TREATMENT OF DAIRY WASTEWATER USING PILOT SCALE TRICKLING FILTER

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Abstract A pilot scale trickling filter and secondary sedimentation are used to evaluate the feasibility of this process for the treatment of raw dairy waste. The BOD in the raw waste of 252 to 1200 mg/l is reduced 50-73% by a single stage and a further 17-55% by sedimentation tank. Treatment efficiencies are determined at various waste strengths and influent flow rates. With a loading rate of 5-12 kg BOD/m^3 per day the average BOD reduction is between 50-60%. The average effluent suspended solid is 15 mg/l and lactose is removed completely but total nitrogen is reduced approximately 30% for the entire study.

چکیده قابلیت یک واحد نیمه صنعتی صافی چکیده بمنظور تصفیه بیولوژیکی پساب صنایع شیریابی-او-دی: ۲۵۲ الی ۱۲۰۰ میلی گرم در لیتر مورد مطالعه قرار گرفته است. کاهش مقدار بی-او-دی ۵، در فاضلاب خروجی از واحد تصفیه کننده قبل از تانک ته نشینی بین ۵۰ تا ۷۳ درصد و بعداز آن در حدود ۹۰ درصد بدست آمد. نتایج بدست آمده در غلظت و شدت جریانهای مختلف پساب نشان داد که با بار ورودی بین ۵ تا ۱۲ $\frac{\text{کیلوگرم بی-او-دی}}{\text{روز متر مکعب}}$ متوسط کاهش بی-او-دی ۶۰ درصد است. دراین فرآیند غلظت لاکتوز در پساب خروجی به حدود صفر می رسد و ۳۰ درصد نیتروژن کل نیز حذف می گردد.

INTRODUCTION

Secondary or biological treatment of wastewater has been provided principally by the activated sludge, trickling filter and rotating biological contact reactor [1-4]. The first can be described as a slurry or suspension process while, the other two are fixed film process. The trickling filter process is readily accepted and widely used because of its simplicity and low operating costs, however, a number of economic and operating problems like clogging by excess biomass exists in the system [5-7]. Recent research has been done on this process, using a packed bed of synthetic media with both air and pure oxygen for aeration. Air is introduced beneath the media to aerate the wastewater and help strip the excess biomass which develops on the packing [8, 9]. Nordstedt et al. [10] have studied the effect of media type and inoculum size on the digestion of whey in anaerobic fixed bed reactors. Two media types, pine wood chips and plastic rings, were used and the reactors with both of them were able to achieve a high methane production rate. There are many studies on attached film fixed reactors for treatment of dairy wastewater [11-13] which indicate the stability and efficiency of the reactors in treating large quantities of wastewater with small residence time.

The character and changes of the biological community in various filter layers and at various temperatures have been studied [14, 15], indicating that BOD removal of anaerobic filters treating dairy wastewater was not significiantly affected by the temperature differences between 21-30°C. The purpose of this paper is to study the effect of some parameters, e.g., loading rate and media type on the efficiencies of trickling filter.

EXPERIMENTAL

A pilot plant scale trickling filter (Figure 1) employed for these investigations was made of plexiglass, 1.5 m long and 0.3 m diameter. The filter was filled with cross flow plastic media with 164 m^2/m^3. (60 degrees). The settling tank was 0.3 m diameter and 0.4 m long with no sludge collection mechanism. The feed is pumped to the top of the filter where it is distributed on the packing by the distributor plate. At the bottom of the column, the treated effluent is collected in a settling tank which contains pipes for the overflow, recycle and drainage of the effluent. Performance criteria for the trickling filter generally have been based on removal efficiency, i.e. percent reduction of some wastewater component between influent and clarified effluent, and on the hydraulic loading rate of the unit.

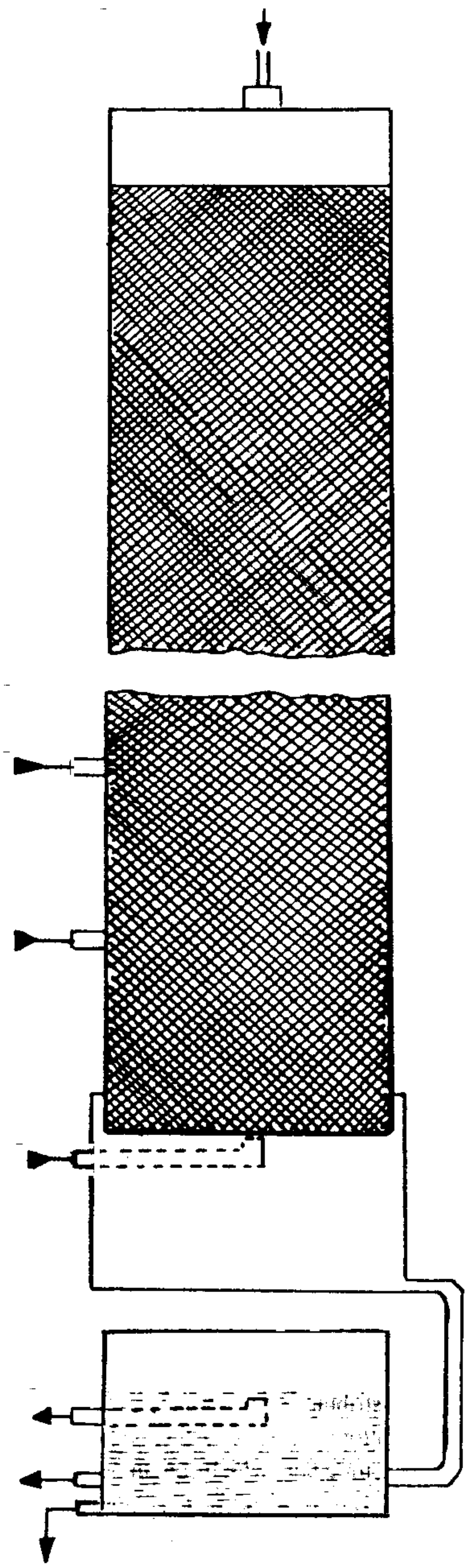

Figure 1. Trickling filter unit.

RESULTS AND DISCUSSION

Trickling filter loading rates varied from a low of 3.92 to a high of 16.2 kg/m^3 per day during the 15 month period. The relationship of effluent quality to trickling filter loading rate for all samples during this period is plotted in Figure 2. The data for BOD_5 removals of about 85% are from operation with an intermediate clarifier which was placed at the bottom of the trickling filter. At very low hydraulic loading rates, the design relationships begin to merge, indicating that the process is approaching first order kinetics at these loadings. For higher hydraulic loading and lower degrees of treatment, the process begins to depart from first-order kinetics and at still higher loading begins to approach zero-order. Data obtained during a 3 month period showed an increase in the final effluent SS from 10 to 40 mg/l. The relationship of effluent SS to filter loading rate is plotted in Figure 3 as a least-squares fit. Analysis of the data indicates that effluent quality varies with loading rate and decreases with increasing the BOD in a constant organic loading rate, because BOD_5 and SS concentrations correspond closely at this level of effluent quality; suspended solid was used as the measure of quality [8].

The effluent soluble BOD_5 concentration obtained from the pilot plant operation at various organic loadings is illustrated in Figure 4. This figure shows also the effect of wastewater temperature on effluent BOD_5 for different organic loadings. As the wastewater temperature decreased the effluent S.BOD_5 increased to an average of 75 mg/l.

Effect of media type. A plastic cross-flow medium was used in the trickling filter column. This medium removes soluble BOD_5 most efficiently and many investigators have reported that cross-flow media demonstrated higher dissolved BOD_5 removal rate coefficient than vertical media, and rock media [9, 10]. The data collected from this study are plotted in Figure 4. An engineering analysis of the data was performed using a simplified form of the modified Velz equation as used by Parker [9].

$$Ln\, S/s_{\cdot} = K_{20} \cdot \theta^{(T-20)} \cdot A \cdot D / Q^n$$

Temperature and flow coefficient (n) were assumed to be 1.035 and 0.5 as proposed by Parker and Douglas [9,11]. The specific surface area of the media (A) was 164 m^2/m^3, the media depth (D) was 1.5, and the average wastewater temperatures (T) were 13.5 and 22.5°C. K_{20} can be determined by plotting $S/s.$ versus $\theta^{(T-20)A D/Q^n}$ on semi-log paper. The value of the slope of the line passing through the

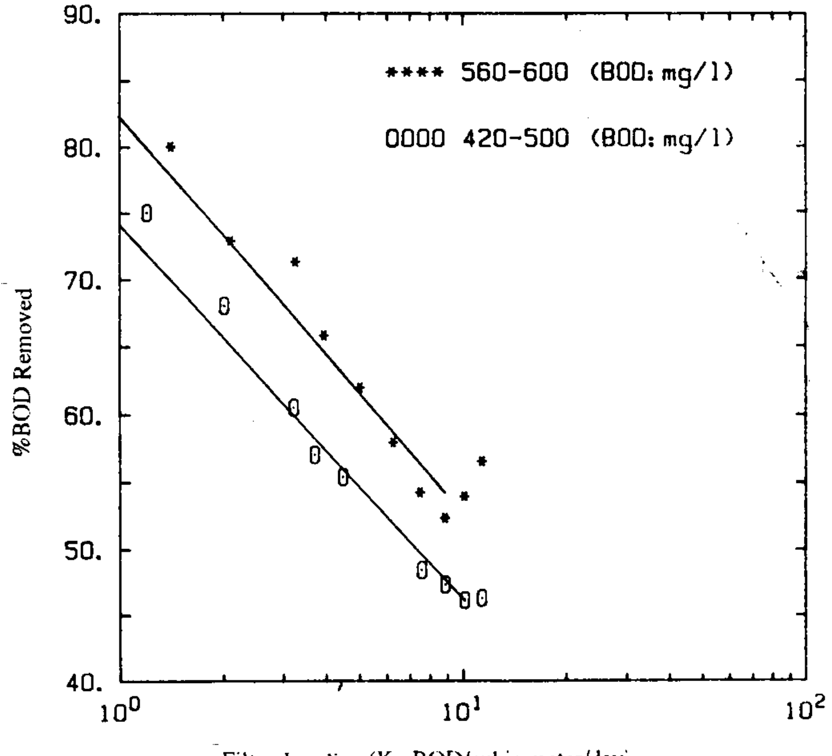

Figure 2. BOD Removal as a Function of Looding

origin and the data point is K_{20}. The data for the two different temperatures, 13.5 and 22.5°C, are shown in Figure 5. The value of K_{20} was determined to be $1.25 * 10^{-3}$ $(L/m^2.Sec)^{0.5}$. A significant point for discussion is the difference between these results and the K_{20} value reported elsewhere [9,11]. The possible effect of this is that this work was conducted on a tower 1.5 m deep and 0.3 m diameter, while the other studies were conducted on a shallow-bed trickling filter or on a tower with greater diameter size. However, if oxygen was limited in the

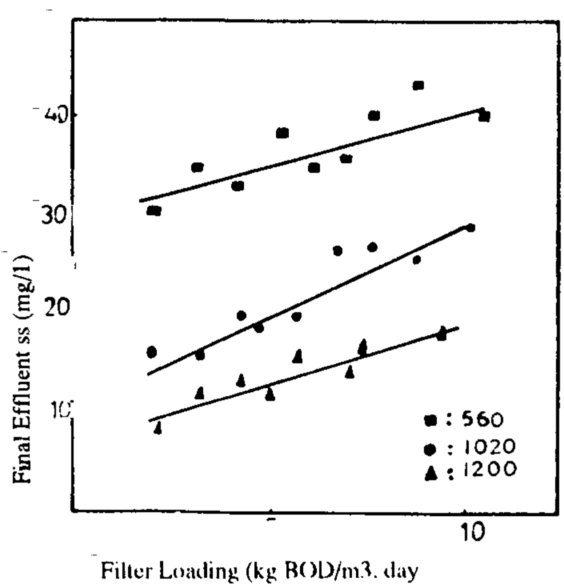

Figure 3. Plant effluent quality as a function of filter loading

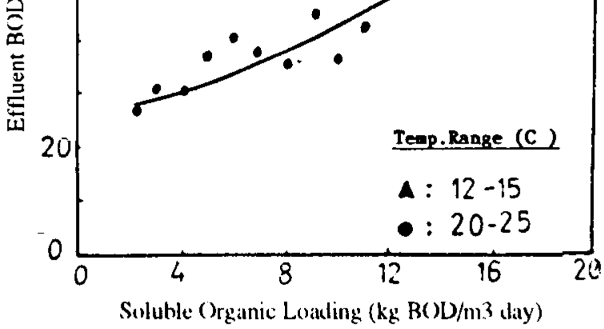

Figure 4. Effect of Organic Loading on the performance of cross-flow media.

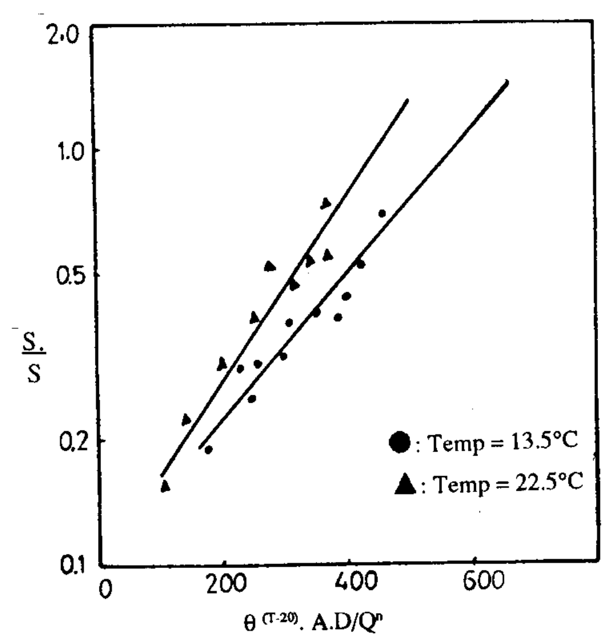

Figure 5. Determination of K20 for Trickling filter

tower, then the resultant K_{20} value would be less than when sufficient oxygen was present.

CONCLUSION

Analysis of the data indicates that effluent quality varies with increasing the BOD in a constant organic loading. With the moderate loading rate the process approaches first - order kinetics, but for higher (above 10 kg /m^3 per day) begins to depart from first - order to zero order kinetics.

The effect of wastewater temperature on effluent BOD for different organic loading shows that as the wastwater temperature decreased the effluent S.BOD increased to an average of 75 mg/l.

Experiment was conducted to study the effect of media type on the soluble BOD removing in fixed bed reactor. Cross-flow media were used with temperature control. The reactor was able to remove S.BOD up to about 75%.

The value of K_{20} for two different temperatures (13.5 and 22.5°C) were determined to be 0.000125 and 0.00023 * $(L/m^2.\,Sec)^{0.5}$, respectively.

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