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Start-up of EGSB reactor for treatment of piggery wastewater

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ABSTRACT

The start-up of the Expanded granular sludge blanket (EGSB) reactor for treatment of piggery wastewater was investigated. Using anaerobic granular sludge as seed sludge, the EGSB reactor can be successfully started up in 110 days at 35±1 °C by gradually increasing the volume load. The optimal volume load was 11.8 kg COD/(m^3·d) with 12.2h of hydraulic retention time (HRT). The COD removal efficiency reached about 79%, biogas production was 58.17 L/d, and CH_4 content was 53.6%0The results showed that the EGSB reactor had good performance for treatment of piggery wastewater.

KEYWORDS

Expanded granular sludge blanket (EGSB) reactor;
Start-up;
Piggery wastewater;
Methane production.

INTRODUCTION

In recent years, the rapid development of large-scale farms, which produces a large amount of wastewater brought great harm to the surrounding environment[1]. Livestock wastewater treatment is very difficult because of the high concentrations of ammonia nitrogen and organic matter in wastewater[2]. Anaerobic digestion technology can not only remove the large amount of organic matter in the wastewater, but also recover methane, which has been extensively studied and applied in livestock wastewater treatment[3,4]. But the traditional anaerobic reactor such as CSTR[5], UASB[3] increased construction costs because of the low volume load. EGSB reactor for the third-generation high-rate anaerobic reactor offers many advantages, such as large volume load, small footprint, and high efficiency etc. The use of effluent recycle technology can enhance the effect of mass transfer, so the EGSB reactor has a strong resistance to impact load[6]. At present, the EGSB reactor in the treatment of high concentration industrial wastewater has been widely studied[7], but the study of livestock wastewater treatment less. This paper focuses on the characteristics of the start-up of EGSB reactor for treatment of piggery wastewater. The effects of volume load on chemical oxygen demand(COD) removal, biogas production and other parameters was researched to provide the technical basis for the application of EGSB reactor in livestock wastewater treatment engineering

MATERIALS AND METHODS

Reactor system

The EGSB reactor made of plexiglass with a working volume of 12.2L (90mm in diameter and 1000mm in height of the reaction zone, 190mm in diameter and 250mm in height of the precipitation zone). The tem-

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perature of the reactor was maintained at 35 ± 1 °C. The Reactor system is shown in Figure 1.

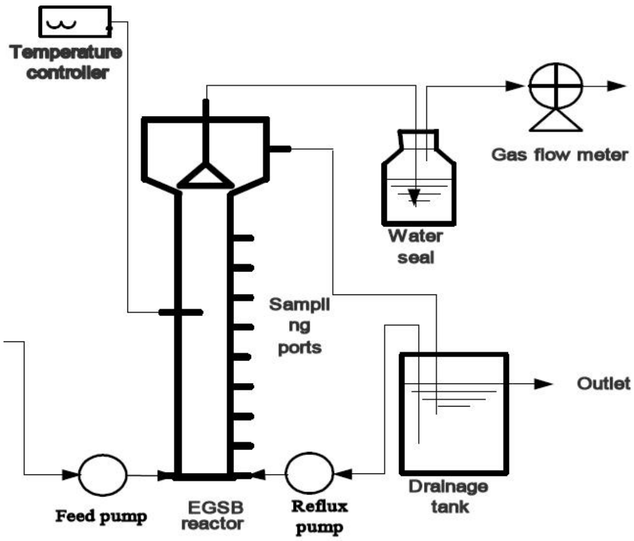

Figure 1 : Sketch of EGSB reactor system

Materials

The precipitate treated piggery wastewater was used. Water quality parameters are as follows: COD concentration about 6000mg/L, ammonia about 400 mg / L, SS about 1100mg / L, the pH value about 7.0, alkalinity about 3000mg / L.

The seed sludge of the EGSB reactor was taken from the IC reactor of a xylose plant. Granular sludge particle is 0.5 ~ 2mm, the VSS is 79.59g / L, VSS / SS is 0.72. The sludge concentration in the reactor was 9.26gVSS / L after inoculation.

Experimental procedure

EGSB reactor started up after inoculating granular sludge with initial hydraulic retention time (HRT) of 48h. The influent COD concentration was about 2000mg / L through dilution, temperature controlled at 35 ± 1 °C. When the COD removal efficiency exceeded 80%, the volume load increased gradually by increased influent flow and influent COD concentration.

According to the Variation of COD removal efficiency, gas yield, effluent VFA and pH value to determine the volume load of the EGSB reactor. During the start-up, reactor recirculation ratio was 20:1 ~ 5:1 according to the flow rate (in 1m/h) of the reactor and HRT.

Analytical methods

COD, MLSS, MLVSS, VFA and alkalinity were analysed by standard methods[8]. pH was measured using a portable pH meter(Model HI9125), biogas production was measured by LML-1 wet gas flow meter, CH_4 contents analysed by gas chromatograph.

RESULTS AND DISCUSSION

Variation of COD concentration during the start-up of the EGSB reactor

Variation of influent and effluent COD concentration during the start-up of the EGSB reactor is shown in Figure 2 (a). The effluent COD concentration was significantly lower than the influent COD concentration. Keeping the influent COD concentration continued to significantly improve, 1-95d, the effluent COD concentration slower increase and remained at about 1000mg / L, COD removal efficiency exceeded 80%. 95-102d, the effluent COD concentration was significantly increased up to 2500 mg / L, COD removal rate decreased significantly, the lowest dropped to 60%; 102-110d, COD removal rate gradually increased nearly 80%, the effluent COD concentration gradually decreased to about 1500 mg / L.

The COD removal efficiency with the change of volume load is shown in Figure 2 (b). At the sludge acclimation stage (1-6 d), when the volume load is about 1 kg COD /(m^3·d), in the next day, COD removal rate was 53.22%, COD removal rate increased gradually with the methanogens activity recovery in seed sludge, the sixth day, the COD removal rate reached 78.16%. At the early stage of the volume load increase stage, 7-24 d, due to the shorter of hydraulic retention time gradually, make the hydraulic load increases and enhance the mass transfer effect. When the COD volume load of 1 kg COD/(m^3·d)increased to 1.6 kg COD/(m^3·d) COD removal rate steady at around 80%, reactor operation is relatively stable. In the period of 25 days to 62 days, with the influent COD concentration gradually increased from 2000mg / L to 6000mg / L, the volume load of 2 kg COD /(m^3·d) gradually increased to 5.9 kg COD /(m^3·d). By the change of COD removal rate can be seen that the COD removal rate will drop slightly at the beginning of the load increase, but two days later, the COD removal rate can restore to 80% - 83.5%. In the period of 63-102d, with the reduction of HRT, the volume load of 5.9

kg COD /(m^3·d)gradually increased to 13 kg COD / (m^3·d). By the change of COD removal we can see that when the volume load of 10.6 kg COD / (m^3·d), COD removal can maintain more than 80%; volume load of 11.8 kg COD /(m^3·d), COD removal rate dropped to about 79%; when the volume load up to 13 kg COD / (m^3·d), COD removal rate decreased. After a week of operation, the COD removal efficiency continued to show a downward trend, indicating the volume load has exceeded the maximum load of the EGSB reactor. the volume load back to 11.8kg COD /(m^3·d) through adjustment HRT. After a week of recovery operation, COD removal rate gradually increased, eventually restored to 79.55%.

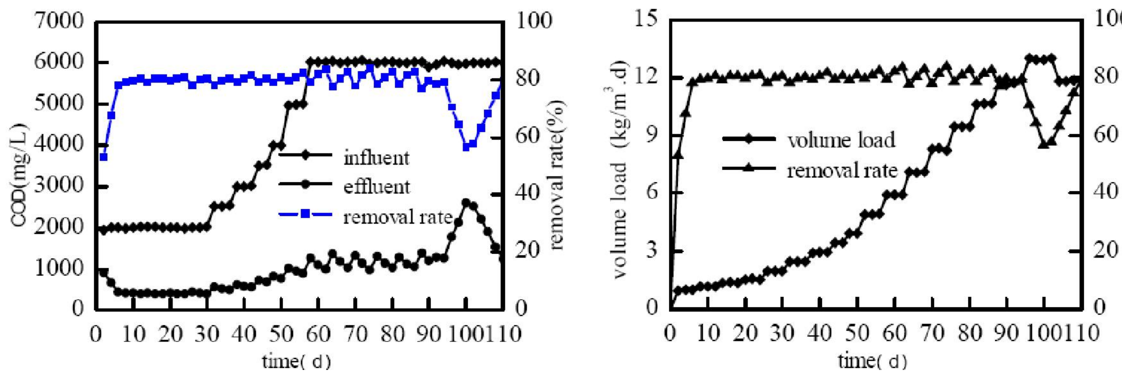

Figure 2 : Variation of COD concentration and volume load during the start-up of the EGSB reactor

Variation of effluent VFA concentration during the start-up of the EGSB reactor

Figure 3 shows the effluent VFA concentration of the EGSB reactor startup process. The Fig shows that when volume load from the beginning of 1 kg / (m^3·d)increased to 11.9 kg /(m^3·d), the effluent concentration of VFA has maintained below 200 mg/L, show the EGSB reactor running stable in this period of time; When continue to rise volume load to 13 kg / (m^3·d), VFA concentration more than 200 mg/L, the max up to 348 mg/L, indicate that high volume load has been in danger of "acid", need to reduce the volume load. When COD volume load is reduced to 11.8 kg/ (m^3.d), A day later, VFA concentration down to about 303 mg/L, after a week, VFA concentration decreased to 134 mg/L, the reactor back to stable operation state.

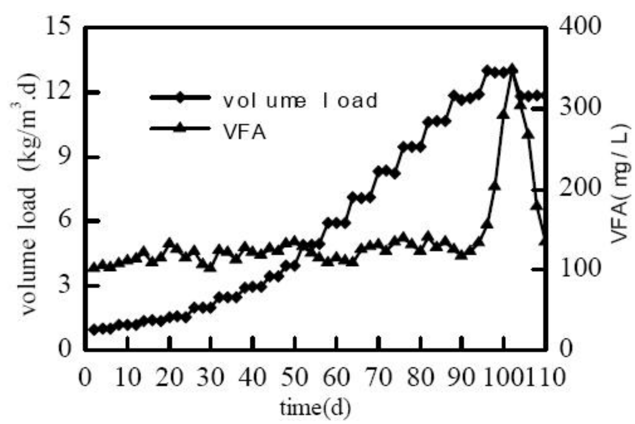

Figure 3 : Variation of effluent VFA concentration with volume load

Variation of the pH during the start-up process

During the start-up process of the ESSB reactor, influent pH kept 7±0.3, the changes of effluent pH shown in Figure 4. When the volume load is less than 13 kg COD/(m^3·d), the effluent pH value slightly larger than the influent pH, that was 6.9-7.2. But when the volume load increased to 13 kg COD /(m^3·d), the effluent pH value has been declining, after 6 days, decreased to 6.02. which shows that the reactor could be operation stablly of the volume load less than 13kg COD /(m^3·d),

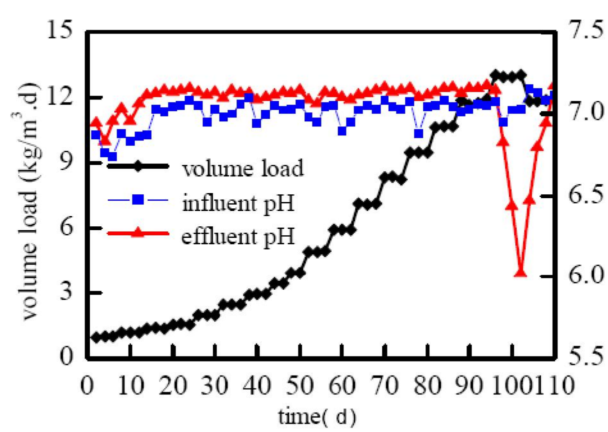

Figure 4 : Variation of pH with volume load

but when the volume load greater than 13kg COD / (m^3·d), Methanogens could not decompose the VFA timely, the pH value declined becaused of the accumulation of VFA. When the volume load dropped to 11.8 kg COD /(m^3·d), the pH value began to rise, a week later, the pH value has returned to 7.1, reached the normal state.

Variation of the gas production and methane content during the start-up process

Figure 5 shows that the gas production below the 1L / d at the first week of start-up, which is mainly due to the bacteria do not adapt to the environment of the wastewater. with the operation of the reactor, the bacteria gradually adapt to environment, and the gas production increased. 36d ago, gas production increased slow becaused of the influent COD concentration was low, and the organic substance of the bacteria needed was restricted. 36-94dÿWith the improvement of influent COD concentration and volume load, gas production increased from 11.13L / d to 58.17L / d gradully. After 94d, with the volume load increases again, due to the accumulation of VFA, pH value decreased, the activity of methanogenic bacteria was inhibited, resulting in gas production also began to decline. 103d, the volume load decreased to 11.8 kg COD /(m^3·d), gas production began to increase due to the VFA utilized timely by the methanogens.

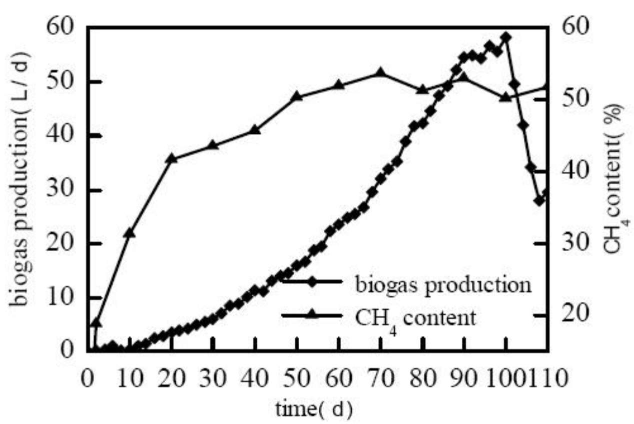

Figure 5 : Variation of biogas production and methane content

The Variation of methane content is consistent with in gas production. 2d, the methane content was only 18.8%. With the improvement of methanogens activity and influent loading, methane content increased with the increase of gas production. 50-90dÿthe methane content was more than 51%, and up to 53.6%. After 90 days, due to high volume load, the activity of methanogenic bacteria was inhibited, the methane content also decreased. 100d, the methane content decreased to 50.2%. When the volume load reduced, the methane content increased with the recovery of gas production, and ultimately to 51.8%.

Discussion

The optimal volume load of the EGSB reactor is not same treatment of the different wastewater. The volume load could up to 15 kg COD / (m^3·d) of the Juice[9], soybean and other wastewater disposal, and the volume load could up to 25 kg COD/(m^3·d) of the sucrose and alcohol wastewater disposal[10]. But the volume load only could up to 5 kg COD /(m^3·d)of the toxic and non-biodegradable wastewater[11]. According to the test results, the optimal volume load of the piggery wastewater was 11.8 kg COD/(m^3·d), and the COD removal rate could up to 79%.compared with the above studies, the volume load of EGSB reactor is relatively low, mainly because of the quality of wastewater. The Component of the piggery wastewater was complex, high ammonia content, easy to inhibition of methanogens, thus making the EGSB reactor volume load is lower.

The effect of different anaerobic reactor treating piggery wastewater is shown in TABLE 1. the maximum volume load were 10 kg COD / (m^3·d) of UASB reactor and 11.5 kg COD /(m^3·d) of IC reactor, respectivelly. The maximum volume load of the EGSB reactor was 11.8 kg COD / (m^3·d), slightly higher than the IC and the UASB reactor, but the COD removal rate was slightly lower than the IC and the UASB reactor.

TABLE 1 : The effect of different anaerobic reactor treating piggery wastewater

Reactor	Optimal volume load (kg /(m^3·d))	Gas production (m^3/m^3.d)	COD removal rate (%)	References
IC reactor	11.5	4.9	≥82	12
IC reactor	10	4	≥80	13
UASB reactor	10	\	≥81.2	14
EGSB reactor	11.8	4.77	≥79	This test

CONCLUSIONS

The EGSB reactor inoculated with anaerobic granular sludge for the treatment of piggery wastewater can be successfully started up in 110 days at 35±1 ! when the initial influent COD concentration was 2000mg / L, and the volume load was 1 kg COD / (m^3·d).The optimal volume load was 11.8 kg COD/(m^3·d) with 12.2h of HRT. The COD removal efficiency reached about 79%, biogas production was 58.17 L/d, and CH4 content was 53.6%.

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