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Study on Anaerobic Treatment of Effluent Obtained from SCR Processing and Water Hyacinth

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The preparation of biogas using anaerobic fermentation of effluent obtained from Standard Chinese Rubber processing and water hyacinth planted in an oxidation pond was studied. The results showed that water hyacinth was a satisfactory raw material for the production of biogas using fermentation method. In batch fermentation, a gram of dried water hycinth produced 0.344 L biogas, of which the methane content was 62.6%. At ambient temperature (27°C~34°C), by mixing the pre-fermented water hyacinth with effluent in a ratio of 1:3 (calculated in COD), a gram of COD of the mixture produced 0.556 L biogas (of which the methane content was 62.8%) through continuous fermentation. The volume output of biogas was 1.78 L/(L. d). This study provides an effective method for treating water hyacinth planted in oxidation pond.

After anaerobic fermentation of the effluent obtained from Standard Chinese Rubber (SCR) processing for preparation of biogas, most of the organic pollutants are removed, but concentrations of the amino nitrogen and chemical oxygen demand (COD) are still high[1]. Therefore, the effluent can meet the discharge criterions only after further aerobic treatment. According to the present practical application, the natural aerated oxidation in an oxidation pond is an economical and practical technology and is suitable for most SCR processing factories in China. It has been reported that planting water hyacinth in an oxidation pond can increase the ability of the removal of amino nitrogen and COD and shorten the retention time for effluent. Hence, the area of oxidation pond and investment can be reduced[2]. However, the propagation of water hyacinth is fast owing to its uptake of nutrients such as amino nitrogen in effluent. So, if the excessive and aged water hyacinths are not cleared regularly, the effects of the removal of amino nitrogen and COD will be reduced. The water hyacinth, which is commonly used as fertiliser, is a kind of hydrophyte. On account of its high water content and bulky volume, the cost of transportation of water hyacinth is very high. Therefore, treating the water hyacinth *in-situ* by use of anaerobic fermentation is an economical method for the treatment of water hyacinth planted in the oxidation pond. In our research work, the preparations of biogas using the anaerobic fermentation of water hyacinth and effluent obtained from SCR processing were studied through batch tests and trials, and the corresponding treatment technology was

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also supplied. Therefore, an effective method for treating the water hyacinth planted in oxidation pond has been suggested; it makes the treatment system of effluent obtained from SCR processing a biological cycle.

EXPERIENTAL

Collection and Chemical Properties of Effluent

The effluent was obtained from the SCR processing factory at Wuyi state farm in Zhanjiang, China. The latex serum was collected from the coagulating tank with a 25 kg plastic bucket for cold storage. The pH, COD and volatile acids content were determined within 24 h. The main chemical properties of the effluent are showed in *Table 1*.

Collection and Chemical Properties of Water Hyacinth

The water hyacinth was collected from the water pond near Guangdong medical college and planted in an tin-plated tank of 1 m^3 for further tests. The chemical properties of water hyacinth are shown in *Table 2*.

Collection of Seeding Sludge

The seeding sludge was collected from the sludge silted up by the wastewater in Zhanjiang suburb, China and was cultured with the effluent obtained from SCR processing factory.

Apparatus

The glass bottles of 5 L were used for fermentation and pre-fermentation and glass bottles of 1 L were used for the separation of biogas from water.

Test Method

The test was carried out in three steps.

Batch fermentation of water hyacinth. 1000 g of water hyacinth (total solids : 59 g) is placed with 700 mL of water into a DS 2000 tissue crusher and the water hyacinth is made into

TABLE 1. CHEMICAL PROPERTIES OF EFFLUENT

Parameter	pH	COD (mg/L)	Volatile acid (mg/L)	Total nitrogen (mg/L)	Amino nitrogen (mg/L)
Values	5.2~5.6	13 200~18 010	3100~480	574~605	405~450

TABLE 2. CHEMICAL PROPERTIES OF WATER HYACINTH

Parameter	Total solid content (%)	COD (mg/g)	Volatile solid (mg/g)	Nitrogen content (%)	Cellulose (%)	Lignin (%)
Values	5.9	779	816	1.93	24.4	13.3

The values of COD, volatile solid, cellulose and lignin were calculated in dry basis.

pulp. The pulp is placed into a fermentation apparatus of 5 L for batch fermentation at ambient temperature (27°C~34°C).

Fermentations of water hyacinth mixed with effluent. The COD values of the water hyacinth is determined after pulping and the pulp is then mixed with effluent in a ratio of 1:3 (calculated as COD) and placed into a 5 L fermentation apparatus for fermentation at ambient temperature (27°C–34°C). The feed quantity was 16 g COD/d. An interval feeding and discharging method was used for twice a day. The effluent with feed quantity of 12 g COD/d was used as control under the same anaerobic fermentation conditions.

Fermentation test of the pre-fermented water hyacinth mixed with effluent. The water hyacinth was placed into a 5 L fermentation apparatus for pre-fermentation after pulping. The pre-fermentation solution was taken from the apparatus every day for determining the COD values. The solution is then mixed with the effluent in a ratio of 1:3 (calculated as COD) and placed into a 5 L fermentation apparatus in two batches for fermentation at ambient temperature (27°C–34°C). The feed quantity was 16 g COD/d.

Analytical Items and Test Method[3]

The pH value was determined using a PHS-25 acidimeter and the COD value was determined according to the potassium dichromate method. The volatile acid was determined by distillation and titration. The total nitrogen was determined by Kjeldahl method and cellulose was determined by nitric acid-ethanol. The lignin was determined by 72% sulphuric acid. The output of biogas was determined using a gas flowmeter and analysed with gas chromatography.

RESULTS AND DISCUSSION

Batch Fermentation of Water Hyacinth

The water hyacinth was fermented at ambient temperature (27°C–34°C). The biogas output was recorded daily from the beginning of the feeding. The days from the beginning of the feeding to the date when the biogas output approached nearly to zero formed a periodic cycle. The results are shown in *Table 3* and *Figure 1*.

It can be seen that the fermentation cycle of water hyacinth is long (about 40 days). After pulping of water hyacinth with a crusher, a great amount of water-soluble materials which were secreted from cell tissues of the water hyacinth were quickly utilised by bacteria to produce biogas. Hence, the first biogas output peak appeared at the third day after feeding, the corresponding biogas output was 3.6 L. The biogas output then decreased.

TABLE 3. BATCH FERMENTATION OF WATER HYACINTH

Feed quality Total Solids (g)	COD (g)	Periodic cycle for biogas production (d)	Date for biogas output	Total output (L)	Output/g of dried water hyacinth (L)	Output/g of COD (L)	Methane contents in biogas (%)
59	46	41	Third day after feeding	20.30	0.344	0.441	62.6

with the water-soluble materials being consumed gradually by bacteria and the biogas output approached nearly to zero at the eighth day. The organic matter in the cell tissues of water hyacinth, such as cellulose then decomposed to low molecular compounds (for example volatile acids) by bacteria, which were then transferred into methane. Therefore, at the tenth day, the biogas output rose again and the second biogas output peak appeared. The second output peak maintained for 3 days, then the biogas decreased again and was stable at the fifteenth day. From the biogas output curve it can be seen that bacteria can transfer the organic matter such as cellulose in water hyacinth into biogas only after decomposition. From *Figure 1* it also can be seen that the biogas output within 15 days after feeding accounts for about 70% of the total biogas output in the biogas production cycle, indicating that although the fermentation cycle is long, the biogas is produced mainly within 15 days after feeding.

Fermentation of Water Hyacinth Mixed with Effluent

The results of the fermentation of the effluent and of the water hyacinth mixed with effluent are shown in *Table 4* and *Table 5*.

It can be seen from *Table 4* that, during the fermentation of water hyacinth mixed with effluent after pulping, when the feed quantity is 16 g COD/d, the volume output of biogas is 1.64 L/(L.d), the removal of COD approaches to 64%. This indicates that the water hyacinth mixed with the effluent can be used as fermentation material to produce biogas.

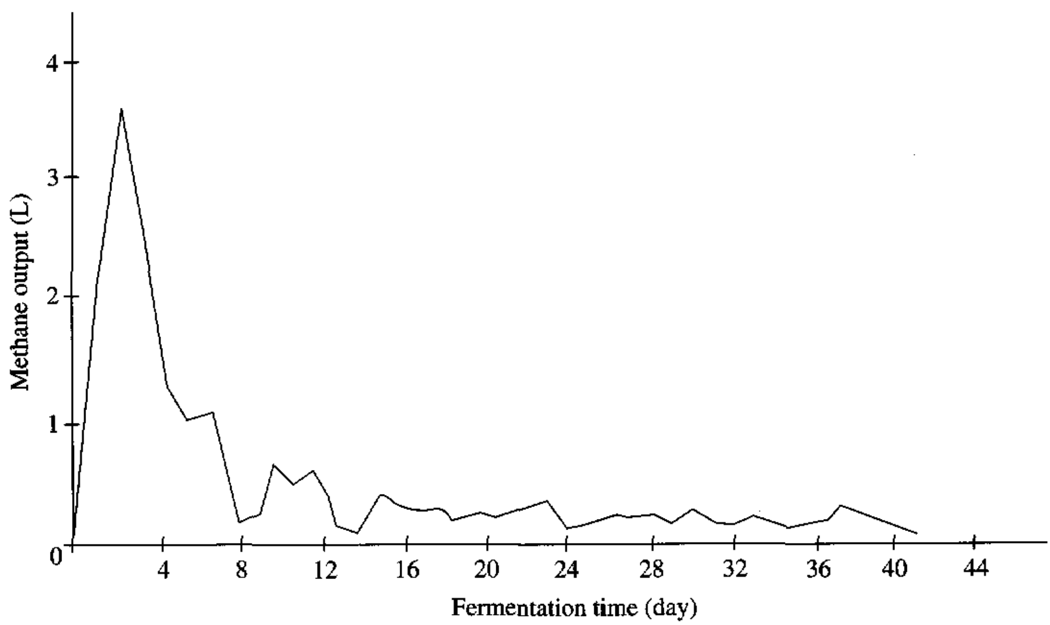

Figure 1. Biogas output for batch fermentation of water hyacinth.

From *Table 4* and *Table 5* it can be seen that, when the fermentation of water hyacinth with the addition of effluent was carried out on condition that the feed quantity keeps unchanged, the biogas output increased obviously, showing that the water hyacinth, like effluent, is easy to be decomposed by bacteria to produce biogas. But it also can be seen that when the effluent was added to the water hyacinth, the output per gram of COD and the rate of removal of COD were reduced. The reason being the organic matter such as cellulose can be utilised by the methanogenic bacteria to produce biogas only after a certain period of decomposition. But the organic matters in effluent are easy to be decomposed and transferred into the low molecular compounds such as volatile acids, which was then used by bacteria to produce biogas. Hence, the productive rate of biogas from effluent is faster than that from the water hyacinth.

Fermentation of Pre-fermented Water Hyacinth Mixed with Effluent

The results of the fermentation of pre-fermented water hyacinth mixed with effluent are shown in *Table 6*.

It can be seen from *Table 6* that when the fermentation of pre-fermented water hyacinth mixed with effluent was carried out at the same feed quantity, the volume output of biogas and the rate of removal of COD were increased obviously. The reason is that after the pre-fermentation, the water-soluble materials from water hyacinth increased greatly, and the rate of transfer of volatile acids produced during decomposition to methane quickened. From *Table 7* it also can be seen that when the fermentation of pre-fermented water hyacinth mixed with effluent was carried out, the volume output of biogas, the rate of removal of COD and the output per gram of COD increased by 8.5%, 17.5% and 8.6%, respectively.

TABLE 4. FERMENTATION OF WATER HYACINTH MIXED WITH EFFLUENT

Feed quantity (g COD/d)	Volume load g COD (L.d)	Testing days (d)	Total feed quantity (g COD)	Total output (L)	Mean output per day (L/d)	Output per gram of COD (L)	Volume output (L/L.d)	Removal of COD %	Methane content in biogas %
16	3.2	30	480	245.7	8.19	0.512	1.64	64.0	60.1

Note: In the feed quantity, the amounts of effluent and water hyacinth are 12 g COD/d and 4 g COD/d, repectively.

TABLE 5. FERMENTATION OF EFFLUENT (AS CONTROL)

Feed quantity (g COD/d)	Volume load g COD (L.d)	Testing days (d)	Total feed quantity (g COD)	Total output (L)	Mean output per day (L/d)	Output per gram of COD (L)	Volume output (L/L.d)	Removal of COD %	Methane content in biogas %
12	2.4	30	360	213.8	7.13	0.594	1.43	87.1	64.2

TABLE 6. FERMENTATION OF THE PRE-FERMENTED WATER HYACINTH MIXED WITH EFFLUENT

Feed quantity (g COD/d)	Volume load g COD (L.d)	Testing days (d)	Total feed quantity (g COD)	Total output (L)	Mean output per day (L/d)	Output per gram of COD (L)	Volume output (L/L.d)	Removal of COD %	Methane content in biogas %
16	3.2	30	480	266.9	8.90	0.556	1.78	75.2	62.8

In the feed quantity, the amounts of effluent and pre-fermented water hyacinth are 12 g COD/d and 4 g COD/d, repectively.

TABLE 7. COMPARISION OF FERMENTATIONS OF PRE-FERMENTED AND NOT PRE-FERMENTED WATER HYACINTH MIXED WITH EFFLUENT

Treatment of water hyacinth	Feed quantity (L) (g COD/d)	Output per gram of COD	Volume output (L/L.d)	Removal of COD %
Pre-fermentation	16	0.556	1.78	75.2
No pre-fermentation	16	0.512	1.64	64.0

CONLUSION

The water hyacinth, like the effluent obtained from SCR processing, is a good material for the production of the biogas using fermentation technique; the biogas output is satisfactory. When the batch fermentation is carried out at room temperature (27°C–34°C), one gram of total solids can produce 0.344 L biogas. The methane content of the biogas is 62.6%. By use of the present technology for treatment of the effluent obtained from SCR processing, the area of an oxidation pond in a SCR processing factory with an output of 20 tons dry rubber a day is about 6000 m^2, and 6322 kg fresh water hyacinth (373 kg dried matter)[4] can be harvested daily from the pond. According to the estimation of the test results, when the fermentation of the water hyacinth mixed with the effluent after pulping is practised, the biogas output can be increased by 20%. Therefore, when the anaerobic fermentation is carried out with water hyacinth and effluent together as raw materials, the biogas output from the fermentation pond can be increased. At the same time, this method can effectively treat the excessive water hyacinth in the oxidation pond; increase the ability for removal of amino nitrogen from effluent in oxidation pond; reduces the area of oxidation pond and investment; and makes the effluent treatment system to form a biological cycle.

The properties of water hyacinth are different from that of the effluent obtained from SCR processing. If the water hyacinth is fermented directly with effluent, the biogas output is unstable and the rate of removal of COD is low, because the biogas production rates of the water hyacinth and the effluent are different. Besides, the water hyacinth will float on the surface of effluent and is difficult to mix them evenly. To overcome the shortcomings stated above, the anaerobic fermentation of the water hyacinth can be divided in two steps. The first step is to transfer the water hyacinth into a liquid by a pre-fermentation process, then the fermentation of the water hyacinth liquid is mixed with effluent out, which makes their biogas production rates similar to raise the stability and processibilty of the fermentation process and increase further the biogas output and the rate of removal of COD.

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