Development of a Low Volume, Low Cost, Composting Septic Tank for Use in Low Water Available Environments

Authors: Geoff Jordan, CEO, Water Serve Foundation and Steve Stewart, CEO, Access Development

Presented by: Geoff Jordan, CEO, Water Serve Foundation

Introduction:

The practice of open defecation by people living in many countries and the resulting contamination of surface waterways with fecal matter, parasites and bacteria, is inescapable responsible for the deaths of over 2 million people annually, mostly children less than 5 years of age. Around 800 million people globally do not have access to improved water supply services and 2.3 billion people do not presently have access to any type of improved sanitation facility.

The Composting Septic Tank (Tube Toilet) would bring the cost of a private toilet down from $550 average per stall to $100 per stall – which, in combination with access to loan capital, makes the system affordable to the rural and urban poor. The possibility of crop enhancement using the generated nutrient enhanced effluent may provide further economic benefit.

Additionally, the Tube Toilet would provide much needed privacy and protection for rural women who are presently at increased risk of sexual assault on a daily basis.

Research by Makerere University in Uganda shows the poor are 8 times more likely to use a private latrine than a shared or public latrine, and almost 4 times more likely to keep it clean.

Aim:

To conduct a feasibility study on the Tube Toilet concept at Oklahoma State University at the Animal Science Department with Dr. Scott Carrier as Principal Investigator. The test will evaluate the ability of the Tube Toilet in function as a low volume septic tank and assess its present performance and benefits.

Procedure:

These separate Tube Toilets with sheet chambers were constructed using 12” diameter PVC pipe and mounted on a trailer. The trailer was installed in the hog facility, Dept. of Animal Science, Oklahoma State University in Stillwater, Oklahoma.

To approximate a Sub-Saharan Africa environment, the Tube Toilets were contained in a normally uninhabited housing which included a steel frame, maintaining a constant 76-78F.

Fifteen young hogs were purchased and housed in a barn where feces and urine could be collected daily. The hogs were fed a diet of animal products along with essential vitamins and minerals but no antibiotics (which are usually fed to commercially raised hogs).

On January 21, 2014 feces and urine addition to the Three Tube toilets began.

• Manure addition, to increase the food to microbe (F/M) ratio.

Tube Toilet 1: Floating solids, out gassing, sludge depth 6-8”
Tube Toilet 2: No floating solids, reduced out gassing, sludge depth 2-3”
Tube Toilet 3: No floating solids, reduced out gassing, sludge depth 2-3”

Test Sequence:

The three tube toilets were filled with water.
On January 21, 2014, feces and urine addition to the Three Tube toilets began.
On January 25, the carbon was added to each of the Tube Toilets in chamber 1, with 30 seconds mixing of chamber 1 in Tube Toilet 1 being the control, and Tube Toilets 2 and 3 having the bacterial treatment added and mixed. Also, Tube Toilet 2 remained empty while Tube Toilet 3 was mixed with an install propeller for 30 seconds after mixture addition, to increase the food to microbes (F/M) ratio.

These three tube toilets were filled with water.
On February 14, the first collection was made out of the second chamber of each Tube Toilet into a collection bucket which was then weighed. On February 17, first measurements of sludge depth and other observations were made.

Test Parameters:

• Qualitative and quantitative analyses of emission gas samples from each Tube Toilet.
• Determination of accumulated sludge depth in chamber 1 of each Tube Toilet.
• 800x magnification.
• Shave analysis of immersed liquid in chamber 2 for NPK fertilizer content.
• Microbiological analysis and identification of organisms present in the immersed liquid and the CFU/100ml assay.
• Temperature recorded daily in the test containment chamber.

University Tested:

Dr. Mike, Iowa State University showed Activaid to give a 97% reduction in hydrogen sulfide gas, to deep storage pits for hog waste.

Dr. Bundy, Iowa State University found that Manu-Rx gives an average odor reduction efficiency of 40% in hog manure.

Gas analysis tests in the present test program at Oklahoma State University will provide updated data on these observations.

Natural Treatment:

The composting function is initiated and maintained by the annual addition of a bacterial treatment pack that is added to the Tube Toilet, consisting of three components which are all naturally occurring.

• A proprietary high surface area microorganism based activated carbon like material, trade named Activaid, which has a surface area of about 200 sq. meters per gram, and surface active properties.
• A stabilized naturally occurring anaerobic and facultative bacterial blend, trade named Manu-Rx, which itself was derived from subsoil environments.
• A fat eating lipase enzyme also derived from natural sources, cultured and stored on dextrose sugar.

Biological Activity:

The carbon particles have surface active properties and will bind ketonic, the normally binder bacterial growth. The high surface area of the carbon features bacterial growth and a direct nutrient and carbon source. The 2 sq. ft (195cm²) carbon addition has over 11,000 sq. meters (2.7 acres) of surface area.

The introduced bacteria blend grows on the carbon surface and as the biomass concentration increases, both flocs and colloids form the final matrix. Primarily anaerobic in character, the anaerobic decomposition produces the flocs and urine sulfide gases and other VOC's. A thinning mechanism keeps the food to microbes (F/M) ratio high, maximizing digestion, reducing BOD and preventing sludge formation.

Commercial Application:

“HOG WASH” has used the technology since 1998 in the treatment of waste in CAFO hog lagoons.

The benefits have included:

• Reduction of ammonia and sulfide gas odors
• Liquidified solids
• A resulting nutrient enhanced effluent with high organic nitrogen, free sodium and phosphorus, that has quadrupled field crop production while also eliminating the need to use commercial fertilizers, when local applied.
• Reduced greenhouse gas emissions of CH₄ and CO₂
• Formation of a rich 8” humus layer

Table of Biological Oxidation-Reduction Functions ΔE°<sub>red</sub> = ΔE°<sub>ox</sub>

<table>
<thead>
<tr>
<th>Biological Oxidation-Reduction Function</th>
<th>Reduced form to highest</th>
<th>Oxidized form to lowest</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔE°&lt;sub&gt;red&lt;/sub&gt;</td>
<td>ΔE°&lt;sub&gt;ox&lt;/sub&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Preliminary Results:

Table 1: Floating solids, out gassing, sludge depth 6-8”
Table 2: No floating solids, reduced out gassing, sludge depth 3-4”
Table 3: No floating solids, reduced out gassing, sludge depth 2-3”
The solids are reduced in tubes 2 and 3 which is expected. However, the results do not support any conclusions at this early stage.

Acknowledgements:

The authors wish to express their sincere thanks to Water, World Vision and Oklahoma State University for making this research project possible.