The Effectivity of the Terra Preta Sanitation (TPS) Process in the Elimination of Parasite Eggs in Fecal Matter: A Field Trial of Terra Preta Sanitation in Mindanao, Philippines

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Abstract:

Earlier studies have shown that *Ascaris lumbricoides* ova persist in dried human faeces from urine diverting dehydration toilets (UDDT) vaults even up to 10 months without secondary treatment. To address gaps in the knowledge for effective secondary treatment methods, this study aimed to determine the effects of a bacterial mix (obtained from Dr Jurgen Reckin) as a fermenting medium, in combination with charcoal (Terra Preta Sanitation process) on parasite egg reduction.

The study was conducted using twenty (20) UDDTs in Lumbia, Cagayan de Oro City, in Mindanao, Philippines. The users of 10 UDDT toilets were told to add powdered charcoal and 20 ml of the bacterial mix after using their toilets for defecation, while owners of 10 different UDDT toilets were told to just add charcoal after defecation. The study was conducted for three (3) months after which the collected faeces from all the UDDT toilets were collected, stored for another 3 months, and were then vermicomposted separately for six (6) weeks.

Results showed that after 3 months of undergoing the terra preta sanitation (TPS) process (addition of powdered charcoal and bacterial fermenting mix), fecal material was virtually free of parasite eggs, especially that of *Ascaris lumbricoides* which proved to be very difficult to eradicate in earlier studies, when compared to faecal material to which only charcoal was added. Nitrogen, Phosphorus and Potassium (NPK) values for both experimental groups were also comparable after undergoing vermicomposting.

Therefore, the TPS process is an effective secondary treatment method for eliminating parasite eggs from dried human faeces in a country with a tropical climate like the Philippines. It is capable of rendering faeces safe for re-use in a shorter time compared to just drying or using no secondary treatment. This is of particular importance in developing countries like the Philippines where the parasite load in the population is extremely high. Furthermore, NPK values after vermicomposting showed that there is no significant difference between the two experimental groups.

It is therefore recommended that the TPS process be used as a secondary treatment method for faeces collected from UDDT toilets particularly in countries like the

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Philippines, with a tropical climate and where re-use of faeces poses a risk to health and hygiene because of a high parasite load in the population.

Keywords: terra preta, terra preta sanitation, urine diverting dehydration toilets

Introduction:

"Terra Preta de Indio" (Amazonian Dark Earths; earlier also called "Terra Preta do Indio" or Indian Black Earth) is the local name for certain dark earths in the Brazilian Amazon region. These dark earths occur, however, in several countries in South America and probably beyond. They were most likely created by pre-Columbian Indians from 500 to 2500 years B.P. and abandoned after the invasion of Europeans (Smith, 1980; Woods et al., 2000). However, many questions are still unanswered with respect to their origin, distribution, and properties.

The global carbon cycle has been brought to wide attention due to its importance for the global climate. The Intergovernmental Panel on Global Change (IPCC, 2001) recently confirmed that the anthropogenic greenhouse effect is a reality, which we have to deal with in the future. The atmospheric CO2 has increased from 280 ppm in 1750 to 367 ppm in 1999 and today's CO2 concentrations have not been exceeded during the past 420,000 years (IPCC, 2001). The release or sequestration of carbon in soils is therefore of prime importance.

Soil organic carbon is an important pool of carbon in the global biogeochemical cycle. The total amount of organic carbon in soils is estimated to be 2011 GtC, which constitutes about 82% of the global organic carbon in terrestrial ecosystems (Watson et al., 2000). Amazonian Dark Earths have high carbon contents of up to 150 g C/kg soil in comparison to the surrounding soils with 20-30 g C/kg soil (Sombroek WG et al., 1993; Woods and McCann, 1999; Glaser et al., 2000). Additionally, the horizons which are enriched in organic matter, are not only 10-20cm deep as in surrounding soils, but may be as deep as 1-2m (average values probably around 40-50cm). Therefore, the total carbon stored in these soils can be one order of magnitude higher than in adjacent soils.

The potential of terra preta soil as a means to enrich soil and make it more productive is important for an agricultural country such as the Philippines. Furthermore, the potential of creating terra preta from bio-waste such as human excreta is a possibility which needs to be investigated further. Of particular interest for investigation, is the potential of the terra preta sanitation process to eliminate parasite ova, particularly of *Ascaris lumbricoides*, which have been proven by a number of studies (Itchon G et al 2008; Sanguinetti G et al 2009) to persist for extended periods in dried fecal material. These studies have shown that *Ascaris lumbricoides* ova may persist in dried human faeces from UDDT vaults even up to 10 months without secondary treatment (Itchon et al, 2008). To address these gaps in the knowledge, this study aimed to determine the effects of a bacterial mix (obtained from Dr Jurgen Reckin[*]) as a fermenting medium, in combination with charcoal, as well as the influence of time on parasite egg reduction.

Specifically, it aimed to achieve the following objectives:

a) to determine the optimum Carbon: Nitrogen (C:N) ratio suitable for vermicomposting;
b) to investigate the potential of terra preta (TP) as a source of nutrients to plants.

Materials and Methods:

Type of Study: Analytic Observational

Study Location: Lumbia and Palalan, Cagayan de Oro City, Philippines

Study Procedure:

Phase 1

Twenty (20) toilets were initially identified for the first phase of the study. 10 urine diverting dehydration toilets (UDDTs) from Lumbia, and 10 from Palalan, Cagayan de Oro City. The 10 UDDTs in Lumbia were designated for use with the microbe fermenting mix and powdered charcoal; while the 10 UDDTs in Palalan, were designated for use with powdered charcoal only. This was to ensure that comparison could be made regarding the effect of the bacterial mix on the reduction of pathogens and parasite eggs in the collected faeces contained in the toilet vaults.

Toilet owners in both Lumbia and Palalan were oriented on the proper use of UDDTs and the addition of material after defecation. Designated toilet owners in Lumbia were told to add around 20 ml of bacterial mix and a cup of powdered charcoal after defecation; while designated toilet owners in Palalan were just told to add a cup of powdered charcoal. Residents were told to use their toilets for a week before the observation period was started and before addition of bacterial mix. Fecal samples were then taken from all toilets for baseline data. Additional samples were then taken 30 days after and 60 days after the start of the observation period. Bacterial mix and powdered charcoal was provided to all toilet owners

Phase 2

At the end of 60 days, 6 toilets were discarded as experimental sites in Palalan because of a number of problems. Among the problems identified were the following: wet fecal material in the UDDT vaults due to improper use of the toilets; charcoal was not added adequately; identification of other discarded material in the toilet vaults (food scraps). The faeces collected from all the experimental UDDTs were put in separate black plastic

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[*] This bacterial mix contains the following bacteria: *Bacillus subtilis, Bacillus mesentericus, Geobacillus stearothermophilus, Azobacter croococum,* and *Lactobacillus sp.*

garbage bags and transported to the storage shed of the community in order to undergo drying for 6 weeks. There were 10 bags from Lumbia (with bacterial mix) and 4 bags from Palalan (without bacterial mix).

After 6 weeks of drying, the faeces from Lumbia and Palalan were put in 2 separate beds for vermicomposting. 44 k of faeces with bacterial mix and 44 k of faeces without bacterial mix were placed in 2 beds. C:N ratio of 70:30 was used and 1 k of African nightcrawlers were used for composting for each of the beds. Standard vermicomposting procedures were used. Fecal samples were then taken at monthly intervals to further monitor for presence of parasite eggs for the next 3 months during the vermicomposting phase. Samples were also taken for N P K analysis after 3 months. Vermicast analysis was done at the Regional Soil Testing Laboratory of the Department of Agriculture Regional Office 10.

Results:

The tables below show the results during Phase 1 and Phase 2 of the study. Table 1 and 2 show the results during Phase 1while Table 3 and 4 show the results for Phase 2.

Table 1. Number and Type of Parasite Ova in Fecal Samples with Bacterial Mix

	Baseline	After 30 days	After 60 days
Ascaris	5-6	Irregular 2-3	0 (none seen)
Taenia	0-1	0 (none seen)	0 (none seen)
Trichuris trichura	2-3	0 (none seen)	0 (none seen)

Table 2. Number and Type of Parasite Ova in Fecal Samples without Bacterial Mix

	Baseline	After 30 days	After 60 days
Ascaris	3-4	Irregular 1-2	2-4, Irregular
Trichuris	2-3	1-2	0 (none seen)
Enterobius vermicularis	0-1	0 (none seen)	0 (none seen)

Table 3. Number and Type of Parasite Ova in Fecal Samples with Bacterial Mix During Vermicomposting

	After 30 days	After 60 days	After 90 days
No parasite ova	0 (none seen)	0 (none seen)	0 (none seen)

Table 4. Number and Type of Parasite Ova in Fecal Samples Without Bacterial Mix During Vermicomposting

	After 30 days	After 60 days	After 90 days
Ascaris ova	Irregular 0-1	0 (none seen)	0 (none seen)

Tables 5 and 6 show the assay results for vermicasts, specifically testing for Nitrogen, Phosphorus, and Potassium content.

Table 5. Assay for Vermicast of Fecal Samples with Bacterial Mix

Contents (Constituents)	Air Dry Basis (%)	Oven Dry Basis (%)
Total Nitrogen (N)	1.61	1.79
Total Phosphoric Acid (P_2O_5)	0.80	0.89
Total Potassium (K_2O_5)	1.27	1.41
TOTAL N,P,K =	**3.68**	**4.09**
Available Phosphoric Acid (P_2O_5)		
Calcium Oxide (CaO)		
Calcium Carbonate ($CaCO_3$)		
Magnesium Oxide (MgO)		
pH of the Sample		
Moisture Content (as received - 73.5)	10.00	

Table 6. Assay for Vermicast of Fecal Samples Without Bacterial Mix

Contents (Constituents)	Air Dry Basis (%)	Oven Dry Basis (%)
Total Nitrogen (N)	1.24	1.33
Total Phosphoric Acid (P_2O_5)	0.80	0.86
Total Potassium (K_2O_5)	1.03	1.11
TOTAL N,P,K =	**3.07**	**3.30**
Available Phosphoric Acid (P_2O_5)		
Calcium Oxide (CaO)		
Calcium Carbonate ($CaCO_3$)		
Magnesium Oxide (MgO)		
pH of the Sample		
Moisture Content (as received - 73.5)	7.00	

Discussion:

The most important finding of this study is that it has been able to demonstrate the effectiveness of using the terra preta sanitation process as a secondary method of eliminating parasite ova from faeces collected in the vaults of urine diverting dehydration toilets. Aside from the advantages of creating terra preta to enrich soil and complete the carbon cycle, the fact that the process also shortens the time required to render human faeces safe for agricultural re-use is a very important finding for a developing country such as the Philippines. Earlier studies have illustrated that in developing countries, the issue of safe re-use of human excreta is often one of the principal barriers to completing the sanitation cycle primarily because of the high parasite load in populations (Itchon et al 2008; Phasha 2005).

The study was also conducted in an actual community where a number of UDDT toilets have been installed and are in use. Thus, this study has also been able to highlight several problems in the use of dry toilets. As mentioned earlier, some toilets were later discarded for data collection since a number of problems were identified. Among other factors, toilet design and proper training and orientation of users were the most important. However, the field trial was also able to demonstrate very clearly, that addition of a bacterial mix and charcoal to faeces after defecation is a very feasible secondary treatment method in humid environments such as what is normally found in the Philippines.

Another important finding of this study is the use of 70:30 C:N ratio during vermicomposting after 6 weeks of drying the collected faeces. The slightly higher Carbon content ratio was necessary to make vermicomposting possible because of the use of charcoal. A C:N ratio of 60:40 was not possible and killed the earthworms after 1 week. This problem was avoided when Carbon content was raised to 70%.

It is also noteworthy that after vermicomposting, assay of the vermicompost from both batches of vermicomposted dried faeces (with and without addition of bacterial mix and charcoal) showed remarkably similar macronutrient and moisture content. Both sample assays also showed that both samples conformed to organic fertilizer standards set by the Philippine National Standards for Organic Fertilizer (Department of Trade and Industry, Bureau of Product Standards, Republic of the Philippines 2008).

Conclusions:

Three (3) important conclusions can be drawn from the results. These are:

1. The terra preta sanitation (TPS) process is an effective secondary treatment method for human faeces collected in UDDT vaults;

2. Vermicomposting of dried human faeces that have undergone the TPS process requires a slightly higher C:N ratio (70:30 instead of 60:40);

3. Assay of vermicompost from dried human faeces which have undergone the TPS process conformed to Philippine standards for organic fertilizer in terms of NPK and moisture content.

Recommendations:

It is therefore recommended that the TPS process be used as a secondary treatment method for faeces collected from UDDT toilets particularly in countries like the Philippines, with a tropical climate and where re-use of faeces poses a risk to health and hygiene because of high parasite load in the population.

It is further recommended that a larger scale field trial be conducted in order to validate the findings of this study.

References:

1. Department of Trade and Industry, Bureau of Product Standards, Republic of the Philippines. Philippine national standard for organic fertilizer. Department of Trade and Industry, Republic of the Philippines, 2008, p 5.

2. Glaser B, Lehmann J, Zech W. Ameliorating physical and chemical properties of highly weathered soils in the tropics with charcoal – a review. Biol Fertil Soils (2002) 35: 219-230.

3. Intergovernmental Panel on Climate Change. Climate change 2001: Synthesis report. Summary for policy makers. Intergovernmental Panel for Climate Change 2001.

4. Itchon GS, Holmer R, Tan MLB. The public safety of using human excreta from urine diverting dehydration toilets for agriculture: the Philippine experience. The Xavier University Journal of Medicine (2008) 5: 9-14.

5. Lehman J, Kern DC, Glaser B, Woods WI. Amazonian dark earths: origin, properties, management. Kluwer Ac Publ 2003., 523 pp.

6 Phasha MC. Health and safety aspects of the use ofproducts from urine diversion toilets. Thesis submitted for the degree of Master of Science in Microbiology May 2005, Faculty of Natural and Agricultural Sciences, University of Pretoria, South Africa.

7 Sanguinetti G, Ingalinella AM, Ferrer V. Ecological sanitation: inactivation of faeces from dry toilet – greywater disposal. Book of Abstracts Dry Toilet 2009 3rd International Dry Toilet Conference 12-15 August 2009, Tampere, Finland. P 25.

8. Sombroek WG, Nachtergaele FO, Hebel A. Amounts, dynamics, and sequestering of carbon in tropical and subtropical soils. Ambio (1993) 22: 417-426.

9. Watson RT, Noble R, Bolin B, et al. Land use, land use change, and forestry. Intergovernmental Panel on Climate Change Special Report 2000. Cambridge University Press, UK, 375 pp.

10. Woods WI and McCann JM. The anthropogenic origin and persistence of Amazonian dark earths. Yearb Conf Latin AM Geogr (1999) 25: 7-14.

Deriving from these concepts, Terra Preta Sanitation (TPS) has been re-developed and adopted. TPS includes urine diversion, addition of a charcoal mixture and is based on lactic-acid-fermentation with subsequent vermicomposting. Lacto-fermentation is a biological anaerobic process that generates a pre-stabilization of the mixture. The main advantage of lacto-fermentation is that no gas and no odor is produced. What makes it particularly interesting for in-house systems even in urban areas. Instead, vermicomposting is an aerobic decomposition process of the pre-digested materials by the combine