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Research Article

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Application of bioaugmentation for natural rubber wastewater treatment in A_2O process

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ABSTRACT

Taking wastewater treatment project in a natural rubber processing plant in Xishuangbanna for example, this paper introduces the operation of natural rubber wastewater treatment in A_2O under bioaugmentation. The project adopted the wastewater treatment process of sand settling, anaerobic, oxygen deficit, aerobic, sedimentation and disinfection. At stable operation, indexes of PH, SS, COD, BOD_5 and NH_3-N in outlet water reached 7.43, 35mg/L, 40mg/L, 18mg/L and 0.27mg/L respectively. The quality of outlet water reached grade I discharge standard specified in Sewage Comprehensive Discharge Standard (GB8987—1996), and also reached urban reclaimed water reuse standard.

Keywords: Bioaugmentation, Dominant bacteria, Natural rubber wastewater, A^2O process, Engineering application

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INTRODUCTION

Natural rubber processing plants in Xishuangbanna, Yunnan usually use latex and scrap as raw materials. Wastewater generated by latex has high concentration while wastewater generated by scrap has low concentration. Wastewater usually contains a small amount of unset latex and serum, a large amount of proteins, carbohydrates, sugar, lipid, carotenoids, and organic and inorganic salt. Washing water produced in various processing stages is also contained. (1) Besides, since a large amount of ammonia was added in fresh latex when staying at the farmers' to prevent hardening, wastewater generated in rubber production process is high concentration organic wastewater containing ammonia nitrogen. If the wastewater is discharged without treatment, these compounds vulnerable to be degraded by bacteria can easily cause eutrophication of receiving water to increase nutrients of algae and aquatic plant, thus leading to oxygen depletion in river and death of fish. (2) Bioaugmentation is to add microorganisms of specific function to traditional biological treatment system to enhance the ability of degradation of specific contaminants. The purpose is to improve the effect of the entire treatment system for the removal of hardly degradable substances in wastewater. Bioaugmentation can significantly improve the quantity of functional strains, stabilize microbial colony structure and decrease the startup time.

Researchers before once proposed the research on the application of bio-film process in the actual industrial wastewater. By so far, there is seldom engineering research report on the application of bioaugmentation for rubber industrial wastewater in bio-film system.

WASTEWATER QUALITY INDEXESs AND CHINESE NATIONAL DIACHARGE STANDARD
Rubber wastewater is high concentration organic wastewater with complicated composition. It is characterized by seasonal discharge and large water quantity fluctuation, high concentration of organic matters, good biochemical property, high SS concentration, acid wastewater, particularly high ammonia nitrogen concentration, high S^{2-}

concentration, easy for the growth of sulfur bacteria and other filamentous bacteria and constraint of the growth of other bacteria. See rubber wastewater quality and discharge standard as shown in Table 1.

Table 1 Wastewater Quality and Discharge Standards

Parameters [a]	Wastewater quality	Discharge standard of wastewater pollution for natural rubber processing NY687-2003—Standard A	National Industrial Water Quality- Washing Water Quality Standard GB/T 19923-2005
PH	6.5-7.3	6-9	6-9
SS	68-6520	70	30
CODcr	221~4654	100	30
BOD5	52~1049	30	-
NH3-N	11.27~474.86	20	-

a. All other parameters are in mgL^{-1} except pH.

PROCESS FLOW

Process route

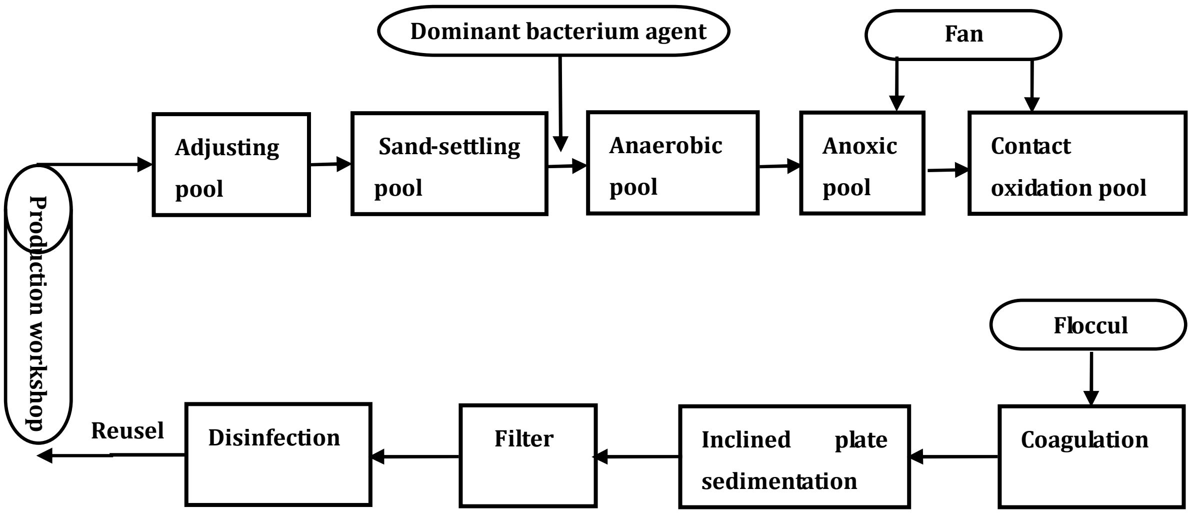

Figure 1 Process Flow

Technical process

The process flow of the project is as shown in Figure 1. Whey after latex coagulation, extrusion wastewater of the presser and first time cleaning water of solidified rubber will first of all enter the collection pool. After mixing, the water performance will be relatively stable. Then, wastewater will enter the sand-settling pool for the settling of silt and impurities.

Wastewater will then overflow from the top of the sand-settling pool to anaerobic tank. Continuously add microbial agent at the inlet of the anaerobic tank. Under the action of a large amount of hydrolytic bacterium and acidate bacteria, insoluble organic matters will be hydrolyzed to be soluble organic matters and macromolecular substances hard for biological degradation will be biodegraded to be small molecular substances, thus improving the biological property of wastewater.

In plug flow, wastewater will go through anaerobic section, anoxic section and then enter the aerobic section. Organic matter degradation and nitrification and denitrification actions will then take place. Oxygen needed by the anoxic bio-film reaction pool will be supplied by air pump. Even oxygen supply can be ensured through the microporous aerator set up at the bottom of the contact oxidation reactor.

3.3 Dominant microbial agent and biological carrier bio-film culturing method

According to characteristics of rubber wastewater and microbial co-metabolic principle and microbial self-adaptive principle, strain screening, restructuring and domestication were implemented repeatedly to build the microbial flora; expanded culturing through fermentation to produce inoculants. Through adding exclusive degradation microbial agents to the system, the treatment efficiency was improved and enhanced and the stability of system operation was also enhanced (4-6).

Combined fiber packing was used as bio-film carrier. Quickly multiplied microorganisms in the water environment then attached to the packing to form microbial flora and microbial film. Co-cultivation method was adopted for biological carrier bio-film culturing (7). Namely, bacterium agent was continuously added in the biological carrier bio-film culturing process for the co-culturing of exogenous microbes and indigenous microorganisms in wastewater.

OPERATION EFFECT

The commissioning of the project started in April 2011 and the project was put into operation formally in August this year. In October, 2011, it was accepted with outlet water indexes reaching designed discharge standards (see table 2, table 3 and table 4).

Anaerobic section and anoxic section treatment effect

After water inflow, exclusive dominant microbial agent was continuously added in the anaerobic pool. The system gradually entered normal operation after 2 months of trial run. After treatment in 3-level anaerobic pool and 1-level anoxic pool, the water color turned from gray to black accompanied by slight odor. It can be seen from the treatment results (table 2), COD_{cr} was reduced from 1997mg/L to 104mg/L at the removal rate of 94.79% on average; BOD5 was reduced from 947mg/L to 68mg/L at the removal rate of 92.82% in this section on average.

Table 2 Anaerobic section Wastewater Treatment Results

	Time	Results			
		2011/10/09	2011/10/11	2011/10/12	Average
PH	Before treatment	6.6	6.59	6.9	6.67
	After treatment	7.39	7.30	7.25	7.31
SS	Before treatment	267	211	123	200
	After treatment	123	61	56	80
	Removal rate (%)	53.93	71.09	54.47	60
NH3-N	Before treatment	65.33	58.54	103.09	75.65
	After treatment	113.74	107.62	138.57	119.98
	Removal rate (%)	—	—	—	—
CODcr	Before treatment	1490	2000	2500	1997
	After treatment	101	101	109	104
	Removal rate (%)	93.22	94.95	95.64	94.79
BOD5	Before treatment	1470	1247	1447	947
	After treatment	68	67	69	68
	Removal rate (%)	95.37	94.63	95.23	92.82

a. All other parameters are in mgL^{-1} except pH.

Aerobic section treatment effect

After 45 days of domestication for strain in biological contact oxidation pool, the packing has been attached with thick bio-film. In spite of continuous operation culturing later, the thickness of the bio-film was unchanged and basically maintained at this level. DO value in the aeration pool was maintained at around 2.5mg/L. It can be seen from aerobic section bio-film system treatment results (table 3) that COD_{cr} was reduced from 104mg/L to 40mg/L after aeration at the removal rate of 61.54% on average; BOD5 was reduced from 68mg/L to 19mg/L after aeration at the removal rate of 72.06% on average; NH3-N was reduced from 119.98mg/L to 7.35mg/L after aeration at the removal rate of 93.87% on average.

Table 3 Aerobic Section Wastewater Treatment Results

	Time	Results			
		2011/10/09	2011/10/11	2011/10/12	Average
PH	Before treatment	7.39	7.30	7.25	7.31
	After treatment	7.67	7.6	7.64	7.64
SS	Before treatment	123	61	56	80
	After treatment	50	23	24	32
	Removal rate (%)	59.35	62.30	57.14	60.00
NH3-N	Before treatment	113.74	107.62	138.57	119.98
	After treatment	3.12	9.46	9.46	7.35
	Removal rate (%)	97.26	91.21	93.17	93.87
CODcr	Before treatment	101	101	109	104
	After treatment	41	39	40	40
	Removal rate (%)	59.41	61.39	63.30	61.54
BOD5	Before treatment	68	67	69	68
	After treatment	23	17	17	19
	Removal rate (%)	66.18	74.63	75.36	72.06

a. All other parameters are in mgL^{-1} except pH.

Process operation results analysis

Table 4 lists water quality monitoring results at the outlet of the middle pool. Combining table 2, table 3 table 4, A^2O can be regarded as a technically feasible process for natural rubber wastewater treatment with stable effect. COD_{cr}

and BOD_5 were reduced from 1997mg/L to 38mg/L at the removal rate of 98.10%, and from 947mg/L to 18mg/L at the removal rate of 98.09% respectively. The average discharge concentration of NH_3-N was 15mg/L. Although slight out-of-standard of BOD_5 appeared at the beginning, after the system reached stable operation, outlet water quality reached grade I discharge standard as specified in *Sewage Comprehensive Discharge Standard* (GB8987-1996), and also reached urban reclaimed water reuse standard.

Table 4 Outlet Water Quality Monitoring Results

	Time	Results			
		2011/10/09	2011/10/11	2011/10/12	Average
PH	Monitored value	7.52	7.40	7.39	7.43
	Standard value	6-9	6-9	6-9	6-9
	Evaluation results	Standard	Standard	Standard	Standard
SS	Monitored value	23	43	40	35
	Standard value	70	70	70	70
	Evaluation results	Standard	Standard	Standard	Standard
NH3-N	Monitored value	0.21	0.14	0.45	0.27
	Standard value	15	15	15	15
	Evaluation results	Standard	Standard	Standard	Standard
CODcr	Monitored value	40	38	43	40
	Standard value	100	100	100	100
	Evaluation results	Standard	Standard	Standard	Standard
BOD5	Monitored value	21	15	17	18
	Standard value	20	20	20	20
	Evaluation results	OFS by 0.05 times	Standard	Standard	Standard

a. All other parameters are in mgL^{-1} except pH.

CONCLUTION

Natural rubber wastewater has complex composition and large variation of water quantity and quality. The following aspects shall be considered in the design process: the adjusting pool shall be designed to the volume at least adequate for water produced in a production cycle, thus achieving the purpose of even water quality and balanced water quantity and reducing impact load; select suitable pre-treatment section to reduce pollutant concentration and pressure of follow-up treatment sections; ensure certain DO concentration and ensure aerobic microorganisms oxygen demand; at the system startup stage, co-culturing of exogenous microbes and indigenous microorganisms in wastewater shall be adopted for bio-film culturing; in the system operation stage, continuous adding of bacterium agent shall be ensured to ensure microbial populations in the system. The treatment of natural rubber wastewater by bioaugmentation has good application prospect.

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