Kwame Nkrumah University of Science and Technology

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**SMALL GRANTS FOR THE AFRICAN YOUNG WATER AND SANITATION PROFESSIONALS (AFYWSP)**

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**Project Title:** Assessment of anaerobic digestion of faecal sludge in Kumasi Metropolis, Ghana

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## Background & Introduction :

Of the world's population, 40% lack basic sanitation, 2.4 billion using unimproved sanitation facilities, and 946 million practising open defecation (JMP, 2015a). Safe handling, treatment and disposal of faecal sludge (FS) are key to achieving SDG target 6.2 (Hutton and Varughese, 2016). The FS treatment facility at Dompoase, Kumasi faced operational challenges since 2014, thus affecting FS treatment and safe disposal. Various considerations in FS management has lead to innovative technologies (Lebersorger *et al.,* 2011; Lalander *et al.,* 2013). Anaerobic digestion (AD) of FS is effective and has opportunities for resource recovery, hence, the crave to capitalize on the multipurpose nature of these bioreactors to the gain of society (Nghiem *et al.,* 2017).

## Purpose and Objective :

The purpose of this research is to assess the potential of anaerobic digestion as an alternative means of pre-treating faecal sludge from the Kumasi Metropolis.

The specific objectives of the study are as follows:

1. To quantify and characterise the faecal sludge as feedstock for anaerobic digestion
2. To determine the substrate digestibility and biomethane yield of the faecal sludge
3. To investigate the effect of prevailing local temperature on the faecal sludge digestibility
4. To assess the stability of the effluent from the anaerobic digestion process

## Summary of main achieved activities :

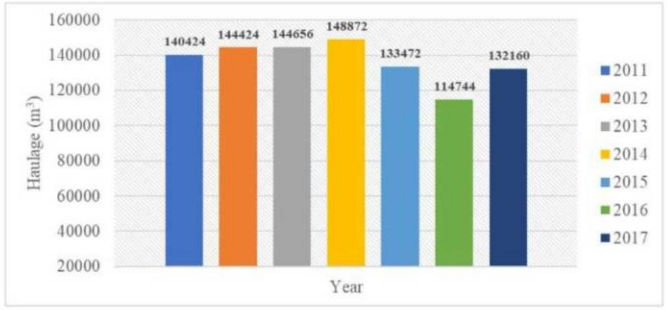



Figure 1: Average annual volumes of faecal sludge transported for treatment

Thus, the average daily quantity of sludge that require treatment is 375 $m^3$/d.

## Summary of main achieved activities

Table 1: Characteristics of the faecal sludge compared with literature values

| | | Public toilet | Pit latrine | Water closet | Combined sludge | Literature |
|---|---|---|---|---|---|---|
| **Parameter** | **Unit** | Mean | Mean | Mean | Mean | |
| **Temp.** | °C | 29.9±1.0 | 29.7±1.2 | 30.0±1.1 | 29.9±1.1 | - |
| **pH** | - | 7.7±0.2 | 7.8±0.1 | 7.7±0.2 | 7.7±0.1 | 6.55-9.34 |
| **TS** | % | 2.4±1.0 | 1.4±0.6 | 1.0±0.4 | 1.7±0.6 | < 3 |
| **MC** | % | 97.6±1.0 | 98.6±0.6 | 99±0.4 | 98.3±0.6 | > 97 |
| **VS** | %TS | 70.1±3.5 | 63.6±5.3 | 66.9±4.0 | 69.6±3.8 | 50-73 |
| **AC** | %TS | 29.8±3.5 | 36.3±5.2 | 33.1±4.1 | 30.4±3.8 | 27-50 |
| **COD** | mg/L | 14160 | 12111 | 7972 | 12855 | 10000-30000 |
| **TP** | mg/L | 32.2±3.6 | 25.9±7.5 | 25.3±6.1 | 30±5.1 | 150-450 |
| **TKN** | mg/L | 2355 | 2163 | 949 | 2063 | 1000-3400 |
| **VS:TS** | - | 0.7 | 0.6 | 0.7 | 0.7 | 0.50-0.73 |
| **COD:TP** | - | 451 | 491 | 310 | 441 | 109 |
| **COD:TKN** | - | 7.4 | 9.2 | 10.8 | 7.2 | 1.2-7.8 |

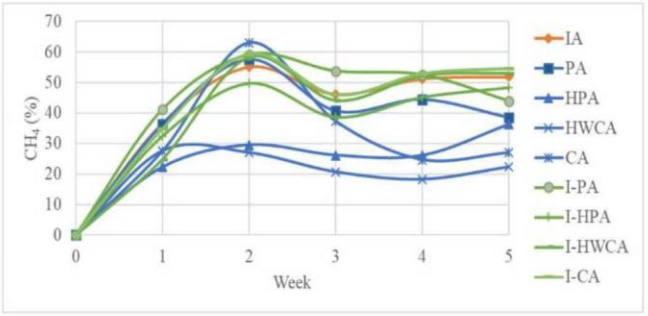



Figure 2: Methane yields at ambient temperature (20.5-35°C)

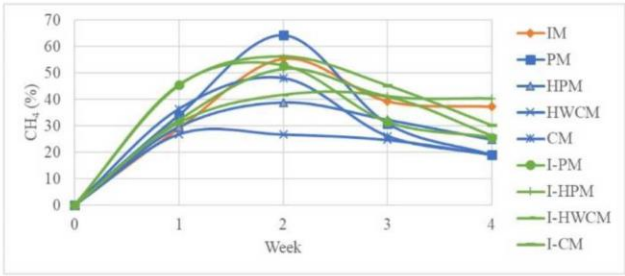



Figure 3: Methane yields at mesophilic temperature (37°C)

## Summary of main achieved activities

Table 2: Percentage removals at ambient temperature (20.5-35°C)

| Reactor ID | IA | PA | HPA | HWCA | CA | I-PA | I-HPA | I-HWCA | I-CA |
|---|---|---|---|---|---|---|---|---|---|
| COD (%) | 47.98 | 74.53 | 55.22 | 46.67 | 63.29 | 48.55 | 45.59 | 39.57 | 47.53 |
| TP (%) | 93.09 | 97.76 | 95.19 | 90.60 | 91.85 | 95.77 | 91.52 | 93.61 | 95.92 |
| TKN (%) | 49.17 | 15.09 | 7.41 | 48.41 | 24.37 | 33.39 | 28.26 | 0.72 | 39.88 |
| Helminth eggs (%) | 25.23 | 23.53 | 39.02 | 35.77 | 15.32 | 37.78 | 26.67 | 20.83 | 22.88 |

Key for charts and tables:
I— inoculum, P— public toilet, HP— household pit latrine, HWC— household water closet, C— combined sludge (P+HP+HWC), I-'S'— inoculated 'faecal sludge samples', A— ambient temperature (20.5-35°C), M— set mesophilic temperature (37°C).

## Outcomes:

The study showed that faecal sludge treatment plants that employ waste stabilisation ponds as the case is at Dompoase in the Kumasi Metropolis can replace the anaerobic ponds with anaerobic bioreactors. This would eliminate the problem of frequent plant shutdowns and its associated environmental and social consequences due to the frequent sludge build-up and difficulties (financial and technical) encounted in desludging the anaerobic pond. Anaerobic bioreactors equipped with gas havesting installations would be relatively easier to desludge, have smaller footprint, and would be more environmentally friendly as they allow for the capture and utilisation of gases which otherwise would have contributed to greenhouse effect.

Unless to maintain a certain desired temperature constant throughout operations, there would be no need for external heat supply in order the the reactor to function in any locality where the mean temperatures range between 20.5 to 35°C. This is because the study showed comparable results for the setup at prevailing local temperature range of 20.5 to 35°C with the 37°C mesophilic mode. However, the higher the temperature, the faster the rate of biomethanation.

## Conclusion :

Faecal sludge that required treatment at the Dompoase treatment site was found to be 375 $m^3$/d and its characteristics (with the exception of the VS:TS ratio) were suitable for anaerobic digestion.

The biomethane yields were low for the two different temperature modes considered; ranging from 0.10-0.30 NL $CH_4$/g $VS_{added}$ at 37°C and 0.06-0.27 NL $CH_4$/g $VS_{added}$ at 21-35°C.

The effects of the temperature regimes considered were not significantly different on the digestion process. (p.value of 0.16; >0.05).

Anaerobic digestion could be used as good replacement for the traditional anaerobic ponds in faecal sludge treatment (40-75 % COD removed, 10000-20000 mg COD/L digestate).

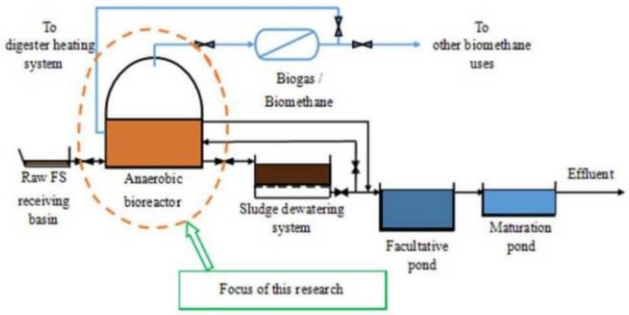
## Recommandations and future considérations :

Further studies ris ecommended using feedstock (faecal sludge) with optimized properties to compare results with the findings of this work.

Thorough microbiological study of the digestion process is recommended as such data would be very useful in the case of process optimisation.

Pilot field test is recommended prior to large-scale implementation.

Post treatment of effluent (using for instance, facultative and/or maturation ponds) is recommended before end-use or discharge into the environment.

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