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Effect of salinity on biogas generation from anaerobic digestion of aquaculture wastewater

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ABSTRACT

The effect of salinity on biogas generation from anaerobic digestion of aquaculture wastewater was examined in this study. Different food to microorganism proportion were examined (0.29, 0.14, 0.082, 0.27, 0.13, 0.075, 0.27, 0.13 and 0.076), so as to evaluate the digester performance. COD elimination, the highest biogas production were estimated for evaluating the efficiency of the anaerobic system. COD removals were above 85% for all of the salinities. When the saltiness was increased from 0 to 18 g/l, and a high feed to microorganism proportion (0.28) was utilized the biogas production was diminished. Biogas yield was decreased to 63%, when saltiness was expanded from 0 to 18 g/l. The examination on the utilization of anaerobic sludge molded at high saltiness shows a promising viewpoint for the treatment of wastewater and to enhance the biogas generation.

Key words: *Anaerobic digestion, Salinity, Aquaculture wastewater, F/M ratio*

Introduction

The utilization of fish has been increased remarkably due to the increase inpopulation (Siddique and Wahid, 2018). The gradual demand was brought about by a blend of a few elements, such as high population, rising earnings, urbanization and the expanded accessibility of these items, produced by the extension of farming (Islam Siddique *et al.*, 2020).

During the handling of fish, various types of effluents are generated. The properties of these effluents may differ for the handled species. Viscera, a piece of these effluents are assessed as sixteen percent of the entire load of the fish (Kaburagi *et al.*, 2020). Viscera may be disposed to the ocean, shipped to a landfill and recouped for fishmeal. It provides viscera an additional advantage to be used in the next procedure (Siddique *et al.*, 2014). The aquaculture wastewaters (AWW) carry a COD rangingfrom 0.25 to 43 g/ L (Syukor *et al.*, 2016).

The AWW has its own ecological ramifications, similar to oxygen reduction in water sources, eutrophication and smell issues (Siddique, *et al.*, 2015). A few scientists have concentrated on considering the biodegradability of various streams, produced in the fish handling industry and have discovered that organic treatment is a possible alternative to manage these wastewaters. The aerobic procedure may accomplish totally natural degradation of AWW (Siddique *et al.*, 2017). A hindrance to these procedures is oxygen prerequisites that might be

huge in some cases (Siddique *et al.*, 2015).

Anaerobic systems had been effectively utilized for the degradation of the AWW. The effluent produced by the fish canning industries was being treated with anaerobic procedures; the COD removal efficiencies ranged between 66 to 91%, and methane generation was more than 2.41 m^3 / day (Siddique *et al.*, 2016a).

In any case, the anaerobic digestion of AWW is problematic because of its sodium chloride inhibition (Krishnan *et al.*, 2017). Less amount of Na+ is needed for microbial development. Na+ levels between 3.6 to 9.0 g/ L, may cause inhibition to methanogenic bacteria (Siddique *et al.*, 2016b; Zaied *et al.*, 2019). The majority of the fish, utilized by the business, are collected from the ocean. It has been a typical exercise to utilize the saline solution to freeze the fish; the brine water likewise can be utilized to carry the catch via all the commercial procedures and treated by waste treatment plants. Furthermore, AWW is wealthy in protein that provides a high level of alkali; both nitrogen and salt can restrain anaerobic processing, and these were the chief causes why the anaerobic system had been inadequately utilized to treat AWW. The greater part of AWW is utilized to make up other intriguing items, such as gel, nourishment supplements and pharmaceutical items. It is also utilized as feed in water and agribusiness or potentially for the generation of bioenergies, yet it needs high venture budgets and big machinery (Khalid *et al.*, 2019). Limited works have been carried out on the possibility of biogas generation from AWW (Islam Siddique *et al.*, 2020; Zaied *et al.*, 2020). In addition, these works concentrated on enhancing methane generation without thinking about the impact of salinity. In this work, the use of an anaerobic digester, that treats AWW with salinity for the removal of effluents, rather than utilizing them as crude ingredients in other expensive forms. Different food to microorganism proportion were examined (0.29, 0.14, 0.082, 0.27, 0.13, 0.075, 0.27, 0.13 and 0.076), so as to evaluate the digester performance.

Materials and Methods

All techniques might be continued in three stages (Figure 1)

1. Acclimatization of sludge to high saltiness fixations by gradual increment and by including a marine silt inoculum;
2. AWW was collected from theFisheries department of university Malaysia Terengganu;
3. At last, bio-examines, where COD elimination productivity and biogas generation were studied.

Fig. 1. Experimental setup ofanaerobic digestion of AWW.

Seeding

The anaerobic sludge from a water treatment plant and marine residue were utilized as seed sludge; this seed sludge has Total volatile solids of 23 g/ L. The marine residue was gathered from Terengganu, which receives fishmeal discharges.

Acclimatization

A culturingera of 25 weeks was taken to adjust sludge to high saltiness and high organic loading. The approach for biomass adjustment to the salinity levels of 18 g/ L was with gradual enhancement followed by reduction and once again increment. The saltiness was enhanced up to 3 g/ L and let it adjust for a week; at that point, the saltiness was reduced to 2g/ L, and after one week of acclimatization, the saltiness was expanded once more. A similar approach was applied forthe salinity of 7 g/ L; at that point, the saltiness was expanded from 7 to 11 g/ L. Also, a similar procedure was utilized for salinity level of 18 g/ L; this progression took 25 weeks (Figure 2).

Substrates

AWW was collected from the Fisheries department of university Malaysia Terengganu, Terengganu, Malaysia. A 100 L of AWW sample was collected in the sample collection ice-box and transported immediately to UMT reservation and preserved it at 4 ºC. The properties of AWW are listed in Table 1.

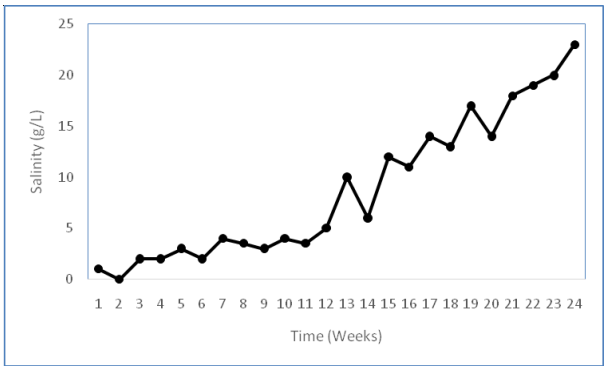

Fig. 2. Variation of salinity during acclimation state.

Table 1. Aquaculture wastewaterproperties

Parameters	
pH	7.2
COD (g/L)	177
Total solids (TS) (g/L)	21
Total volatile solids (TVS) (g/L)	29
Total nitrogen (TN) (g/L)	1
Conductivity (mS/cm)	1

Analysis

Every experiment was carried out three times in 350 mLbottles with a working volume of 250 mL; each container was given with a HACH gas generation framework module for estimating pressure (in psi), created by the produced biogas inside the container. The register of weights was made in the HACH Gas Pressure Monitor ® programming (Figure 1). All the analyses were done at 37 °C in a thermos-agitator. The bottles were put in a thermos-agitatorat 35 °C. Biogas generations were estimated each hour. COD, pH, total solids, total nitrogen, and saltiness were by APHA Standard Methods (2005).

Results and Discussion

COD elimination proficiency at 3 different F/M proportions and salinity

AWW are difficult to treat. The fundamental factors that control COD elimination and biogas generation are salinity and alkali levels (Nasrullah *et al.*, 2014) (Siddique *et al.*, 2016). As referenced previously, the inhibition can be decreased if a few methodologies are completed, such as a pre-acclimatization state (Siddique *et al.*, 2019). The seed-sludge, utilized in the present work was subjected to a 6-month time of steady salinity state, so as to decrease hindrance brought by saltiness (Siddique and Wahid, 2018). Besides, the sludge was at that point adapted to treat waters with high nitrogen content, because of its previous application (Siddique and Sakinah, 2014a). Figure 3 and Table 3 show the preliminary COD,COD elimination, various F/M proportions and salinities. It is seen that at a saltiness of 0 g/ L, the aggregate COD elimination efficiency is in the range of 91 and 95%, after 48 hof thebatch test. Nevertheless, the results were in accordance with the previous study of (Siddique and Sakinah, 2014b).It was seen that when saltiness was enhanced from 0 to 11 g/ L, the reactor indicated a slight decrease in COD elimination; the eliminationefficiencies reduced from the mean estimation of 95 to 85 % that lasted from 32 to 48 h (Figure 4). The reduction in the COD elimination rate is in line with the literature. A high saline concentration may decrease the COD elimination because of plasmolysis (Siddique and Wahid, 2014). A few scientists reported that the impact will rely upon the attributes of the inoculum and the sort of wastewater, making accentuation on that utilizing halophilic biomass, it can diminish the

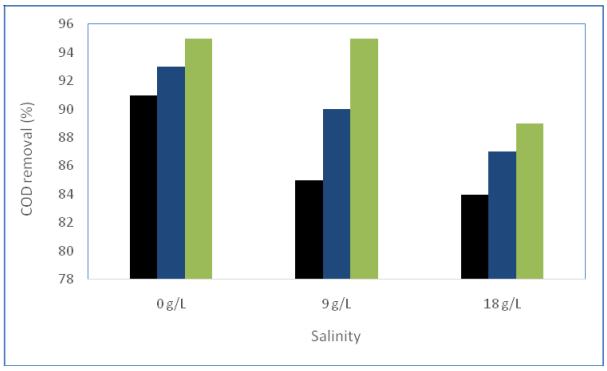

Fig. 3. COD removal at different salinities and F/M ratios (%) Low (%) Medium (%) High

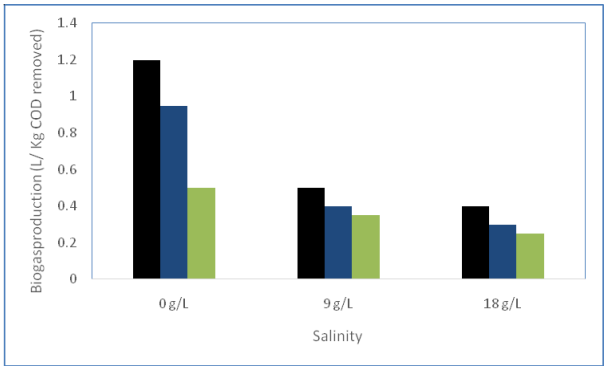

Fig. 4. Biogas production at different salinities and F/M ratios (%) Low (%) Medium (%) High

inhibitory impact brought about by sodium chloride (Siddique and Wahid, 2012; Siddique and Wahid, 2012). In the present work, the digester was seededwith marine sediment which supplied halophilic microscopic organisms; along these lines, the inhibitory impact brought about by salt on the COD elimination was decreased. The past acclimation time of the anaerobic sludge may decrease hydraulic retention time, decreasing test times and expenses (Siddique and Wahid, 2012). Thus, experimental time utilized in this work was lower than those of Sakinah *et al.*, 2012; Siddique and Wahid, 2013; Siddique and Wahid, 2018 and Siddique *et al.*, 2013a, who revealed the utilization of experimental time somewhere in the range of 95 and 661 h.

At last, at saltiness of 18 g/ L, the elimination efficiencies reduced to runs somewhere in the range of 84 and 89%. At this saltiness, the most effective removal was acquired at a low F/M proportion. COD elimination was marginally influenced by salt augmentation; It was in accordance with the study of Siddique *et al*., 2013b, to the adjustment of anaerobic microbes to salinity levels up to 18 g/ L. At this saltiness, adequate COD elimination and methane generation might be acquired if the sludge is subjected to gradual salinity before; nonetheless, they also stated that as saltiness passes an edge limit, the sludge will be forever influenced by salinity inhibition. Siddique *et al.*, 2014 added that slight hindrance happens in the anaerobic treatment of saline wastewaters at salinities beneath 18 g/ L. The batch treatment timeutilized in this work varied between 32 to 48 hour; which was in line with the studies of Siddique and Wahid, 2012.

Biogas yield at three F/M proportions and three salinities

Figure 4 demonstrates biogas generation at three different salinities and F/M proportions (0.27, 0.13 and 0.076) (Table 3). As per (Trivedi *et al.*, 2019), at higher salinities, the utilization of low F/M proportion may enhance anaerobic digestion. This concurs with the outcomes generated from the present work, as it tends to be seen in Figure 4, the highest biogas was generated froman F/M proportion of 0.076. Be that as it may, it is notable that high saltiness can diminish extensively themeasure of the generated biogas from anaerobic reactors (Picos-Benítez *et al.*, 2019). In this study, at a saltiness of 0g/ L, the biogas generation was 0.4, 0.5 and 1.2L biogas/ Kg COD removed for the separate F/M proportion of 0.27, 0.13 and 0.076. At the point when

Table 2. Operational plan during different salinity and F/M ratios

Salinity (g/L)	COD (g/L)	Sludge (mL)	SWF (mL)	F/M ratio
0	3±0.04	171	81	0.29
		126	126	0.14
		91	151	0.082
11	2.85±0.05	171	81	0.27
		126	126	0.13
		91	151	0.075
21	2.8±0.12	171	81	0.27
		126	126	0.13
		91	151	0.076

Table 3. Operational plan for different F/M ratios and mean COD values

Salinity (g/L)	Initial COD (g/L)	F/M ratio	Mean COD value (mg/L)
0	3±0.04	0.29	193±12
		0.14	181±20
		0.082	166±20
11	2.85±0.05	0.27	387±26
		0.13	297±21
		0.075	193±15
21	2.8±0.12	0.27	477±20
		0.13	427±17
		0.076	289±14

saltiness was expanded to 10g/ L, the biogas generation was reduced to 0.35, 0.40 and 0.5 L biogas/ Kg COD removed for the individual F/M proportion. At long last, when saltiness was expanded to 18g/ L, the decrease in biogas yield, because of the hindrance by salt, arrived at 0.25, 0.3 and 0.4 L biogas/ Kg COD removed. It may be seen in Figure 4 that, when saltiness expanded from 10 to 18g/ L, biogas had no remarkable decline; this can be ascribed to the low F/M proportion utilized (0.076) and the methanogenic restraint brought by salt was decreased. As per (Nowak *et al.*, 2019), higher F/M proportion in saline wastewaters may interrupt thydrolyzation and methanization procedure. Besides, higher F/M proportions may permit the accretion of harmful intermediates causing a synergetic hindrance effect by salinity (Riaño *et al.*, 2011). Alternatively, a lower F/M proportion upgrades natural expulsion and sludge occulation and decreases restraint brought about by high saltiness. (Dhanke *et al*., 2018) stated thatthe most suitable F/ Mratioforthehighest methane generation may be accomplished at an F/M proportion of 0.51; on the other hand, the inhibitory effect, brought about by a high saltiness, was not mentioned. The maximum biogas generation, acquired in the present investigation, was near to the study of (Chowdhury *et al.*, 2010), who observed the maximum biogas generation at F/M proportions of 0.051.

Conclusion

In this work, it was tried the influence of salinity on an anaerobic procedure, that treated AWW. Regardless of the inhibitory influence, brought about by high saltiness from the AWW, the adjusted anaerobic sludge was fit for eliminating COD from this wastewater at three different salinities. Satisfactory COD elimination and biogas generation may be accomplished if the right technique is applied in a past molding time of the anaerobic sludge. The inhibitory effect, brought about by saltiness, delivered a signicant decrease in the most extreme aggregated biogas and biogas yield parameters after saltiness was enhanced. These effects were decreased by diminishing the F/M proportion to the estimation of 0.076; notwithstanding, if these F/M proportions were applied in the treatment of these wastewaters, it must be viewed as that this will significantly enhance hydraulic retention time.

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