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A concept for a sustainable sanitation chain based on the semi centralised production of Terra Preta for Moldova

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Abstract
Terra Preta Sanitation (TPS) arises as a sustainable sanitation alternative which can improve several social and ecological issues in rural regions. Moldova is a country, whose rural population has limited access to sewerage system and limited resources for high tech sanitation. UDDT system is relatively well accepted by the local population. Introducing TPS for human waste treatment may open new perspectives for human waste treatment and therefore better acceptance for their reuse in agriculture.
Based on literature review and some preliminary data, this paper introduces the concept of TPS and presents some views on semi-centralized production of terra preta nova at household and school level from 5 villages from the Nisporeni district of Moldova. Current research is based on some preliminary observation on existent faeces management system and discussing the potential for its improvement.

Keywords: *human excreta – urine diverting dry toilet (UDDT)t –semi-centralized faeces collection-Terra Preta Sanitation.*

Introduction

More than 20 million people from Central and Eastern Europe will not have a healthy and adequate sanitation system in the near future (Bodik and Ridderstolpe 2007). The first National Report on MDGs in the Republic of Moldova (Government of Moldova, 2005) set the long term targets as to increase the rate of population with access to improved sanitation from 40 % (2001) to 56 % in 2006 and from 73 % in 2010 to 90 % in 2015. Nevertheless, only 5% of rural population up to now has access to operating sewerage systems, which follows up a low probability for achieving the set targets. The most

widespread form of sanitation system in rural areas at present is the pit latrine which pollutes shallow wells, which serve as important water resources for the communities in these areas. The current available financial resources in Moldova, including the user charges, international loans and grants as well as the government contribution are insufficient for maintaining and extending the sanitation system. Promoting low cost, alternative ecological sanitation systems can offer sustainable solutions to poor rural areas, which in the long term may contribute to soil nutrient recovery and to the improving of food security.

The UDDT system in Moldova was firstly introduced in 2007 via demonstration facilities at household and school level by the Swiss Development and Cooperation Agency and WECF in collaboration with local NGOs WiSDOM, Ecotox and SEAM. During 2009 the SKAT Foundation has joined the initiative, within of SDC ApaSan project. Likewise, during 2011, one UDDT was built by Ormax, an organization from the North of Moldova, with the support of the Church World Service.

Up to now limited research has been done on the reuse of excreta in Moldova, for example the preliminary recommendations on the application of urine in agriculture developed by the Institute of Zoology Moldovan Academy of Sciences and Institute of Pedology, Agrochemistry and Soil Sciences „N. Dimo" (Plămădeală et al., 2011) and the ongoing project on urine agricultural application carried out jointly by SDC within ApaSan project and Agroinform. Also, practical guidelines were recently elaborated by SDC ApaSan Program (ApaSan, 2012). Some limited applications of human faeces and urine were implemented during the Soviet Union time by selected collective farms (sovkhozes, kolhozes) (Artiushin & Derzhavin, 1984). Specific guidelines on the application were developed, for example regarding the treatment before application and sanitization. During 1949, in Kamenka sovkhoz human faecal materials mixed with water were applied during several years at doses of 3-4 tons/ha, supplemented with ammonium fertilizer and 2-3 tonnes of superphosphate in the period of formation of offshoots. During autumn manure was also applied. The Sovkhoz was distinguished by a comparatively high fruit production 110-160 quintal/ha as compared to the country average of 36 quintals.

Assessing the possibility for reuse of human urine and faeces in agriculture via TPS is an important consideration, taking into account the availability this waste and relative well acceptance by the local population. Many small holder farmers from rural areas in Moldova cannot afford to buy fertilizers or to pay for the increasing fuel for their transport and application across the fields. Considering the predictions for the further price increase in fertilizers because of the phosphorous resource depletion at global level as well as the global energy price increase (Cordell et al., 2009; Lumpkin, 2011) - it is expected that the farmers will face more difficulties for improving productivity through the use of commercial fertilizers. Terra preta sanitation is a simple low cost technology, which reduces the smell, minimize the risk of exposure to pathogens (limited handling is necessary) and contribute to high value soil improvers. By encouraging combined reuse of excreta and animal manure in TPS can contribute to a quicker acceptance of excreta reuse in rural areas.

The current paper is based on a review and preliminary data collected from UDDTs introduced in Bolduresti, Soltănești, Valea Treisteni, Selişte and Băcșeni villages in

Moldova. The research and practical applications of semi-centralized approach of terra preta production will be carried out during 2013-2014 by WECF, WiSDOM association in partnership with Unesco-IHE Institute for Water Education. Based on literature data, some models are discussed on TPN production at household and school level.

Terra preta sanitation

The Terra Preta Sanitation (TPS) technology applied in UDDTs arises as an innovative sustainable technique for dry sanitation which could be successfully worked out in rural communities and developing areas. The soil amendment produced by TPS is a low-cost fertiliser alternative which helps farmers from developing countries against dependence on commercial fertilisers, but also entails a remarkable reduction of household water consumption.

The TPS concept has been developed from the Terra Preta soils (also called Amazonian dark earths) discovered in Amazon River basin. These Amazonian dark earths are anthropogenic soils (anthrosols) which are found in plots from 0,05 to 3,5 km2, derived from the activity of pre-Columbian Amerindian population and are distributed along the Amazon river basin and its tributaries (Brazil) and in some minor areas in Colombia, Venezuela and Peru (Sombroek et al, 2002).

The most exceptional characteristic of Terra Preta lays in its soil organic matter (SOM), which remains stable for a long time but simultaneously more re-active than the SOM from surrounding primary forest soils (Sombroek et al, 2002). The SOM stems from charcoal, which itself refers to incomplete combustion derived mainly from cooking fires (Glaser et al, 2001) but also from the process of charring the slashed biomass (commonly named as “slash and char”) from forest residues (Glaser, 2007). These anthrosols hold on average 70 times more charcoal and three times more soil organic matter, nitrogen and phosphorus than the nearby soils (Glaser, 2007). One hectare of metre-deep Amazonian dark earth contains up to 250 tonnes of carbon while carbon in unimproved soils reaches only 100 tonnes per hectare (Lehmann et al, 2006). This makes the Terra Preta useful in terms of carbon sequestration and global warming remedy. However, it should be taken into account that the charcoal alone is unlikely to provide soil fertility. The addition of organic matter together with charcoal contributes to a high nutrient availability of the terra preta soils. Besides the large proportion of charcoal, Terra Preta soils contain human excreta, which contribute highly to the nutrient richness of these soils, as well as mammal and fish bones, turtle backs, shells of mussels and molluscs, vessels and ceramics. (Glaser, 2007) (Sombroek et al, 2003) (Baleé, 2010).

The Terra Preta Sanitation approach applies the ancient knowledge of Terra Preta for human waste treatment by using lacto fermentation as the first stage of waste treatment, coupling it with vermicomposting to obtain a nutrient-rich “compost” and safe soil amendment with analogous properties to the Terra Preta soils (Factura et al., 2010). In this way, macronutrients, particularly nitrogen, phosphorus and potassium,

contained in human excreta, mainly in urine, can be used as an alternative to industrial man-made fertilisers (Langergraber & Muellegger, 2005).

Factura *et al.* (2010) argue that the TPS method can be successfully carried out in UDDTs, as these toilets make possible the separation of the human excreta at source. Once the urine and faeces are individually confined, the lacto fermentation process can be attained. This phase generates no unpleasant odours due to the air exchange absence and can be carried out by different microorganisms (mainly the commercial product EM or pickled sour cabbage) (Factura et al., 2010).

In TPS, urine can be applied directly to the lacto-feremented compost or adsorbed preliminarily to biochar and added to the compost that will reduce volatilization of nitrogen. This can increase the value of urine as fertilizer, as the process of separation, extended storage, transport and field application can lead to nitrogen loss via volatilization and leaching (Karak & Bhattacharyya, 2011). However, additional research shall be carried out on absorption capacity of biochar.

One of the wide spread form of faeces sanitization in UDDT is extended storage. If only the storage is applied a period of 12 months is recommended for tropical climates (28-30°C) and 18 months for temperate climates (17-20°C) (WHO, 2006). The prolonged storage can also lead to loss of C and N. For example, up to 45-69% losses of C were reported in manure stored for 6 months (Titonell et al. 2010). TPS can improve the management of human faeces by shortening sanitization time and improving the quality of end product. The sanitization of faeces results from lacto fermentation, which can be initiated already starting in the toilet chamber. Thereby, there is no need of construction of two vaults for the faeces dehydration, thus the overall toilet costs can be reduced (Otterpohl, R., 2009). Lacto-fermentation can be also performed outside the toilet chamber, in closed containers, earth pits or hips. A more detailed description on this process is given in the following chapter.

Scheinemann & Krüger (2010) showed that the efficiency of pathogen removal is higher in lactofermentation than in composting. For example, the process leads to a reduction of the enterobacteria below the detection limit and even helminth eggs could be removed in tests with animal excreta (Scheinemann & Krüger, 2010).

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In Moldova there is a positive attitude of the population for ecological sanitation. However due to lack of reuse practice, application of excreta still remains a problem. For example at household level, the faecal material is not always stored enough time for full sanitization (1.5-2 years). During summer time, if several containers are kept in the toilet chamber, flies may appear and also the smell becomes stronger, that is why the toilet owners apply the faeces, immediately the container is filled. Accumulation of big amount of urine at school toilets and the high costs for the urine transportation and renting of equipment may also create barriers for a successful large scale application. If the faeces are kept too dry by adding only soil as covering material, they become very hard and

degrade very slowly. Comparing two types of faeces stored for a period of approximately one year (Figure 1) from Boldureşti and Băcşeni, we have found big differences in the end product. In the first case where only soil was used as covering material and stored under dry conditions, the obtained product was very hard and still smelly. On the contrary, the faeces kept in plastic bags covered with fine sawdust and soil, had no bad smell, but was homogenous, good texture compost, similar to the one from the market. The difference could be explained by the fact that the faeces from first site were only desiccating, with little decomposition. Due to lack of plastic containers, the faeces from second place were kept in closed plastic bags and most probable, the anaerobic conditions created in the plastic bags, favoured partial lacto fermentation. The From this observation it can be presumed that plastic bags can be used as a low cost solution for temporary storage and pre-treatment for human faeces under the toilet chamber of household UDDT, instead of plastic containers. This would avoid the problems that appear with flies in open containers from the toilet chamber. Also, the quality of end product to be applied to the soil can be improved. To ensure an initiation of lacto-fermentation process microbial innoculum, as well as biochar can be added in the plastic bags, when they are closed for storage or in the covering material. Additional research is needed for proving these facts.

Figure 1 Stored faeces from Băcșeni (covering material: soil) and Boldurești (covering material: fine sawdust and soil (3:1)

Terra Preta Sanitation emerges as an attempt to improve the UDDT system. The research is underway on optimization of lacto-fermentation conditions to ensure complete sanitization (Scheinemann & Krüger, 2010) or increasing the efficiency of vermicomposting (Factura et al. 2010). Based on literature review and our field observations, we have developed a model for TPS in a single vault UDDT at household level (Figure 2). The faeces can be collected during a period of 5-6 months of the cold year period, using a container of 65L. As covering material, a mixture of sawdust, soil, biochar and dried microbial innoculum can be added. When a container is filled, faeces can be transfered to plastic bags and closed to create anaerobic conditions and initiate the process of lacto-ferementation. In Boldurești village, where several household UDDTs were built, a semi-centralized approach in faeces collection and treatment can be applied. Semi-centralized approach consists in source collection of excreta at household and schools and their centralized transportation and production of terra preta at one location. During spring-summer, the faeces can be mixed with chopped vegetation waste (garden waste, kitchen waste, fruit residues) and animal manure. Adding biochar (5-10%)

will stabilize the lacto-fermented compost and reduce the loss of organic carbon (Fisher, 2012). The waste mixture shall be packed air tight in the fermentation pit lined with plastic sheet and sprinkled with acido-lactic bacterial innoculum (for example, sauerkraut juice and/or fermented wheat bran), at about 1 to 3 % of wet weight (Schmidt. 2011). In countryside of Moldova sauerkraut and fermented wheat bran are readily available. Pickled cabbage can be found in almost every family, the fermented wheat bran is also a widespread product, used in preparing the traditional soup called ciorba. To ensure a full sanitization process fermentation can be extended over 2-3 months (May-July). An additional way to sanitize the faeces and manure would be to apply vermicomposting, however this would require more space and additional care. The best time to apply compost is fall (September-October). The compost can be used also in greenhouses, for growing vegetable, shrub and fruit tree seedlings.

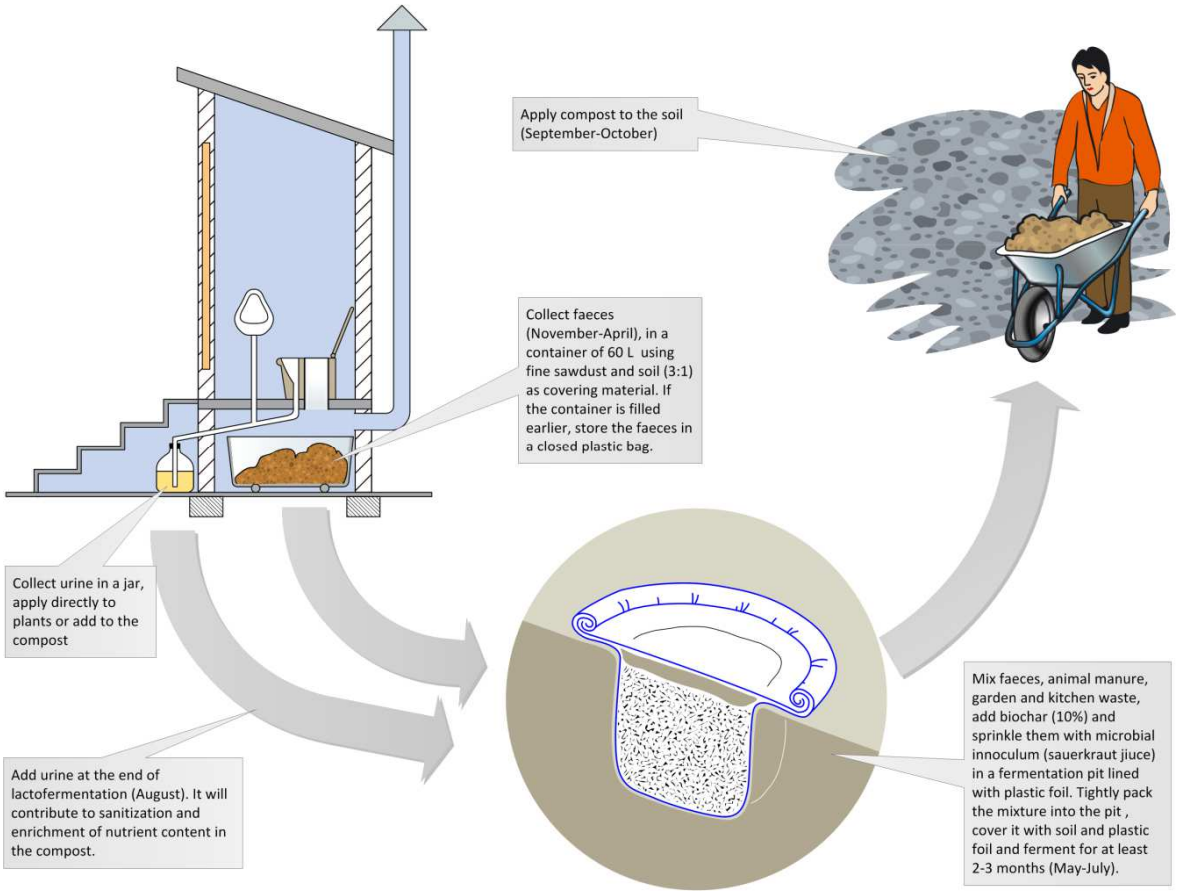

Figure 2 Main principles of TPS approach carried out in an UDDT system at household level (adapted from Gensch, 2010)

For schools with UDDT facilities, a semi-centralized approach be more feasible only in the case they are located close to each other, for example Bolduresti, Băcșeni,Valea Treisteni,Soltănești, so that the costs for faeces transportation would be minimal (Figure 3). By monthly weighing (April-May, 2012) of covering material and accumulated faeces in Bacseni school with about 120 users it was possible to estimate that the total amount

of 40 kg waste/month, or 360 kg per school year. During a whole academic year, from 4 schools and one mayoralty hall, a rough estimation tells that a total amount of 3.5-4 tonnes of human waste (including the covering material) can be collected. If this can be combined with other type of waste such as pig and cattle manure, corn stalks, garden waste, fruit residues, will not only improve the efficiency, but also will contribute to solving environmental and aesthetic problems from the disposal and burning of such waste. In addition, this will add to the development of local business schemes for compost production or growing agricultural products (such as decorative plants, vegetable and fruit tree seedlings). For a successful implementation and following a standardized procedure for faeces collection, it is important that the covering material is prepared at one place (for example Soltănești) and distributed to all other schools and also care takers shall be trained on managing the toilets (right use of covering material, levelling of faeces, helping in collection and transportation of faeces).

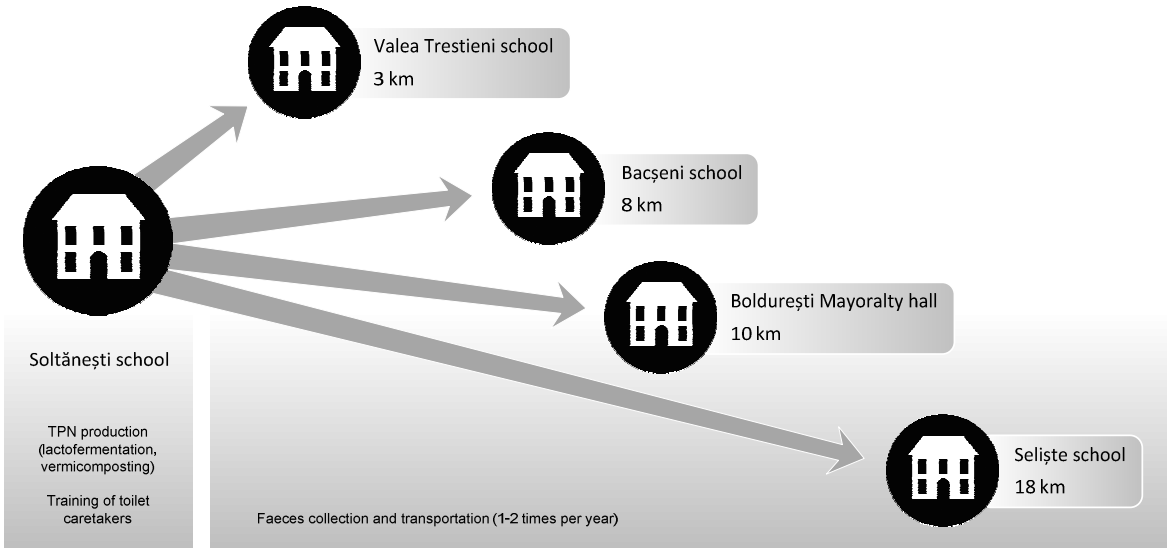

Figure 3 Proposed model for semi-centralized production of TPN in Nisporeni district, Moldova

One important issue to consider for terra preta production is the availability of biochar. Currently in Moldova there are two state enterprises that are producing wood charcoal for grilling. A lot of unmarketable pieces and dust remain after the charcoal is packed for commercial purposes. This charcoal waste is not used being spread with the bulldozers or accumulated near the production installations. According to the estimated quality (volatile matter, surface area) such biochar residues can be used for soil enrichment. Also, it is important to look for alternatives for producing the biochar from low value waste. During 2013, attempts will be made to produce biochar from mixed faeces and sawdust using traditional stove/oven or simple two barrel installation.

Conclusions

TPS is a promising opportunity for treating of human excreta from UDDTs in the many rural parts of the EECCA region where the UDDT technology has been well introduced through the WECF network and is appreciated by the population, but the acceptance for excreta reuse is still lacking. Evaluating the possibility for semi-centralized approach for terra preta sanitation would improve the management of human excreta and provide better solutions for agriculture. Moldova is a suitable country for applying it, considering

that several UDDT are located in one district (f.e. Nisporeni) and the acceptance for UDDT technology is high. Research shall be undertaken on quality of biochar to be applied. In order to ensure the sustainability of these systems, the reuse practice shall be promoted. In addition, terra preta sanitation, would allow reusing low value waste such as corn stalks, garden waste, fruit residues pig/cow manure, which create environmental and esthetical problems. The current paper presented only a concept on semi-centralized based on literature data and observations on functioning of UDDT system in Nisporeni district, Moldova. More research on TPS will be done during 2013-2014 and the economic feasibility will be evaluated on semi-centralized production of terra preta.

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