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The addition of microbes for treating textile wastewater

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Abstract—Some strains and culture of bacteria which are able to decolorize dyes and degrade polyvinyl alcohol(PVA) were isolated and selected. A pilot scale facultative anaerobic-aerobic biological process was applied for treatment of textile wastewater containing dyes and PVA. Activated carbon adsorption was used as a tertiary treatment stage, and residual sludge from clarifier returned to the anaerobic reactor again. The pilot test were carried out with two systems. One was inoculated by acclimated sludge, and the another was adding the mixed culture of dye-decoloring and PVA-degrading bacteria for forming biological films, the latter was observed to be more effective than the former. The test has run normally for ten months with a COD loading of 2.13 kg/m^3/day, a BOD_5 loading of 0.34 kg/m^3/day in anaerobic reactor; a COD loading of 1.71 kg/m^3/day, a BOD_5 loading 0.44 kg/m^3/day in aerobic reactor. The pollutants removal efficiency by adding microbes was about 20% higher than that by acclimated sludge. The average removal efficiency of COD stood about 92%, BOD_5 97%, PVA 90% and decolorization 80%. The other parameters of effluent quality are also satisfactory.

Keywords: addition of microbes; facultative anaerobic-aerobic process; textile waste water.

INTRODUCTION

Textile wastewater contains various kinds of macromolecular compounds, including, dyestuffs and auxiliary agents, which are more difficult to biotreatment. However, activated sludge process for treatment of textile mill wastewater has been frequently used, the quality of effluent could not be desirable, especially color. Ogawa (1981) reported that a continues test was applied to improve the biological treatment for waste dye-liquor by an azo dye assimilating bacterium. Some basic researches on biodegradation of azo dyes indicated that decolorization of azo dyes with microorganisms was carried out by azo-reducing enzyme (Kulla, 1983). The treatment

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of wastewater containing PVA by activated sludge which made up from a PVA-assimilating bacterium was discussed (Suzuli, 1973). A pair of PVA-utilizing symbiont were isolated and were possible for treatment of PVA wastewater (Shimao, 1984).

In this paper, a facultative anaerobic-aerobic process for treatment of textile wastewater containing dyestuffs and PVA was proposed, and the efficiency of treatment by acclimated sludge was compared with that by dye-decoloring and PVA-degrading bacterial mixed culture for forming biofilms.

MATERIAL AND METHODS

The schematic flow diagram of the pilot experiments is shown in Fig.1. Two filters of equal size—2m (diameter) × 3.2m (height) were used as static submerged biofilter and aerated submerged biofilter. The former was facultative anaerobic and the latter was aerobic, within the filter 310 stings of fiber media were installed. Activated carbon filter (diameter 1.6m; height 1.2m) was linked up with clarifier. The residual sludge was returned from clarifier to static biofilter.

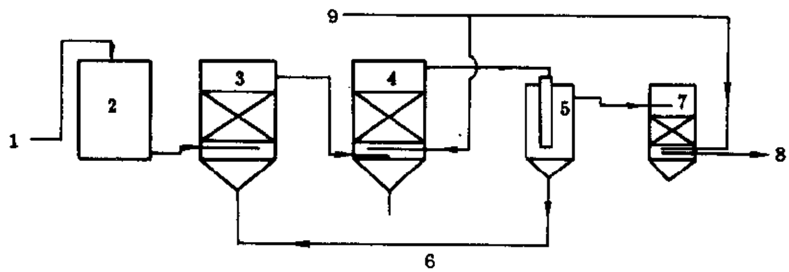

Fig. 1 Schematic flow diagram of pilot run

1. raw wastewater; 2. wastewater regulating tank;
3. static biofilter; 4. aerated biofilter;
5. clarifier; 6. returned sludge;
7. activated carbon filter;
8. effluent outlet; 9. air supply

For comparing the effects of treatment between acclimated sludge and bacterial mixed culture, two systems were applied. In system I both filter were inoculated with acclimated sludge. In system II the dye-decoloring bacterial culture was added into the static filter and the PVA-degrading bacterial mixed culture into the aerobic filter for forming biological films. The character of raw wastewater is shown in Table 1. During the experiment, COD, BOD_5 and color of the influent were changed with a wide range, which made difficult of the treatment.

Table 1 The characters of raw wastewater

Parameters	Minimum value	Maximum value
pH	7	13
COD	200 ppm	1980 ppm
BOD_5	120 ppm	1980 ppm
Detergent (ABS)	1.89 ppm	3.53 ppm
Color (dilution ratio)	20	500

EXPERIMENTAL RESULTS

Microorganisms

Dye-decoloring bacteria and PVA-degrading mixed bacterial culture were isolated from sludge and soil. As shown in Table 2 seven strains of bacteria, including Altermonas D32, D33, Alcaligenes D27, Pseudomonas D41, S42, S59 and Paracoccus S98 are able to remove color more than 10 kinds of dyestuffs under the static condition. Of these strains, Alteromonas D32 and D33 most effectively decolorized dyes.

Table 2 Bacterial decolorization of various dyestuffs*

Dyestuffs	Bacteria strains						
	D32	D33	D41	D27	S42	S59	S98
Acid red B	+++	+++	+++	+++	+++	+++	+++
Acid mordant brown RH	+++	+++	+++	+	+	+++	+++
Mordant blue B	–	–	+++	–	+	+++	++
Dimond chrome red B	+++	+++	–	–	–	+++	+++
Mordant grey B	+++	+++	+++	–	+	+	+
Mordant orange G	+++	+++	++	–	–	–	–
Direct dark brown M	+++	+++	+	–	–	+++	+++
Direct red brown RN	+++	+++	–	+++	–	–	–
Cibacron violet K3R	+++	+++	–	–	–	–	–
Cibacron red brown KB3R	+++	+++	–	–	–	++	+
Cibacron blue KGL	–	–	–	–	++	+++	+

*Number of "+" signs represents degree of decolorization; "–"=no decolorization

The mixed bacterial culture No. 65, which can degrade PVA and utilize PVA as a sourse of carbon for growth under the aerobic condition was selected. The contents of cells reached a maximum in 2 days. The degradation of PVA still occurs, when the alive cells have been decreasing (Fig. 2).

Cultivation of biological films in biofilter

Acclimated sludge and cultural liquid of mixed bacteria were added into biofilter of system I and system II at a dosage of 3–5% respectively. The raw wastewater after 7 days incubation and aeration at room temperature (15–20°) was slowly flowed at flow rate of 0.2 m^3/h. The biofilms

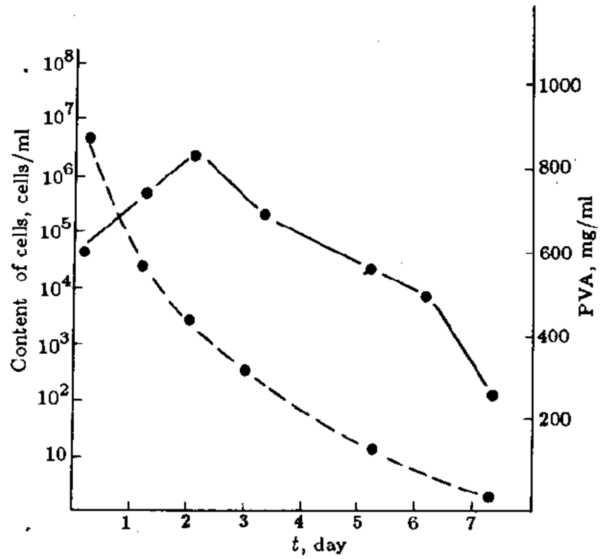

Fig. 2 Utilization of PVA by mixed bacterial culture No.65

1. Content of cells, cells/ml
2. Concentration of PVA, mg/L

were developed. During the formation of biological films the efficiencies of COD removal for two systems were compared. The results in Fig. 3 show that the system II was observed to be effective than system I.

Operation of the pilot test

The pilot test has been normal run since the establishment of facultative anaerobic-aerobic treatment system for ten months, with average COD loading of 2.13 kg/m^3/day, BOD_5 loading of 0.34 kg/m^3/day in static submerged biofilter, and COD loading of 1.71 kg/m^3/day, BOD_5 loading of 0.44 kg/m^3/day in aerated submerged biofilter, where dissolved oxygen was within the range of 1.65–2.5 ppm. The results of efficiency for treatment of textile wastewater in Table 3 and Table 4 show that the desirable effect was obtained in both treatment system I and system II. The effluent from two-stage biotreatment in system I had an average COD content of 232.38 ppm; BOD_5 23.92 ppm; PVA 62.65 ppm; color 28.25 dilution ratio and in system II the quality of effluent was better than in system I, COD content of effluent was 147.82 ppm; BOD_5 12.57 ppm; PVA 29.69 ppm; color 19.21 dilution ratio. After treatment with activated

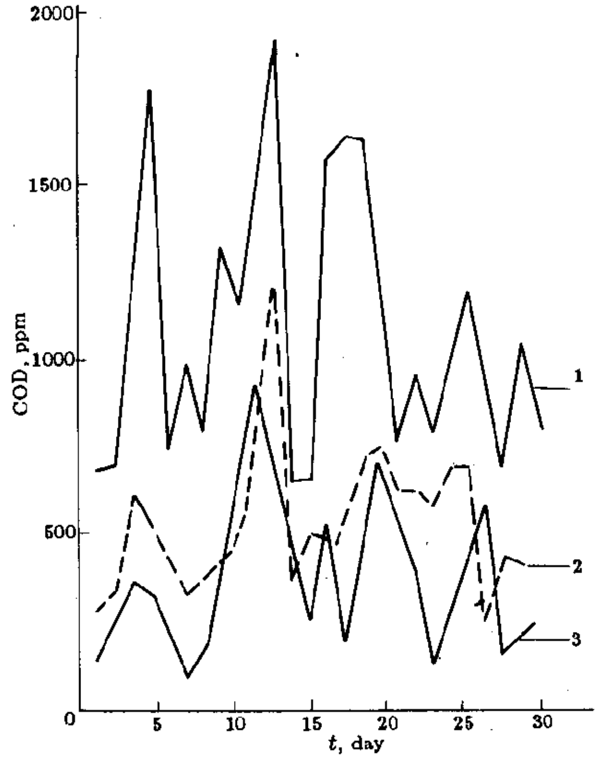

Fig. 3 Efficiency of COD removal during biological film formation
1. influent 2. effluent of system I 3. effluent of system II

carbon filter the total average COD content reached 70–45.8 ppm and BOD_5 3.88–3.22 ppm. The other parameters of effluent were also satisfactory.

Table 3 Effluent concentration of main parameters with treatment of system I

Parameters	Influent, ppm	Effluent, ppm Static filter	Aerated filter	Activated carbon
COD	747.88	667.58	232.38	70
BOD_5	137.52	145.84	23.92	3.8
PVA	123.17	116.05	62.65	16.51
Color (dilution ratio)	68.85	51.87	28.25	13.92
Detergent (ABS)	2.71	2.38	0.5	0.046
pH	9.2	8	7.2	7.2

Table 4 Effluent concentration of main parameters with treatment of system II

Parameters	Influent, ppm	Effluent, ppm Static filter	Aerated filter	Activated carbon
COD	678.31	574.24	147.82	45.8
BOD_5	156.00	132.99	12.57	3.22
PVA	133.64	115.91	29.69	10.71
Color (dilution ratio)	64.27	40.16	19.12	10.15
Detergent (ABS)	2.71	2.18	0.38	0.06
pH	9.2	7.8	7.0	7.0

To understand the role of various reactors in treatment of the textile wastewater we have made a contrast of removal percentage. The results in Table 5 indicate that the removal percentages of different parameters with treatment of two-stage biofilter in system II were 10–20% higher than that in system I. At the first stage (static filter) the removal percentages of COD, BOD_5 and PVA were rather low, however removal of color stood approximately 50% of total removal. It was more obvious in system II. Therefore, we may suggest that the static reactor has played an important role in removal of color. At the second stage (aerated filter) the removal percentage of all parameters has been increased. The tertiary stage (activated carbon filter) gave the assurance that the quality of effluent reached the highest standards.

Table 5 Removal percentage of three stages in system I and system II

Parameters	Removal percentage, % Static filter		Aerated filter		Activated carbon	
	System I	System II	System I	System II	System I	System II
COD	10.73	15.34	68.93	78.20	88.01	91.95
BOD_5	–	14.70	82.60	91.94	96.81	96.63
PVA	5.7	13.26	57.25	77.78	77.18	89.87
Color (dilution ratio)	24.66	37.51	58.69	70.11	76.83	79.64

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