Comparison between conventional and fixed film sequencing batch reactors in the treatment of screened dairy manure

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Lo, K.V. and Liao, P.H. 1995. **Comparison between conventional and fixed film sequencing batch reactors in the treatment of screened dairy manure.** Can. Agric. Eng. 37:335-337. Two 5.0 litre laboratory-scale sequencing batch reactors (SBRs) operated at room temperature were used to treat screened dairy manure. One reactor was modified through the installation of a fixed-film structure made from pinewood panels so as to comprise a fixed-film SBR (FFSBR). The fixed-film structure was positioned on the upper part of the FFSBR reactor in such a way that it did not alter or disturb the operation of the SBR system. When both reactors were operated at a short cycle coupled with a relatively high organic loading rate, the fixed-film microbial retention in the FFSBR improved process stability and treatment efficiency.

Deux réacteurs biologiques séquentiels (RBS) de 5.0 litres ont été utilisés pour traiter, à la température de la pièce, du lisier de vaches laitières. Un des réacteurs fut modifié en installant une structure rigide faite de panneaux de bois de pin pour créer un RBS a film fixe (RBSFF). La structure a été placée dans la partie supérieure du réacteur de façon à ne pas gèner l'opération du RSB. Lors de l'opération des deux réacteurs en cycle court avec une charge organique relativement élevée, la rétention microbienne du film fixe a améliore la stabilité du procédé et l'efficacité du traitement.

INTRODUCTION

The sequencing batch reactor (SBR) is a fill-and-draw activated-sludge treatment system which is more flexible in terms of plant operation than conventional activated-sludge systems, yet which is capable of treating all wastewaters usually treated by the conventional systems. An SBR system consists of one or more tanks, each capable of waste stabilization and solids separation. The operational cycle of each tank consists of five distinct periods: fill, react, settle, draw, and idle. During the fill period, a predetermined amount of wastewater is introduced to the reactor. It is then degraded by biological sludge during the react period in which aeration is provided. With satisfactory degradation of waste materials, aeration is terminated and the settle period is initiated. Subsequently, the clarified supernatant is removed from the reactor in the draw period (Irvine and Busch 1979).

It has been reported that the treatment efficiency of SBR systems could be improved by the installation of fixed-film materials in a conventional system (Kawabata and Oda 1989). Preliminary data were obtained from an experimental comparison between a conventional SBR system and a fixed film SBR system (FFSBR) for treating screened dairy manure. For the FFSBR, a fixed-film structure made from pinewood panels was positioned in the upper part of a conventional reactor such that it did not alter or disturb the operational norms of the conventional system.

MATERIALS AND METHODS

Materials

The dairy manure slurry was screened through a U.S. series No. 50 Tyler screen (0.295 mm openings) before storage at 4°C. The screened manure was stored for a maximum period of four days. The screened wastewaters had a chemical oxygen demand (COD) concentration of 2000 to 3000 mg/L.

SBR operation

Two 5.0 litre acrylic plastic reactors (460 mm in height and 138 mm in diameter) were set up in the laboratory. The first reactor was a conventional SBR. The second reactor was a conventional SBR converted to an FFSBR by installing a fixed-film structure made from 3 mm thick pinewood panels. Two sets of two parallel panels were slotted together at right angles. The calculated surface area of the fixed film was 0.108 m^2. The fixed-film structure was positioned about 100 mm above the reactor bottom and 50 mm below the operating fluid level.

First period In this initial period, the reactors were operated at a cycle of 4 hours with a 3 hour react phase (aeration). The influent was introduced all at once in the beginning of the react phase (0.1 hours). Three different amounts of wastewater (3, 2, 1 L) were treated in each cycle, the treated wastewaters per day were 18, 12, and 6 L, respectively. The corresponding hydraulic retention times (HRT) were 0.28, 0.42, and 0.83 days. The average loading rates were calculated as 0.69, 1.38, and 2.45 g BOD_5/L reactor day, respectively. Both reactors were operated at 22±2°C.

Second period In the second period, a cycle of 3 hours with a 2 hour react phase (aeration) was chosen. The HRTs were 0.62, 0.31, and 0.21 days for 3, 2, and 1 L withdrawal, respectively. The corresponding loadings were 1.03, 1.87, and 2.53 g BOD_5/L reactor day. Both reactors were again operated at 22±2°C.

Analysis

The biochemical oxygen demand (BOD_5), COD, total solids

Table I: Summary of treatment efficiency in period I

Organic loading rate (g BOD_5/L reactor day)		Influent concentration (mg/L)	Effluent concentration (mg/L)		Removal (%)	
			FFSBR	SBR	FFSBR	SBR
0.69	BOD_5	575±57	25.4±10	17.1±7.7	96	97
	COD	3122±454	462±165	520±100	85	83
	NH_3-N	30.3±20.3	1.12±0.4	0.9±0.17	93	97
	NO_3-N	2.3±2.2	6.3±7.7	2.1±2.2	-	-
	TS	2968±445	836±15	773±17	72	74
1.38	BOD_5	574±206	29.3±20	27.3±5.1	95	95
	COD	2752±941	503±21	499±75	82	82
	NH_3-N	25.5±0	7.8±8.8	8.8±8.3	70	66
	NO_3-N	0.62±0.03	0.53±0.14	1.48±2.1	-	-
	TS	1970±32	774±4	782±5	61	60
2.45	BOD_5	681±167	97.4±25	62.3±46	86	92
	COD	2519±220	714±52	509±122	72	80
	NH_3-N	19.4±11.7	10.9±10.7	7.8±9.4	44	60
	NO_3-N	6.59±38	0.21±0.01	0.29±0.18	-	-
	TS	2420±38	947±3	770±168	61	68

Table II: Summary of treatment efficiency in period II

Organic loading rate (g BOD_5/L reactor day)		Influent concentration (mg/L)	Effluent concentration (mg/L)		Removal (%)	
			FFSBR	SBR	FFSBR	SBR
1.03	BOD_5	644±136	17.5±2.1	31.5±4.8	97	95
	COD	3684±332	499±134	487±151	76	77
	NH_3-N	28.7±6.2	2.6±0.3	3.4±1.4	91	88
	NO_3-N	1.9±0.2	2.3±1.3	1.9±0.9	-	-
	TS	3235±46	628	644	81	80
1.87	BOD_5	585±42	77±16	106±34	87	82
	COD	2964±121	682±50	794±115	77	73
	NH_3-N	44±8.1	23.7±5.9	21±2.3	46	52
	NO_3-N	0.6±0.3	0.96±0.48	0.69±0.62	-	-
	TS	3225±9	90±6	881±19	82	73
2.53	BOD_5	527±30	210±48	-	60	-
	COD	2694±114	1065±148	-	60	-
	NH_3-N	20.9±12.1	14.3±13.8	-	32	-
	NO_3-N	0.8±0.028	0.29±0.03	-	-	-
	TS	2620±14	1210±16	-	54	-

(TS), volatile solids (VS), ammonium (NH_4), and nitrate (NO_3) were determined as described in the Standard Methods (APHA 1985).

RESULTS AND DISCUSSION

First period

In the first period, the treatment efficiencies were similar in the two reactors up to a loading rate of 1.38 g BOD_5/L reactor day (Table I). The BOD5 removal efficiencies were also very high in both (about 95%). As the organic loading increased to 2.45 g BOD_5/L reactor day, the treatment efficiency decreased. Average BOD_5 reductions were 91% for the SBR and 86% for the FFSBR.

The lower efficiency of the FFSBR is attributed to the volume of sludge in the reactor. The FFSBR had approximately 20% less suspended sludge than the SBR. Visual observations also indicated that the biofilm had not fully developed on the surface of the pinewood panels at this time. As such, the FFSBR was in effect functioning as an SBR system during this first period.

Second period

In contrast to the first period, the treatment efficiency of both reactors in terms of BOD_5, COD, and TS removal decreased with an increased organic loading rate during the second period (Table II). The differences in treatment efficiency between the FFSBR and SBR widened when the organic loading increased. With a high organic loading and a short react period (2 h), 60% BOD_5 removal was maintained for the FFSBR after an operating period of 42 cycles. SBR operation could not, however, be sustained under these conditions. Thus fixed-film microbial retention appears to have rendered the FFSBR more tolerant of higher organic loading, offering improved stability, and efficiency over the conventional SBR. Given these indications of considerable potential for the FFSBR, further studies are being planned to investigate the effects that changes in the react period and in the level of organic loading might have on the FFSBR process.

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