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Biogass Generation from Standard China Rubber Processing Effluent

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*A production test has been carried out for biogass generation from Standard China Rubber (SCR) processing effluent. The results showed that the biogas yield exceeded $1m^3/m^3$.day in the process of fermentation at ambient temperature. It means that about 30 m^3 biogas containing 60% of methane can be generated from the effluent (latex-serum) on processing one tons of SCR; heat derived being equivalent to that of about 15 kg fuel oil. This amount accounts for 44% of the heat energy needed for drying one ton of SCR now in China (*i.e. *heat derived from* ca. *35 kg of heavy oil and diesel oil). Biogas generation from SCR processing effluent is feasible technologically and economically, a part of energy needed for drying standard rubber can be saved each year. In addition, the environmental pollution of water by the effluent could be considerably mitigated so as to set up a good foundation for the treatment of SCR processing effluent.*

Key words: biogass generation; Standard China Rubber; effluent; rubber processing; methane; pollution

The annual output of natural rubber has reached 450 000 tons in China and a Standard China Rubber (SCR) processing factory with a daily output of 30 tons discharges several hundred tons of effluent per day. In order to utilise the bioenergy, a production test on biogas generation from SCR processing effluent using the anaerobic treatment method was launched in 1990–1992. The aeration of the effluent obtained after biogas fermentation and mixed with waste water discharged from rubber processing factory was carried out for cultivation of water hyacinth (*Eichhornia crassipes*) to observe the effect of natural purification.

EXPERIMENTS

Collection of Effluent

SCR processing effluent consists of latex-serum from coagulation of field latex and from cursher and creepers, with a COD content as high as 15 000 mg/L. Added with some fresh water, the effluent is kept with a COD up to 10 000 mg/L. This part of effluent with higher COD concentration was collected and fermented to generate biogas, whilst the effluent from hammermill, cleaning of factory and processing of field grade rubber was directly discharged to oxidation pond for purification by natural an oxidation.

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Chemical Characteristics of Effluent

The chemical characteristics of the SCR processing effluent vary with processing conditions, season and temperature. For example, when the temperature is high, the dosage of acid for coagulation can be decreased appropriately, and when the temperature is low, the non-rubber constituents in field latex will be higher. These factors can influence the chemical composition of the effluent. The SCR processing effluent is an organic effluent generated from natural rubber processing, in which only ammonia as a preservative and acetic acid as a coagulant are added, no other harmful substance is added. The chemical characteristics of the effluent is shown in *Table 1*.

Process Chart

The schematic diagram of the biogas generation system in shown in *Figure 1*.

Biogas Fermentation

The design of biogas fermentation pond incorporates some characteristics of small marsh gas generating pit for countryside and the sludge bed reactor for industrial sewage

TABLE 1. ANALYSIS OF THE CHEMICAL CHARACTERISTICS OF THE SCR PROCESSING EFFLUENT

Parameters	Chemical oxygen demand (mg/L)	Volatile fatty acid (mg/L)	pH	C:N
Values	10 408 – 14 429	3123 – 6137	5.0 – 5.5	7.0 – 8:1

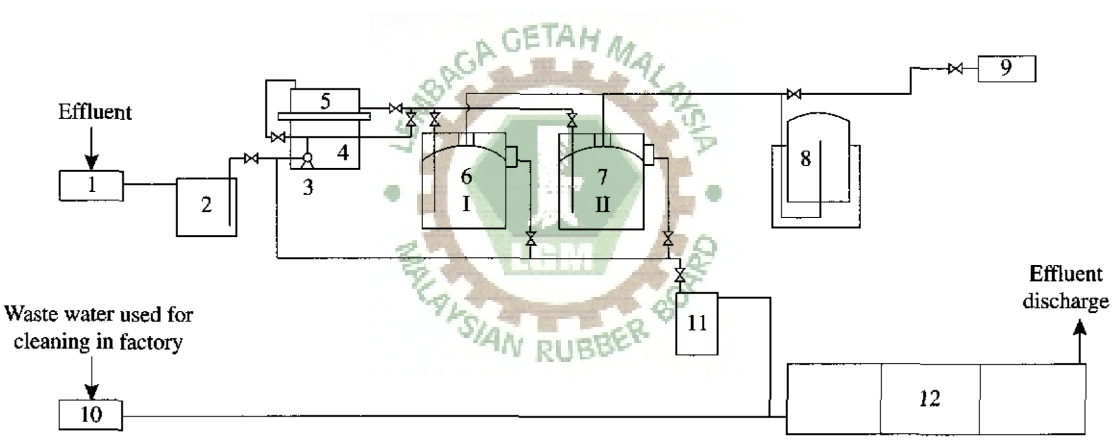

Figure 1. Schematic diagram of the system.

1: Sand setting tank; 2: Effluent pond; 3: Effluent pump; 4: Laboratory and pump room; 5: High level tank; 6: Fermentation pond No. 1; 7: Fermentation pond No. 2; 8: Biogas tank; 9: SCR dryer; 10: Sand setting tank; 11: Setting basin; 12: Oxidation pond.

treatment, with some modifications made. Its easy operation, simple structure and high biogas yield is distinctive of the pond.

The pond is equipped with a water-collecting basin on the top, which keeps the temperature inside the pond relatively stable and prevents the top from cracking due to sunshine and leaking.

A high level tank is used for charging, with potential pressure for discharging.

A bell type gas tank is designed for controlling the biogas pressure, thus facilitating fermentation and enabling gas transportation in tens of meters without pressure device. Combustion is stable.

Fermentation is carried out at ambient temperature. The mean temperature for the rubber processing period is above 25°C.

Effluent discharged from the fermentation pond is treated in the oxidation pond for purification. The capacity of the device for test is 200 kg – 250 kg of COD per day, *i.e.* for treating the effluent from a 'Standard China Rubber' processing factory producing 4 tons – 5 tons per day. The expected yield of biogas of fermentation pond is about $1m^3/m^3$. A comparison between the results from the ponds with different depth was made. The main devices and their specification are shown in *Table 2*.

Inoculation and Starting-up

Starting-up of a large or medium fermentation pond is quite different from that of a small one. The key points of this procedure are inoculation with sludge containing useful strains and culturing a large quantity of highly active sludge. The pond sludge and the active sludge with high yielding of biogas were adopted as inoculum in the experiment.

Still incubation lasted one month after inoculation. The effluent (latex serum) was then gradually added for fermentation. Samples of effluent fed to and discharged from the fermentation ponds were taken regularly and

TABLE 2. MAIN DEVICES

Devices	Number	Specification
Fermentation pond No. 1	1	50 m^3; 3 m in depth
Fermentation pond No. 2	1	50 m^3; 4 m in depth
Effluent pond	1	20 m^3; 3 m in depth
Settling basin	1	30 m^3; 4 m in depth
High level tank	1	14 m^3; divided into two parts
Biogas tank	1	50 m^3
Laboratory and pump room	1	15 m^3 with high level tank on the top
Oxidation pond	2	500 m^3 each, with a surface of 260 m^2
Effluent pump	1	$2^1/_2$ hp

analysed for pH, COD and volatile fatty acids. On the basis of these values the biogas yields per unit weight of raw materials and per unit volume of the pond were calculated, to evaluate the activity of the sludge. In order to ensure stable fermentation, a low load operation was carried out for a longer time in earlier stage, so as to fully activate the sludge, then the full load operation was started.

Analytical Method and Instrument

The pH was measured with a pH meter. COD was determined by potassium dichromate method[1] and volatile fatty acids expressed as acetic acid by distillation followed by titration[1]. The biogas yield was measured with a gas chromatograph.

RESULTS AND DISCUSSION

The relation between operational parameters of fermentation pond No.1 in normal operation and organic loads is shown in *Table 3, 4* and *5.*

Annual output of SCR was 300 000 tons in 1998 in China. According to Wei[2], about 10 500 tons of fuel is needed for the total output. If an attempt is made to make full use of the processing effluent to produce biogas, based on the results shown in *Table 5,* a total heat output equivalent to 4650 ton fuel would

TABLE 3. BIOGAS GENERATION OF FERMENTATION POND

Item	Input (m^3/day)	COD input (kg/day)	Total output of (m^{3*}/day)	Biogas yield (m^{3*}/m^3. day)	Biogas output (m^3/kg COD input)	Biogas output (with discharge part deducted)	CH_4 content (%)
Range	10.2–15.4	128.5–194.0	55.3–91.1	1.11–1.82	0.558–0.370	0.703–0.466	60–68
Mean value	11.7	147	71.7	1.43	0.488	0.613	60

* Calculated under the conditions of a temperature of 20°C and a pressure of 10 m w.c.
The test was carried out at 30°C and 10.22 m w.c.
As shown in *Table 3*, the mean biogas yield is 1.43 m^3/m^3.day, which was slightly higher than the designed yield of *ca.* 1 m^3/m^3.day.

TABLE 4. PARAMETERS OF THE FERMENTATION POND IN CHARGING AND DISCHARGING

Item	COD in influent (mg/L)	COD in effluent (mg/L)	COD Removal (%)	pH in influent	pH in effluent	Volatile acid in influent (mg/L)	Volatile acid in effluent (mg/L)
Range	10 710–14 429	2050–3607	81–75	5.0–5.5	7.0–7.2	3123–6137	697–1956
Mean value	12 597	2667	79	5.1	7.15	4377	1213

TABLE 5. BIOGAS OUTPUT FROM LATEX SERUM PRODUCED BY ONE TON SCR

Item	Biogas output (m^3/m^3 effluent)	Rubber output per day (ton)	Effluent output (m^3)	Effluent from one ton SCR (m^3)	Biogas output m^{3*}/ton SCR	Fuel equivalent (kg)**
Range	12.2–466	1.6–4.4	12–16	4.23–5.65	25.9–34.5	
Mean value	6.13	2.84	14	4.95	30.2	15.5

* Calculated under the condition of a temperature of 20°C and a pressure of 10 m w.c.

** Converted from biogas produced from processing one ton of SCR effluent on the basis of low heat value of methane and fuel[3].

be obtained, accounting for 44% of the total heat output of fuel needed for one year. It is concluded that the utilisation of SCR processing effluent to produce biogas is an effective measure, not only for the purification of effluent, thus protecting environment from pollution but also for the development of bioenergy, contributing to considerable economic results.

At the same time, a test for cultivation of water hyacinth for the purification of effluent was carried out in two oxidation ponds (stage 1 and 2) with an area of 260 m^2 and a volume of 500 m^3 each. The test results showed that water hyacinth suffered from root rot and perished, if a part of the effluent discharged into the oxidation pond was not treated with anaerobic fermentation and its COD exceeded 1000 mg/L. When the whole effluent was treated with anaerobic fermentation, then its COD lowered to 250 mg/L and the water hyacinth rooted and germinated again. Preliminary evaluation showed that a surface area of 200 m^2 would be needed for the cultivation of water hyacinth from processing of one ton(dry)SCR.

A trial on the utilisation of biogas to pre-heat the furnace for SCR drying was carried out. The preliminary results showed that biogas could be used with fuel (heavy oil) in the same furnace. Pre-heating the furnace with biogas achieved the same result as diesel fuel; the temperature at the hot air inlet of the dryer reached 110°C. The output of SCR in 1998 in China was 300 000 tons and 2 kg – 3 kg of diesel fuel were consumed for processing one ton of SCR, then 600 tons – 900 tons of diesel fuel could be saved, if biogas was used instead of diesel fuel. In addition, the kinetic energy for atomising the heavy oil and diesel fuel could also be eliminated by the use of biogas.

Economic Analysis

A comparison between the costs of effluent treatment of a four-ton SCR processing factory with and without biogas recovery is shown in *Table 6*. The data of the former results are from the actual experiment, while the latter is from evaluation.

As shown in *Table 6*, the capital cost for effluent treatment with biogas recovery in a four-ton daily SCR processing factory is RMB 153 500 yuan. The annual operation

TABLE 6. A COMPARISON OF COSTS OF EFFLUENT TREATMENT FOR A FOUR-TON SCR PROCESSING FACTORY

	Description	Number	With biogas recovery RMB 1000 yuan	Without biogas recovery RMB 1000 yuan
Capital cost	50 m^3 fermentation ponds	2	30	30
	20 m^3 latex serum pond	1	6	6
	30 m^3 settling basin	1	9	9
	15 m^2 laboratory and pump room	1	6	6
	50 m^3 biogas tank	1	50	/
	500 m^3 oxidation pond	4	40	40
	Effluent pump	1	1.5	1.5
	Fresh water pump	1	1.0	1.0
	Piping, instrument and installation fees		10	10
	Amount		153.5	103.5
Operation cost (year)	Management	1 person	10	10
	Electric power (200 days)	800 kWh	0.8	0.8
	Maintenance (estimated)		3	2
	Amount		13.8	12.8

cost and the depreciation cost (based on a depreciation period of ten years) are RMB 13 800 yuan and 15 350 yuan, respectively. The costs total up to RMB 29 150 yuan. If biogas was utilised, the fuel cost of RMB 24 800 yuan for a year could be saved (the biogas produced each year is equivalent to 12 400 kg of fuel, the fuel price is RMB 2 yuan per kg). After considering these two items, the expenditure was RMB 4350 yuan annually.

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