Imperial College London

# The Kinetics of Vermi-Compost Accumulation within 'Tiger Toilets' in India

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## 1. Introduction

In the world approximately 2.4 billion people still lack access to improved sanitation. In response to this and the 'Reinvent the Toilet Challenge (RTTC)' proposed by the Bill and Melinda Gates Foundation the 'Tiger Toilet' was developed. A vermi-filter toilet that utilises earthworms *Eisenia Fetida* to aerobically degrade flushed faecal matter into vermi-compost and an effluent fluid. This results in slower filling and a safer product than conventional methods.

***Project Objectives***

- Accurately determine the rate of filling of the 'Tiger Toilet' pits and their expected emptying time.
- Observe and gain a better understanding of the earthworms' activity within the pits.

Table 1: Current fill times

| | Tiger Toilet (Current Design) | Pit Latrine |
|---|---|---|
| **Location** | India | India |
| **Volume of Pit [m³]** | 1.1 | 1.3 |
| **Estimated Rate of Filling [l/capita/annum]** | 19 [1.] | 76.7 [2.] |
| **No. Users** | 6 | 6 |
| **Estimated Time to Fill [years]** | **5** | **2.8** |

**Note: [1.]Furlong et al., 2014 [2.]Norris, 2000**

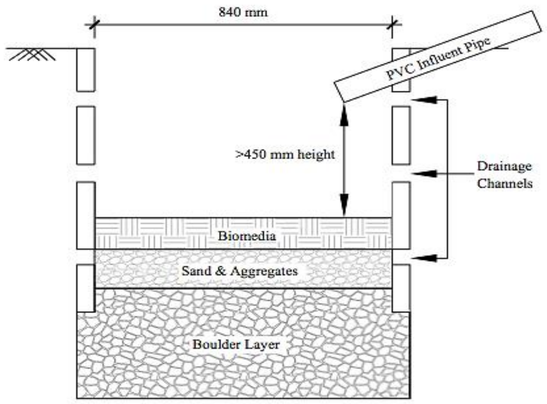


Figure 1: Tiger Toilet Schematic

## 2. Methodology

To accurately determine the volume of the pits, without disrupting on-going digestion, the surface of the pit was modelled measuring from a known datum (the top of the pit). A Laser measure was used at every data point of each of the pit designs, Cylindrical and Cuboid (Fig.2). 15 pits of various ages were measured at 3 sample locations; with 2 newly constructed pits measured as a control. The observations were made from images taken within the pits over a number of hours.

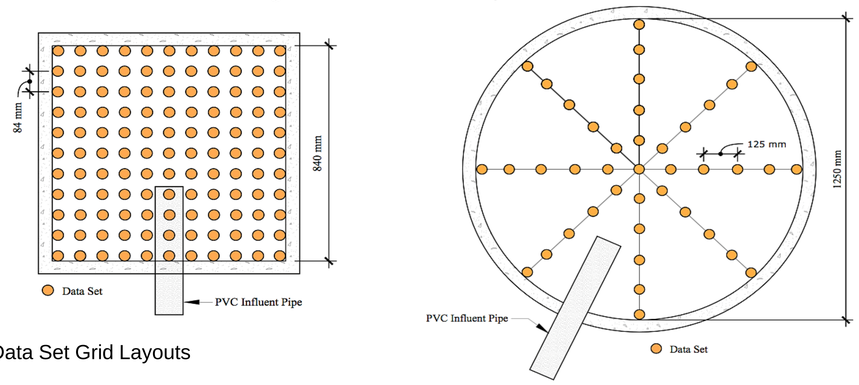


Figure 2: Data Set Grid Layouts

## Acknowledgements

I'd like to thank all at PriMove whose logistics and assistance in the field were invaluable in this project. A thanks to Walter Gibson at Bear Valley Ventures and Ajeet Oak at PriMove India, whom without, the 'Tiger Toilet' would not be the reality it is today. Finally a special thanks to my supervisor, Dr. Michael Templeton, for his support and guidance throughout.

## 3. Modelling & Validation

The pits were modelled in MATLAB, fitting Linear, Quadratic, Cubic and a Thin Plate Spline interpolations to the data and plotting them for comparison. These fits were then validated with the use of MATLABs *Curve Fitting Toolbox* and the validation data collected from each of the sample sites. The model with the least Root Mean Square Error (RMSE) for the data is the **Linear Model.**

## 4. Results

***Fill Rates***

The average volumes at each sample site show excellent correlation ($R^2 = 0.9874$ ) with a data point at each location excluded as an outlier (over 1.5 standard deviations from the mean). The modelled fill rate was predicted with 95% Confidence Intervals giving the range of possible values as **0.0062 – 0.0093 m³/ capita/year,** this is approximately 25% of those predicted previously. The 'Time to Fill' is evaluated from the effective total volume of the pit, the mean number of users and the expected fill rate.

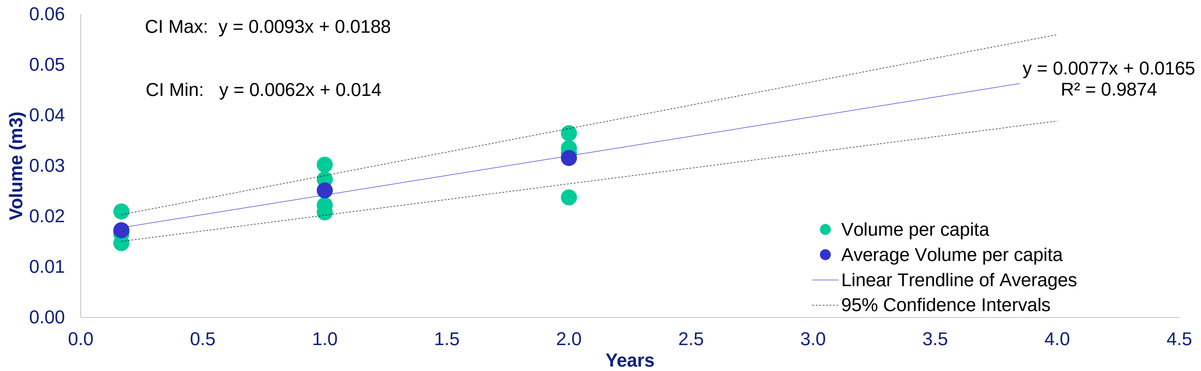


Figure 3: Modelled Fill Rate

***Observations***

- **Kinetics of Sludge:** The hydraulic action from the influent creates a well beneath the influent pipe with vermi-compost accumulating toward the edge of the pit.
- **Population:** Earthworms are found in a high density surrounding the influent well.
- **Feeding:** The worms feed from the sides and beneath the faeces and not from the top.
- **Other Creatures:** Several other creatures are present once influent enters the pit and have a short residency time.

## 5. Recommendations

On the basis of this study I would recommend that PriMove India should expect the pits to last at least **8.2 years** before emptying, with the expected emptying of a pit to be **10.3 years**.

The activity in the pit is shown to be almost entirely at the point of entry of the influent and spreads radially from this point; this should be considered in further design of the pit.

## References

Furlong, C., Templeton, M. and Gibson, W., 2014. Processing of human faeces by wet vermifiltration for improved on-site sanitation *Journal of Water, Sanitation and Hygiene for Development,* 04.2, pp. 231.

Norris, J., 2000. *Sludge Build-Up in Septic Tanks, Biological Digesters and Pit Latrines in South Africa.* 544/1/00. South Africa: Water Research Commission