Producing Sustainable Clean Energy & Ensuring Sanitation Through Blackwater Management

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Abstract: This study determined the Chemical Oxygen Demand removal efficiencies of two Continuously Stirred Tank Reactors (CSTRs) from blackwater under anaerobic conditions, in order to generate sustainable clean energy. Two CSTRs were operated for a period of 100 days where they digested blackwater with cow dung acting as inoculum in reactor I (***RI***) and blackwater alone in reactor II (***RII***) that served as control set-up**.** They were both investigated at the hydraulic retention time (HRT) of 1.57days or approximately 38hours. ***RI*** had a maximum efficiency of 81% with biogas production of 1250mL and ***RII*** had a maximum efficiency of 65% with biogas production of 1030mL during the experimental period. such biogas could be employed for heating or electricity/power generation. This research points to the double advantage of using waste to produce clean renewable energy in the form of biogas. It also ensures removing the waste from the environment, thereby improving sanitation. Similar research should be conducted in order to meet sustainable development goals, particularly by ensuring availability and sustainable management of water and provision of adequate sanitation for all.

Keywords: Anaerobic digestion; CSTR; Blackwater; Renewable energy; Sanitation.

1. Introduction

Blackwater (sewage), comprised of greywater or sullage (domestic sewage) and toilet flushings, poses enormous challenges in its management. This is especially the case with developing countries, without adequate skills to design admirable innovative technologies for its management, together with the chronic problem of paucity in the required finances for their design, operation and maintenance. Environmental sanitation thus becomes a huge challenge, bringing environmental degradation and dire public health outcomes. Anaerobic technology can provide a cost-effective option for stabilising sewage [1,2] and an adapted Continuously Stirred Tank Reactor (CSTR) technology was developed and used for the anaerobic digestion of blackwater.

2. Methodology

The main research aim was to produce sustainable renewable clean energy, in the form of biogas (bio-energy), by using blackwater as a recycling substrate (feeding input) for adapted Continuously Stirred Tank Reactors (CSTRs) that are anaerobic technologies.

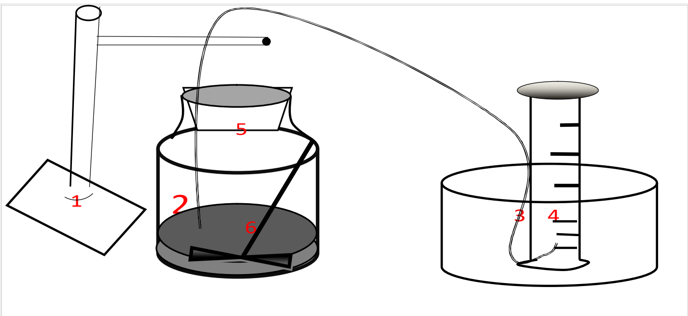

Figure 1. Schematic of major elements of a reactor set-up: 1-Retort stand, 2-CSTR tank, 3-Gas collector tube, 4-Graduated measuring cylinder, 5- rubber stopper, 6-Magnetic stirrer.

Figure 1 shows a sketch of one of the reactors and associated parts.

Forty two blackwater grab samples from the National University of Lesotho Roma campus (population about 9,500 students and staff) were collected over 90 days (3 months) in summer of 2017, for feeding two 2L anaerobic bioreactors (CSTRs). Samples were taken from the main collection manhole before the blackwater entered the campus pond system for treatment. Batch feeding (320mL influent) after equivalent effluent withdrawal (320mL) occurred daily at same time.

One reactor (RI) was spiked with 5g inoculum (cow dung) at start-up. Controlled operational parameters were used to ensure optimal anaerobic digestion through hydrolysis, acidogenesis, acetogenesis and methanogenesis: mesophilic temperature range (measured as 30-36°C during the summer study period), OLR of 2gCOD/L.d, VLR of 320mL/d, HRT of 38hrs. pH (4.6-8.5) was taken daily. Samples were stored at 4°C. Chemical oxygen demand (COD) was analysed thrice weekly, according to standard methods. Reactor efficiency was determined as: Efficiency (%) = ((Influent conc.- Effluent conc.)/Influent conc.)*100.

3. Results and Discussion

Figure 2 shows COD concentrations of influents and effluents for both CSTRs (RI and RII) over the experimental period. Figures 3 & 4 show COD removal efficiencies & collected biogas amounts, respectively.
Influent COD concentrations ranged from 992-2464mg/L. Effluents ranged from 224-1568mg/L & 416-1152mg/L for RI & RII, respectively (figure 2). Computed COD removal efficiencies ranged from 15-81.1% for RI and 16-65% for RII (figure 3). RI produced 1250mL of biogas cummulatively, while RII produced 1030mL (figure 4). The higher COD removal efficiency & higher biogas production of RI could be

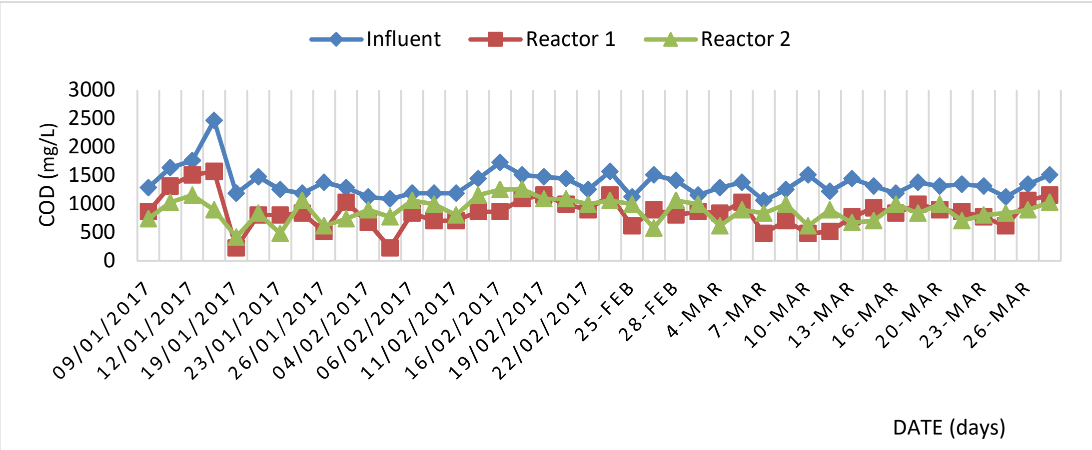

Figure 2. COD concentrations of influent & effluents after treatment.

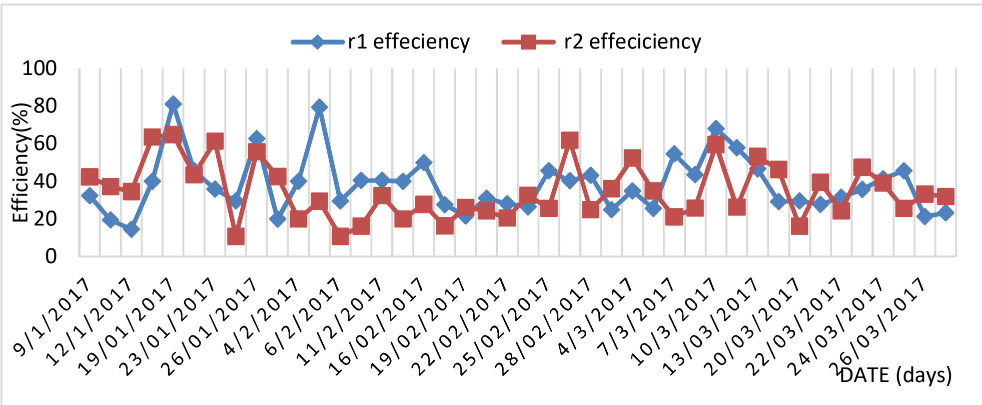

Figure 3. COD removal efficiencies.

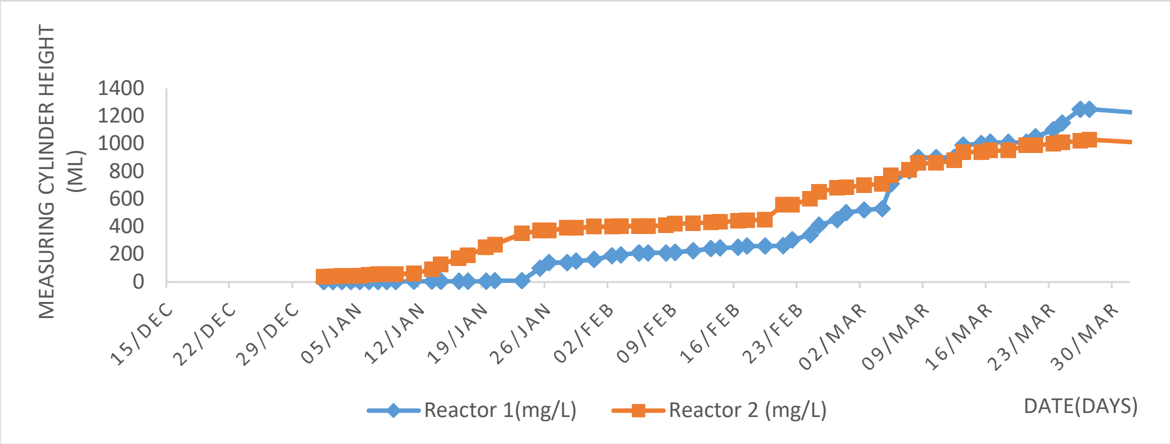

Figure 4. Amounts of biogas collected.

due to the inoculum spike of methanogenic bacteria. Overall, both CSTRs performed admirably, showing potential in bioenergy (biogas) production from sewage. Public health & the environment are also protected, as the sewage is also disposed of.

4. Conclusions

Blackwater was effectively used as input for an innovative technology to produce Sustainable, Renewable Clean Energy as biogas, for possible heating, electricity generation, etc. The design is simple, with high treatment output, ensuring an environmental cleansing (Sanitation) and protecting Public Health. This is an admirable wastewater recycling for energy generation that needs to be tested further.

5. References

1. Aiyuk S.E. (2004). Development of a sustainable treatment technology for domestic sewage. PhD Thesis, Faculty of Bio-Sciences Engineering, Ghent University, Belgium.

2. Bussabong N., Watcharenwong A and Dararat S. (2013). Biogas Production from Ruzi grass in the Continuously Stirred Tank Reactor. International Journal of Chemical, Environmental and Biological Sciences. Vol.1 (2), pp. 348-351.