Dominant decomposition pathways in pit latrines: a commentary

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ABSTRACT

In a recent article an assessment of decomposition within pit latrines measured with regard to chemical oxygen demand (COD) reductions was reported on. Some fundamental concerns were raised with regard to a key assumption of the study. The alternative perspective that is presented here does not support the study’s conclusion that anaerobic processes are the dominant decomposition pathway in pit latrines. Furthermore, it is argued that their analysis and some implications of their data interpretation can be viewed in a different manner.

Key words | aerobic, anaerobic, chemical oxygen demand, decomposition, onsite sanitation, pit latrines

Recently, van Eekert and colleagues presented a study on anaerobic decomposition in pit latrines (van Eekert et al. 2019). Their key reported finding was that anaerobic digestion is the dominant decomposition pathway of faecal material in pit latrines. We believe this bold conclusion is not entirely supported by their data and that a key assumption has misled their data interpretation.

Van Eekert et al. have based their conclusion on their comparison between in vitro (‘potential!’) and in situ (‘actual’) chemical oxygen demand (COD) reductions. We feel that an important oversight in their analysis was to consider that the COD reductions between ‘fresh stool’ samples and the ‘top layer’ was entirely anaerobic. This assumption directly contradicts their acknowledgement of previous works cited in their study that have suggested the presence of aerobic degradation in pit latrines (Buckley et al. 2008; Nwaneri et al. 2008; Torondel et al. 2016). Notably, data from South African latrines also report COD reductions between fresh faeces and surficial layers of pit latrines of up to 50% (Nwaneri et al. 2008), which are presumably in contact with air and potentially subject to aerobic degradation. The average in situ COD reductions between top and bottom layers reported by van Eekart and colleagues are also similar to findings from the other aforementioned studies.

Degradation in pit latrines has been suggested to include aerobic degradation in the top layers of latrine chambers (Buckley et al. 2008; Brouckaert et al. 2015), as they are in contact with air. The importance of the aerobic (or at least not strictly anaerobic) conditions between fresh stools and the top layer is reinforced by the care that needs to be taken to conduct biogas formation potential assays as done by van Eekart and colleagues. Contact with oxygen reduces the anaerobic biodegradation (hence the need to purge O₂ and conduct tests in strictly anaerobic conditions as they did). This is particularly important as it has been shown that faecal sludge samples can undergo aerobically mediated degradation (Bakare et al. 2012). Notably, the aerobic hypothesis is also corroborated by sequencing studies of faecal sludge identifying aerobic microbial diversity (Torondel et al. 2016; Byrne et al. 2017).

Therefore, we contend that it is more plausible to consider that the initial COD reductions (i.e. between fresh stool and top layers) occur in aerobic (or at least not fully anaerobic) conditions, as fresh stools are in contact with air until they get buried by other material. As a result, their assumption (COD removal between stool and top layer being strictly anaerobic) is not valid, thereby affecting the analysis and implication of their data.

The tabulated data presented in their paper have been (re)analysed (Table 1) without assuming anaerobic degradation between stool and top layer samples. Pit latrine D was excluded (inclusion would not substantially alter our analysis) from the dataset on the same basis as other...
exclusions that had lower stool COD values relative to the top layer. We estimated that on average 44% (of about 72%) of the observed COD reductions are possibly due to aerobic (or at least not strictly anaerobic) degradation. This accounts for more than half of the COD reductions and would not support their conclusion that anaerobic processes are the ‘dominant’ decomposition pathway in pit latrines.

We agree that it is reasonable to assume that in situ COD reductions of 27% between the top and bottom layer occur in (possibly strictly) anaerobic conditions. This is supported by their methodologically meticulous in vitro testing that resulted in approximately 38% COD reductions attributable to strictly anaerobic degradation, albeit in idealised conditions. Accounting for the intrinsic non-ideal field conditions (i.e. no mixing, no anaerobically conditioned inoculum, lower moisture content, etc.), possible presence of inhibitors such as urine-originated ammonia (Chaggu et al. 2007), and known variability of faecal sludge properties between and within latrines (Bakare et al. 2012; Strande et al. 2014; Torondel et al. 2016; Gold et al. 2017), the average anaerobic in vitro (38%) and in situ (27%) COD reductions could be considered, in their terminology, ‘reasonably close’. However, we found a relatively weak Pearson correlation (0.230) between individual values as was the Pearson correlation (0.219) between reported individual (total) in situ and ‘possible’ COD reductions. While van Eekart and colleagues clearly reported on the anaerobic degradability potential of the latrine sludges studies, their methodological approach and analysis as well as the relatively weak data correlations do not support their statement that this was the ‘first definitive experimental evidence for the widespread assumption that anaerobic digestion is the dominant pathway in pit latrines’.

Based on their analysis, van Eekart and colleagues suggested that the addition of water to pit latrines could be beneficial to COD degradation. Our view is that in some cases this could be beneficial to pit-emptying activities (i.e. facilitating pumping). However, the benefits of having faecal sludge with lower moisture content, such as increased pathogen inactivation (Koné et al. 2007), reduction of costs related to subsequent transport and treatment of faecal sludge (Strande et al. 2014; Bourgault et al. 2019) should be considered. Furthermore, ideal conditions in pits for in situ treatment of faecal sludge need to be aligned with other relevant design considerations (e.g. anal cleansing method, urine diversion, etc.) affecting moisture content.

Lastly, our interpretation suggests that van Eekart and colleagues may have overestimated the methane emissions from pit latrines by assuming strict anaerobic decomposition in all latrines. They have partially recommended aerobic treatment methods as an alternative to mitigate methane emissions from pit latrines. It stands to reason that their observations are aligned with the aerobic hypothesis and that a significant portion of COD reductions may already be aerobically supported. If true, this would lessen the

Table 1 | Revisited van Eekart et al. (2019) ‘Table 2’ data – excluding sample D

| Latrine ID | COD (g/kg) | COD in situ reduction (%) | COD in vitro reduction (%) | COD ‘possible’ reduction (%) |
|-----------|-----------|--------------------------|----------------------------|----------------------------|
|           | Stool     | Top                      | Bottom                     | Reported<sup>a</sup> | Aerobic<sup>b</sup> | Anaerobic<sup>c</sup> | Strictly anaerobic<sup>c</sup> | Reported<sup>a</sup> |
| A         | 212       | 164                      | 114.7                      | 46                        | 23                       | 23                        | 69                        | 76                        |
| B         | 193       | 111                      | 66.1                       | 66                        | 42                       | 23                        | 32                        | 61                        |
| C         | 213       | 124                      | 49.5                       | 77                        | 42                       | 35                        | 46                        | 69                        |
| E         | 195       | 135                      | 21.5                       | 89                        | 31                       | 58                        | 33                        | 54                        |
| F         | 166       | 41                       | 9.9                        | 94                        | 75                       | 19                        | 3                         | 76                        |
| J         | 181       | 123                      | 103.7                      | 43                        | 32                       | 11                        | 72                        | 81                        |
| L         | 216       | 163                      | 57.2                       | 74                        | 25                       | 49                        | 49                        | 62                        |
| M         | 193       | 28                       | 25.6                       | 87                        | 85                       | 1                         | 0                         | 85                        |

<sup>a</sup>Reported (total) in situ COD reduction between Stool and Bottom layer samples.
<sup>b</sup>COD reductions between Stool and Top layer samples attributed to (assumed) aerobic degradation.
<sup>c</sup>COD reductions based on differences between Stool and Bottom layer samples.
<sup>d</sup>COD reductions between Top and Bottom layer samples attributed to (assumed) anaerobic degradation.
<sup>e</sup>COD reductions based on methane COD equivalents from in vitro biogas assays relative to Top layer samples.
<sup>f</sup>Reported (total) ‘possible’ COD reductions based on differences between Stool and Top samples and in vitro COD reductions.
methane-attributed environmental burden (i.e. climate-forcing) of this most basic, and extremely scalable, form of improved onsite sanitation that can be adequately integrated into a safely managed sanitation service. Considering this, we would argue that perhaps greenhouse gas emission mitigation efforts from sanitation may be better focused on offsite facilities based on passive aerobic processes such as composting (Ryals et al. 2019) so long as it is aligned with a global-scale multi-sectoral analysis for identifying pathways consistent with both the Paris Agreement and Sustainable Development Goal 6 objectives (Parkinson et al. 2019).

We were very delighted to read this type of study addressing a commonly used, but poorly understood, toilet variant serving a significant portion of the global population. The difficulties of conducting this type of research on real systems in the field are immense and the authors are commended for a brilliant collaborative effort. However, we do take issue with some key aspects of this research and its stated implications.

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