour, odour intensity, moisture, bacteriological examination for faecally transmitted potential bacteria and parasitological examination for ova / cysts of faecally - transmitted parasites to recommend whether these composted excreta were suitable for use as manure by the cultivators. ***Results*****:** Majority of the specimens in all three phases contained remarkable moisture: 22.3-80.0% in all specimens in phase I, a considerable number (16, 53.3%) contained 25% moisture in phase II and high moisture content (66.4%-78.9%) in 6(50.0%) of specimens in phase III. Bacteriological examination revealed no pathogenic organism in any specimen of the phases- although, some specimens in all phases showed growth of non-coliform bacteria. Parasitological examinations in all phases revealed ova/larvae of helminths of *Ascaris lumbricoides* (AL)/ *Trichuris trichiura* (TT)/ *Strongyloides stercoralis* (SS). No cyst or trophozoite of any pathogenic parasite, or oocyst of the cryptosporidium was found. ***Conclusion*****:** The composted excreta could not be adequately treated by sun-drying as indicated by high moisture content and were found not suitable to use as manure by cultivators in the field.

Key words: Eco-toilet, Faecal composting, Faecally-transmitted microorganisms

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Introduction

A significant proportion of population, especially in the developing countries, were estimated by World Health Organization (WHO) to lack access to safely-managed sanitation and were developing the guidelines to safely use the human excreta in agriculture.[1,2] The lack of access to safe sanitation also produces significant economic impact. India's GDP was found to face a loss of 6.4% due to inadequate sanitation.[3] Majority of the faecal waste globally does not undergo any treatment to eradicate the possible microbial pathogens and eventually, over 50% of the water sources like pond, lake, rivers, oceans are contaminated with untreated sewage.[4]

Whereas, human excreta as organic biosolids can be recycled onto agricultural land for providing essential nutrients of the crops and for improving soil conditions by increasing

water-holding capacity and aeration, as well as an energy source for earthworms and beneficial microorganisms.[5] Faecal sludges have been found to contain essential nutrients (nitrogen and phosphorus) and potentially beneficial as fertilizers for plants.[6] The organic carbon in the sludge, once stabilized, is also desirable as a soil conditioner, because it provides improved soil structure and aeration for plant roots.[6]

A large number of human pathogens like bacteria - e.g., *Escherichia coli* & Salmonella species and parasites/protozoa e.g., *Cryptosporidium parvum, Giardia intestinalis, Ascaris lumbricoides, Taenia saginata / Taenia solium* primarily originate from human faeces.[7] Therefore, the use of human biosolids in the fields as fertilizer bears the risk of infection by these human pathogens for the users. For the purpose of safely using nutrients in human excreta, the concepts of eco-toilets have been popular worldwide with composting the biosolids by anaerobic digestion (AD).[9] AD is the process treating organic materials biologically in the absence of oxygen and producing biogas. Because of the capacity for efficient conversion of organic materials as well as cost effectiveness, this process became very popular in resource-poor areas of the world. But AD alone can not remove all pathogenic potentialities of the faecal sludges.[10-13]

Keeping in mind the above considerations, the present study was conducted to test composted and sundried human excreta from eco-toilets at different areas of Bangladesh for assessing physical properties favourable for survival of the human pathogens and existence of pathogenic bacteria, protozoa and helminths that could be harmful for cultivators.

Methodology

This was a prospective observational study completed in three phases during 2010 to 2014 and conducted in the Institute of Epidemiology, Disease Control and Research (IEDCR). Human excreta (faeces and urine) were collected separately for 6-months in the especially built latrines (eco-toilets) for this purpose by an Non Government Organization (NGO) named 'Practical Action Bangladesh'. The excreta were then composted after 6-months use being covered by ash, kept unused for next 6-months in phase 1 study and examined for potential pathogens. In the next two phases, following recommendations made from previous phase, the specimens were sundried after initial composting. In phase I, completed during 2010 -2011, a total of 60 composted faecal excreta were examined and recommendations made based on findings to keep excreta for further anaerobic digestion and sun-drying before use as manure; in phase II during 2012, in continuation of phase I recommendations, 120 composted human faeces specimens from 30 different eco-toilets (4 from each including 2 from upper layer and 2 from middle layer) were sundried and examined, found not suitable for use as manure and recommendations made for further adequate sun-drying; in phase III completed in 2014, in continuation of the collaboration, a total of 12 composted and adequately sundried human excreta were examined for the physical properties and pathogenic potential for safety to ensure the reuse of human excreta as safe soil conditioner.

During all phases, examinations of the composted and/or sundried human excreta were performed in the laboratories of IEDCR. The physical examinations of the excreta included smelling odour, looking colour, measuring pH and moisture content14 by standard techniques. The parasitological examination included Microscopy using normal saline, iodine and safranin preparations to see ova/ larvae of AL, TT, AD & SS, cyst/ trophozoites of EH, GI and oocyst of Cryptosporidium species. For bacteriological study, the specimens were crushed aseptically, dissolved in sterile normal saline and inoculated over Thiosulphate Citrate Bile salt Sucrose (TCBS) agar, McConkey's agar and Salamonella-Shegella agar media to see growth of any *Vibrio cholerae*, Salmonella & Shigella species.

Data for each specimen were collected in separate data sheet and entered into computer using SPSS software (version 16.0) for analysis.

Results

Phase I findings:

The colour and odour of the composted excreta of eco-toilets were more or less within acceptable quality. The mean pH was acidic (6.2) and the moisture content was high (22.3-80.0%). Bacteriological examination revealed no pathogenic organism, although non-coliform bacteria were found to grow. Parasitological examination revealed at least one type of parasite in each of the specimens. Ova of *Ascaris lumbricoides* (AL) and *Trichuris trichiura* (TT) were found in all specimens (60,100.0%), although many of them seemed to be nonviable based on physical characteristics. Cysts of amoeba were found in all specimens, but all of them were non-pathogenic. (Table 1).

Table 1: Pathogenic potentials of composted human faeces (n=60) during phase I

Sl no.	Trait	Findlings of majority specimens	Number (%) of specimens
1	pH	6.0 (Acidic)	41(68.3)
2	Moisture content	22.3-80%	60 (100.0)
3	Growth of bacteria (non-pathogenic)	Yes	54 (90.0)
4	Cyst of non-pathogenic amceba	Yes	60 (100.0)
5	Ova of Al /TT / SS	Yes	60 (100.0)

AL-Ascaris lumbricoides, TT- Trichuris trichiura, SS-Strongyloides stercoralis

Phase II findings:

The colour of the specimens was muddy or blackish, had no odour and mean pH was alkaline (8.5). Some of the specimens (31/120, 25.83%) contained moisture (50.0-53.3%). Some of the specimens contained ova of helminths (12/120, 10.0% contained ova of AL, 1/120, 0.8% contained ova of TT and 1/120, 0.8% contained both ova). No cyst/trophozoite/oocyst found among the specimens. There was no growth of potential pathogens by culture on bacteriological media. (Table 2)

Table 2: Pathogenic potentials of composted human faeces (n=30) during phase II

Sl no.	Trait	Findlings of majority specimens	Number (%) of specimens
1	pH	>7.0 (Alkaline)	30 (100.0)
2	Moisture content	25.0%	16 (53.3)
3	Ova of AL/TT/both	Yes	14 (46.6)

AL-Ascaris lumbricoides, TT- Trichuris trichiura, SS-Strongyloides stercoralis

Table 3: Relationship of moisture and ova/cyst of parasites content in the composted human excreta (n=30) from eco-toilets in phase II tested immediately

Moisture content	Number (%) specimens showing-		P value
	No ova/cyst	Ova of AL/TT/both	
No moisture (n=14)	12(85.7%)	2(14.3%)	0.01
25% moisture (n=16)	4 (25.0%)	12 (75.0%)	

Al-Ascaris lumbricoides, TT- Trichuris trichiura, SS-Strongyloides stercoralis

Phase III findings:

Specimens were black/ash and majority (6, 50.0%) had no odour. The mean pH of the specimens examined was 7.9 (SD±0.2875). Moisture content of half of the specimens (6, 50.0%) were between 4.6 to 8.1%, whereas, other half of the specimens had high (66.4%-78.9%) moisture. (Table 4)

Table 4: Pathogenic potentials of the specimens in phase III (n=12)

Sl	Trait	Findlings of majority specimens	Number (%) of specimens
1	Color	Black/ash	12 (100.0)
2	Mean pH	7.9 (Alkaline)	
3	High Mosture Content	66.4-78.9%	6 (50.0)
4	Ova/larvae of AL/TT/SS	Yes	10 (83.3)
5	Tophozoite/cyst/oocyst	No	12 (100.0)
6	Pathogenic bacteria	No	12 (100.0)

AL-Ascaris lumbricoides, TT- Trichuris trichiura, SS-Strongyloides stercoralis

Half (6, 50.0%) of the specimens showed no growth of any faecal pathogen and 3(25.0%) of the specimens were found to yield growth of non-coliform faecal pathogens. Specimens showing growth were also found to contain high-level of moisture (66.4-70.3%). (Table 5)

Table 5: Relationship of moisture content and growth of bacteria in the composted human excreta (n=12) from eco-toilets in phase III tested immediately

Culture growth of faecal pathgens	Number (%) specimens with moisture content	
	Low (4.6-8.1%)	High (66.4-78.9%)
No growth	6 (50.0)	0 (0.0)
Growth of non-coliform bacteria	3 (25.0)	3 (50.0)

Discussion

The proposed Eco-toilets by Practical Action Bangladesh were expected to be safe by not containing any potentially pathogenic microorganism. For this purpose, the physical properties and pathogenic potentials of the composted human excreta have been examined consecutively in three phases. Pathogenic potentiality in the phase I was very high showing ova / larvae of helminths, cysts of non-pathogenic amoeba and non-coliform bacteria. This indicated that treatment of the human faeces was not adequate for

safely use by the cultivators. Consequently, there was a recommendation for further anaerobic digestion, followed by sun-drying of the composted specimens from eco-toilets. Although, in phase II, specimens were composted adequately and sundried before submitted for examination. But yet majority of the specimens contained remarkable moisture and ova / lavae of helminths and yielded growth of some bacteria. Recommended again to increase the duration of sun-drying. Finally, in the phase III specimens also cotained similar problems and could not be recommended for use in the field as manure. To observe the survival of Ascaris eggs, Jensen et al[13] found that >99% die off occurred of the Ascaris eggs in a similar condition of double vault composting latrines used in Vietnam. Berendes et al[15] in a study at Port-au-Prince, Haiti, found that 10.4% viable and 8.3% fully embryonated Ascaris eggs in new compost dropped down to zero in specimens older than six weeks of composting. As Ascaris ova are considered to be most heat-resistant of all enteric pathogens,[16] finding these eggs in composted faecal sludge indicates inadequate composting. A significant number of the specimens contained high-level of moisture, which could be favourable for long-time persistence of some infectious ova of the helminths as well as some bacterial faecal pathogen.[17] Parasitological examination revealed ova of *Ascaris lumbricoides* and *Trichuris trichiura* and larvae of *Strongyloides stercoralis* in many of the specimens. It was found that the specimens showing moisture contained significantly higher number of ova of the parasites. Bacteriological examination by culture revealed growth of some non-coliform bacterial pathogen, which were strongly associated with high moisture content of the specimens.

Conclusion

Many of the specimens contained very high level of moisture and there was a significant relationship of moisture level and ova content of the parasites and bacterial culture growth in the specimens, which strongly suggests that specimens were not composted and sun-dried adequately as well as the proposed system of composting and sun-drying are not adequate to make the human faecal sludges safe for use in fields by the cultivators.

Conflict of Interset: None

References

1. World Health Organization (WHO). WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater- Volume IV: Excreta and Greywater Use in Agriculture. Geneva, Switzerland: WHO. 2006.

2. World Health Organization (WHO) and The United Nations Children's Fund (UNICEF). Progress on Drinking Water, Sanitation and Hygiene-2017: Update and SDG Baselines. Geneva, Switzerland: WHO and UNICEF. 2017.

3. Water and Sanitation Program (WSP). Flagship Report: The Economic Impacts of Inadequate Sanitation in India. New Delhi, India:WSP.2011. Available online at:https://www.sp.org/sites/wsp/files/publications/WSP-esi-india.pdf, viewed on: 12.11.2015.

4. Baum R, Luh J, Bartram J. Sanitation: A global estimate of sewerage connections without treatment and the resulting impact on MDG progress. Environ Sci Technol. 2013 January; 47(4):1994-2000. DOI: 10.1021/es304284f.

5. Evanylo GK. Agricultural Land Application of Biosolids in Virginia: Risks and Concerns. Virginia, USA:Virginia Cooperative Extension. Publication Number 452-304, August 1999.

6. Heinonen-Tanski H, van Wijk-Sijbesma C. Human excreta for plant production [Review]. Bioresour Technol. 2005 March;96(4):403-411. DOI: 10.1016/j.biortech.2003.10.036.

7. Cheesbrough M. Examination of Faecal Specimens. In: District Laboratory Practices in Tropical Countries, Part 2, 2nd Ed. Cambridge, UK: Cambridge University Press. 2006:pp.97-98.

8. Sidhu JPS, Toze SG. Human pathogens and their indicators in biosolids. Environ Int. 2009 Jan;35(1):187-201.DOI: 10.1016/j.envint.2008.07.006.

9. Vinnerås B, Björklund A, Jönsson H. Thermal composting of faecal matter as treatment and possible disinfection method - laboratory-scale and pilot-scalestudies. Bioresour Technol. 2003; 88:47-54.

10. Pecson BM, Barrios JA, Jiménez BE, Nelson KL. The effects oftemperature, pH, and ammonia concentration on the inactivation of Ascariseggs insewage sludge. Water Res.2007;41:2893-2902.

11. United Nations Environment Programme (UNEP). Sludge treatment, reuse and disposal. Web page at:http://www.unep.or.-jp/ietc/publications/freshwater/sb_summary/10.asp, viewed on 24.11.2014.

12. Water and Sanitation Program (WSP). Flagship Report: The Economic Impacts of Inadequate Sanitation in India. New Delhi,India:WSP.2011.Available.online.at:https://www.wsp.org/-sites/wsp/files/publications/WSP-esi-india.pdf,viewed.on: 12.11.2015.

13. Jensen PKM, Phuc PD, Konradsen F, Klank LT, Dalsgaard A. Survival of Ascaris eggs and hygienic quality of human excreta in Vietnamese composting latrines. Environ Health.2009;8:57. DOI: 10.1186/1476-069X-8-57.

14. Standards Association of Australia. Determination of the Moisture Content of a Soil: Oven Drying Method (standard method). AS 1289 B1.1-1977.Webpage available at: https: //www.environment.nsw.gov.au/resources/soils/testmethods/mc.pdf, Viewed on 21.10.2016.

15. Berendes D, Levy K, Knee J, Handzel T, Hill VR. Ascaris and *Escherichia coli* Inactivation in an Ecological Sanitary System in Port-au-Prince, Haiti. PloS ONE. 2015;10(5): e0125336. DOI: 10.1371/journal.pone.0125336.

16. Reimers RS, McDonell DB, Little MD, Bowman DD, Englande AJ, Henriques WD. Effectiveness of wastewater-sludge treatment processes to inactivate parasites. Water Sci Technol. 1986; 18: 397–404.

17. Yeagar JG, Ward RL. Effects of Moisture Content on Long-term Survival and Regrowth of Bacteria in Wastewater Sludge. Appl Environ Microbiol. May 1981;41(5):1117-1122.