Journal of Environmental Sciences Vol.10, No.4, pp.418—422, 1998 ISSN 1001—0742

New process for anaerobic treatment of Vitamin C wastewater in a full scale plant

Huang Qun-xian, Luo Ren-ming

Hebei College of Chemical Technology and Light Industry, Shijiazhuang 050018, China

Wu Zhi-qiang, Wang Yu

First Pharmaceutical Factory in Shijiazhuang, Shijiazhuang 050051, China

Abstract—Wastewater reforming was done rationally on technological process and equipment for treating Vitamin C wastewater with full scale UBF. High concentration wastewater was mixed with recycle effluent from anaerobic treatment, so influent COD was reduced and total alkalinity was increased, meanwhile, appropriate hydraulic loading to the reactor was controlled during its running, thus treatment capacity of reactor was improved. Volumetric loading rate was raised from 6.0 kg COD/($m^3 \cdot d$) to 10.0 kg COD/($m^3 \cdot d$), biogas production rate was raised from 1.8 m^3/($m^3 \cdot d$) to 3.2 m^3/($m^3 \cdot d$), the amount of alkali and dilution water for adjusting pH were also reduced.

Keywords: Vitamin C wastewater; UBF reactor; hydraulic load; recirculation; digestion.

1 Introduction

The First Pharmaceutical Factory in Shijiazhuang City, China, built a set of equipment of full scale treating Vitamin C wastewater in 1991. Its main equipment was two upflow anaerobic sludge bed filters and had an effective volume of 150 m^3 each. The system was put into operation in May 1991 and from the nearly five months start-up operation, the parameters of the equipment met the design standard that is, volumetric loading rate was 6 kg COD/($m^3 \cdot d$), COD removal rate was higher than 80%; biogas production rate was 1.8 m^3/($m^3 \cdot d$). In 1993, the new processing study was achieved.

2 Wastewater quality

The First Pharmaceutical Factory in Shijiazhuang City produces Vitamin C with two-step fermentation technology. In the production, there are many sources high concentration organic wastewater. They are methanol, ethanol, methanoic acid, protein, phosphoric acid *etc*. in the wastewater, and it trends to acidic. Wastewater flows into the storing-tank which is near the workshop. The COD of wastewater is about 80—100 g/L after mixing in storing-tank. The wastewater situation from every main work step is shown in Table 1.

Table 1 Wastewater situation of various main processes

Preface order	Production precess	Wastewater categories	Color	Main pollutants
1	Fermentation	Water of washing tank	Light yellow	Protein
2	Extraction	Resin regeneration fluid	No color	Inorganic acid
		Ethanol remainder fluid	Brown black color	Ethanol, organic substance
3	Transformation	Secondary fluid	Brown black color	Methanol, VC, organic substance
		Methanol remainder fluid	Brown black color	Methanol, organic substance
4	Refinement	Repeated fluid	Brown black color	VC, organic substance

3 Reforms of original technological process

3.1 Original treatment technological process

Fig.1 shows the original process.

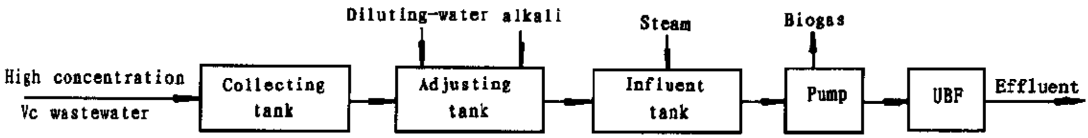

Fig.1 The original anaerobic treatment process

3.2 New treatment process

Fig.2 shows the new process.

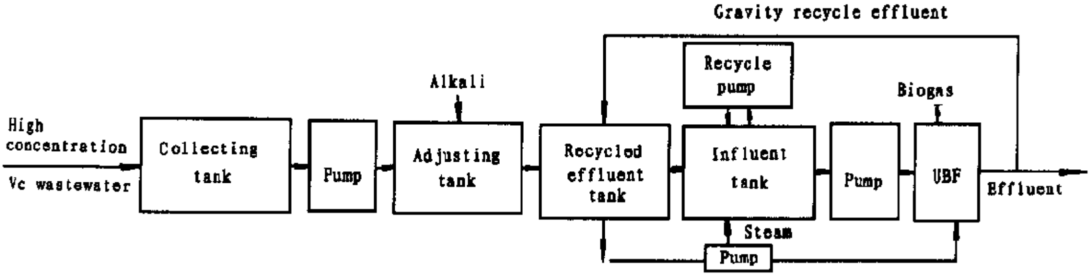

Fig.2 Reformed anaerobic treatment technology

High concentration organic wastewater flows into collecting-tank from VC workshop first, and then is pumped to adjusting-tank, after this, to recycle-tank after pH is adjusted with alkali. By gravity-recycle-effluent anaerobic effluent flows to recycling effluent-tank and is mixed with high concentration wastewater. The wastewater in recycling effluent-tank flow into influent-tank. In this tank, water quality can be averaged by recycling-pump. Moreover, water temperature is raised by steam. The wastewater in influent-tank pumped to anaerobic reactor from the lower. After anaerobic treatment in UBF, a portion of effluent return to recycle-tank, the other is discharged to aerobic biological treatment equipment for further treatment. Through gas-water separating equipment, butter jar produced biogas gets to gas-closet. Little sludge could come out together with effluent, the sludge will deposits in lower part of recycling effluent-tank, it is to anaerobic reactor in due time. The main equipment are two

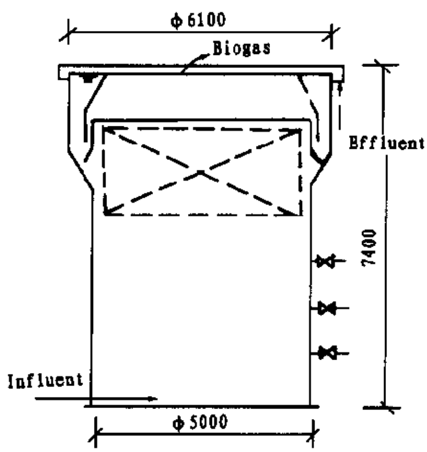

Fig.3 The structure of reactor

UBF reactors. It's volumetric capacity is 150 m^3, the diameter at bottom is 5m and the total height is 7.4m. Suspended sludge is stored in lower part, the upper part is filter bed with fiber stuffing (Fig.3).

4 The content of study

After finishing reforms of the recycle effluent equipment, the system starts to operate. First, operation depends on the former designing technology and operating condition, when every item reaches the former designing standard and operated stably for a time, and then operation starts accords to the reformed technological and operating condition: raise equipment load, adjust the rate of recirculation and study about high load stable-operation and so on.

4.1 Increasing loading

By diluting high concentration water with effluent from anaerobic treatment after a step's operation, loading rate is raised from 6 kg COD/(m^3·d) to 10.0 kg COD m^3/(m^3·d), the data are shown in Table 2.

Table 2 The data of operation during the stage of load rise

Date	Influent capacity, m^3/d	Influent pH	Influent COD, g/L	Effluent pH	Effluent COD, g/L	COD removal rate, %	COD volumetric loading rate, kg/(m^3·d)
94.9.12—13	12.0	5.0	75.7	7.1—7.3	1.01	98.7	6.1
9.14—18	14.4	5.0	75.7	7.3—7.5	2.11	97.2	7.3
9.19—10.5	16.8	6.0	72.2	7.2—7.9	3.13	95.7	8.1
10.6—11	15.0	6.0	89.9	7.4—7.8	4.41	95.1	9.0
10.12—17	16.0	6.0	93.3	7.3—7.7	4.70	95.0	10.0

4.2 Adjusting recirculation ratio

Recirculation ratio is defined as the amount of recirculation divided by the amount of influent, that is to, $r = Qr/Q$, and is shown in Fig.4.

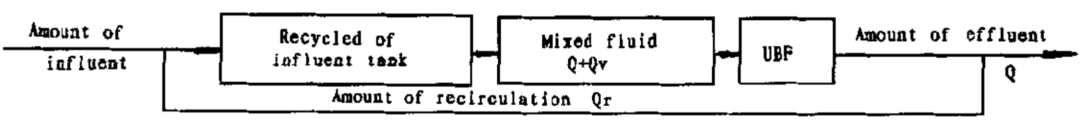

Fig.4 The relationship between the amount of recirculation and the amount of influent

The hydraulic load of the reactor is related to the amount of influent. The formation of granular sludge of UBF depends on certain hydraulic load. Anaerobic sludge starts to be graded when the hydraulic load gets to 0.25 m^3/(m^2·h). When it is 0.2—0.6 m^3/(m^2·h), it is suitable for sludge to gradually grow through bioadsorption. It is possible for minute coagulating sludge to return to the bottom of the reactor, or at top, be intercepted and absorbed by soft stuffing. Generally, the hydraulic load is below 0.6—0.8 m^3/(m^2·h). So, the maximum amount of influent to reactor is 11.76 m^3/h, hydraulic load is 0.6 m^3/(m^2·h).

The relation among volumetric loading rate, hydraulic load, the amount of recycle and the ratio of circulation. Supposing VC wastewater influent COD concentration is 100 g/L, when hydraulic load is 0.2—0.6 m^3/(m^2·h), volumetric loading rate is 6—10 kg COD/(m^3·d). The relation among influent Q(m^3/h), amount of recycled water Qr (m^3/h), and the recirculation ratio r is shown in Table 3.

Table 3 The recycled amount and the recirculation ratio

Hydraulic load, $m^3/(m^2\cdot h)$	Volumetric loading rate, kg/($m^3\cdot$d)														
	6			7			8			9			10		
	Q	Qr	r	Q	Qr	r	Q	Qr	r	Q	Qr	r	Q	Qr	r
0.2	0.38	3.55	9.5	0.44	3.48	8.0	0.50	3.42	6.8	0.56	3.36	6.0	0.63	3.30	5.3
0.3	0.38	5.51	14.7	0.44	5.44	12.4	0.50	5.38	10.8	0.56	5.32	9.4	0.63	5.26	8.4
0.4	0.38	7.47	19.9	0.44	7.40	16.9	0.50	7.34	14.7	0.56	7.28	12.9	0.63	7.22	11.5
0.5	0.38	9.43	25.1	0.44	9.36	21.4	0.50	9.30	18.6	0.56	9.24	16.4	0.63	9.18	14.7
0.6	0.38	11.39	30.4	0.44	11.32	25.9	0.50	11.26	22.5	0.56	11.20	19.9	0.63	11.14	17.8

The actual amount of influent to reactor equals $Q + Qr$, from Table 3, the relation among the amount of recycle. Recirculation ratio, hydraulic load and volumetric loading rate are known.

4.3 Stable operation

After the volumetric loading rate is increased to 10 kg COD/($m^3\cdot$d), keep the operation stable for period of time and the data are shown in Table 4.

Table 4 Stable operation data

Date	Amount of influent, m^3/d	Influent pH	Influent COD, g/L	Effluent pH	Effluent COD, g/L	COD removal rate, %	COD volumetric loading rate, kg/($m^3\cdot$d)
1994.10.18	16.0	4.6	93.1	7.5	6.35	93.2	9.9
19	16.0	5.1	93.1	7.8	6.74	92.8	9.9
20	16.8	4.8	100	7.8	3.04	97.0	11.2
21	16.8	4.3	100	7.4	4.49	95.5	11.2
22	16.8	4.4	100	7.8	5.52	94.5	11.2
23	16.8	4.2	100	7.9	4.80	95.2	11.2
24	16.8	4.9	100	7.5	3.67	96.3	11.2
25	16.8	5.3	100	7.5	3.32	96.7	11.2
26	16.8	5.7	100	7.4	4.31	95.7	11.2
27	16.8	5.6	100	7.3	4.34	95.7	11.2
28	16.8	6.0	100	7.8	4.33	95.7	11.2
29	16.8	4.6	100	7.4	5.45	94.6	11.2
30	16.6	5.1	90.6	7.6	4.64	95.4	10.0
31	16.6	4.7	90.6	7.5	3.97	96.0	10.0

The hydraulic load is raised with recycle technology. With the operation condition of 0.2—0.6 $m^3/(m^2\cdot h)$ hydraulic load is carried out, it's beneficial to anaerobic sludge forming granular sludge. When we watch sludge of reactor, it seems like corns and this can prove that there is a large amount of granular sludge in the reactor.

Because of the formation of granular sludge, it has strong capacity to degrade organism. Moreover, it is easy to deposit and return sludge. In this experiment stage, the concentration of sludge in reactor is raised from 69 g/L to 78 g/L.

When wastewater is sufficiently mixed in the influent-tank, because the amount of recycle is many times higher than the amount of influent, and pH is above 7 slightly, it can raise the actual pH of wastewater which enters reactor, it can also meet needs of alkalinity that wastewater in the reactor requires.

5 Conclusion

The main summary of new processing of Vitamin C wastewater treatment by anaerobic method in full scale, is the mixing of anaerobic effluent recycle and high concentration influent, adjusting appropriate pH, controlling the proper ratio of recycle, maintaining proper hydraulic load or UBF reactor. From experiment, following conclusion can be obtained:

(1) 150 m^3 UBF treating VC wastewater uses effluent recirculation technology, and volumetric loading rate can reach 10 kg COD/($m^3 \cdot d$) and a stable operation can also be gained.

(2) The former wastewater concentration can be controlled between 80 and 100 g/L COD. Anaerobic system can treat high concentration organic wastewater directly, and COD removal rate can get to above 90% when pH of influent is 4.0—6.0.

(3) When volumetric loading rate is 0.2—0.3 $m^3/(m^2 \cdot h)$, the reactor can cultivate the bigger granular sludge.

References

Luo R. China Water & Wastewater, 1988, 4(2):10—15
Yang J. China Biogas, 1995, 13(1):7—11

(Received for review September 4, 1997. Accepted March 1, 1998)