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Low Maintenance Wastewater Treatment

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Introduction

There exists a continuing and increasing need for small scale, conceptually simple, and resource conserving methods of wastewater treatment. Large, complex, and technical sophisticated treatment facilities may be the best engineering alternative for many treatment applications, especially in highly-populated urban areas; however, these plants may be unsuited to many locations where population is limited and highly skilled operators are unavailable.

It is the purpose of this paper to present the results of a nine month investigation of a low maintenance wastewater treatment technique which was conducted in the UCLA Water Quality Control Laboratory. The effort was specifically addressed to verification and development of a wastewater treatment technique which would: (1) Require little or no operator attention; (2) conserve energy and other resources as compared to conventional wastewater treatment systems; (3) produce an effluent quality comparable or better than secondary effluents; and (4) require little or no engineering expertise for implementation.

Background and Experimental Apparatus

The rotating biological contactor (RBC) was selected for development. The operational simplicity and freedom from sludge recycle makes the RBC process especially suited for low maintenance applications. The process also appears to be self-regulating with respect to mean cell retention time; no intentional sludge wasting control is needed. Additionally, no high technology aeration devices are needed. The only energy requirement is for disc rotation, which has been traditionally supplied by electric motors and gear boxes, or rising air bubbles, but could also be furnished by wind or solar energy. The RBC process does not have the disadvantage of filter flies and odors, which tend to discourage the use of trickling filters. For these reasons, the RBC process was selected for evaluation.

Current design guidelines (4) for RBC units range from 0.75 gal/sq ft/day–4 gal/sq ft/day (0.03 m^3/m^2/day–0.16 m^3/m^2/day). In this loading range, secondary treatment objectives can normally be achieved and nitrification usually occurs at the lower loading rates, depending upon biochemical oxygen demand

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(BOD) loading rate, temperature, and other environmental conditions. Design guidelines usually recommend that the RBC be used in conjunction with primary and secondary clarifiers and sludge disposal facilities.

The objective of this experimental investigation was to evaluate the RBC process as a "stand alone" (without clarification) secondary treatment process. In this manner, it was hoped to develop the simplest possible treatment process. It was anticipated that the major problem would be meeting effluent suspended solids criteria. To achieve the desired treatment efficiency, a reduced loading rate of 0.1 gal/sq ft/day (0.01 m^3/m^2/day) was evaluated.

The experimental equipment consisted of a 20-in. diam (0.5-m) commercially available RBC unit, with 250 sq ft (23 m^2). The unit was subdivided into four stages in a series and modified to prevent solids accumulation and backmixing between RBC stages. The unit was operated for approximately five months in the UCLA Water Quality Laboratory. Wastewater was collected from the Westwood Boulevard sewer and consisted primarily of domestic wastewater from the Campus and Western Los Angeles. Start-up of the unit was lengthy due to the very low mean cell retention time. The unit was operated for approx 90 days before it appeared to reach steady state. After reaching steady state, the performance of the process was evaluated for a 45-day period. The BOD, COD, TSS, and nitrogen were measured routinely. The RBC effluent was also clarified in a small laboratory scale clarifier (400 gal/sq ft/day overflow rate) in order to determine the process's efficiency with clarification.

Experimental Results

The RBC process performed very well at the low loading rate and achieved secondary treatment objectives. Five-day BOD is shown in Fig. 1 and is plotted

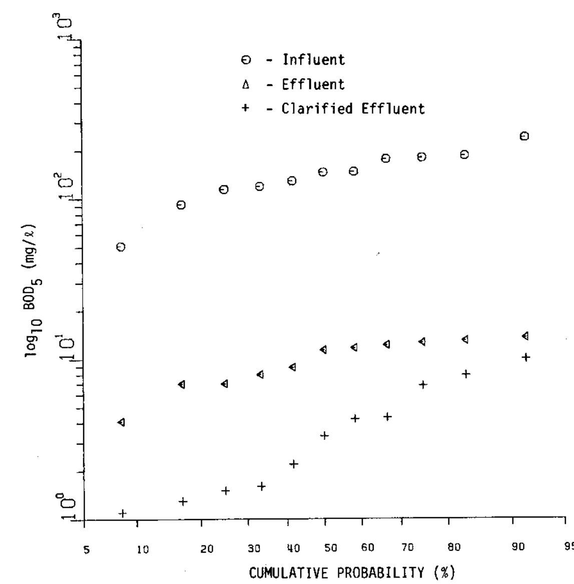

FIG. 1.—BOD$_5$ Cumulation Probability Distribution

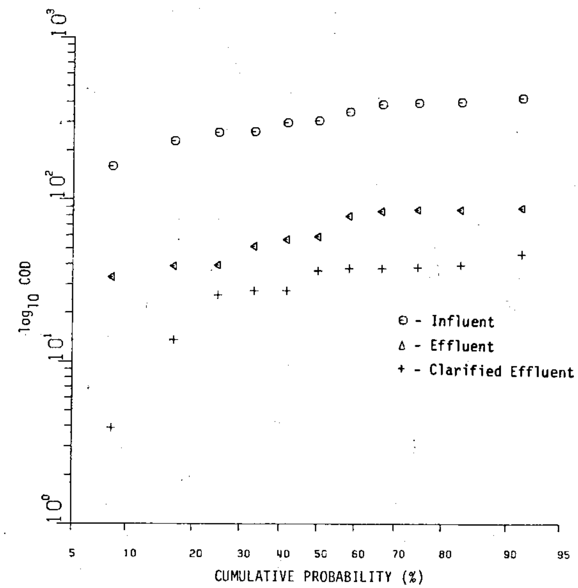

FIG. 2.—COD Cumulation Probability Distribution

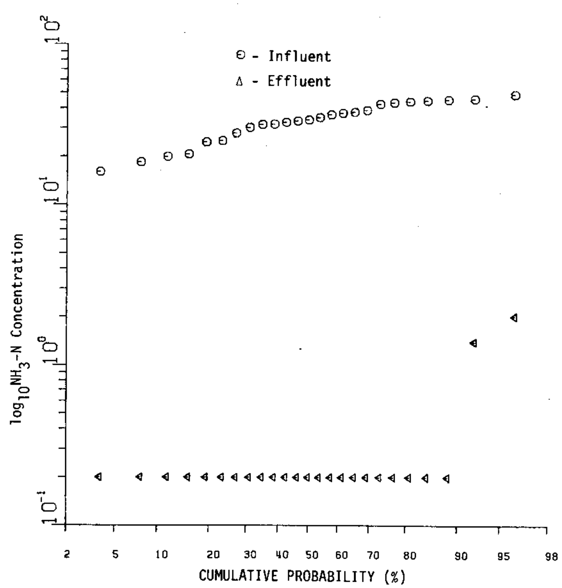

FIG. 3.—Ammonia Nitrogen Cumulation Probability Distribution

on a log-normal probability axis. Mean influent BOD_5 was approx 150 mg/L, a dilute domestic wastewater. Mean unclarified effluent BOD_5 was approx 10 mg/L and clarified effluent mean BOD_5 was approx 3 mg/L. The COD removal performance of the RBC unit is shown in Fig. 2. Mean COD of the influent was approx 300 mg/L, which was reduced to 50 mg/L by the RBC process and was further reduced to approx 30 mg/L by clarification.

The nitrification performance of the RBC unit was excellent, which would be expected at the low loading rate and modest range of temperatures during the study (62° F–73° F or 17° C–23° C). Influent ammonia nitrogen was slightly higher than normal domestic wastewater. Influent of organic nitrogen ranged from 10 mg/L–15 mg/L. Nitrification was virtually complete and the only nitrate nitrogen could be found in the effluent. Occasionally, problems were encountered with pH drop across the RBC due to high influent nitrogen concentration and

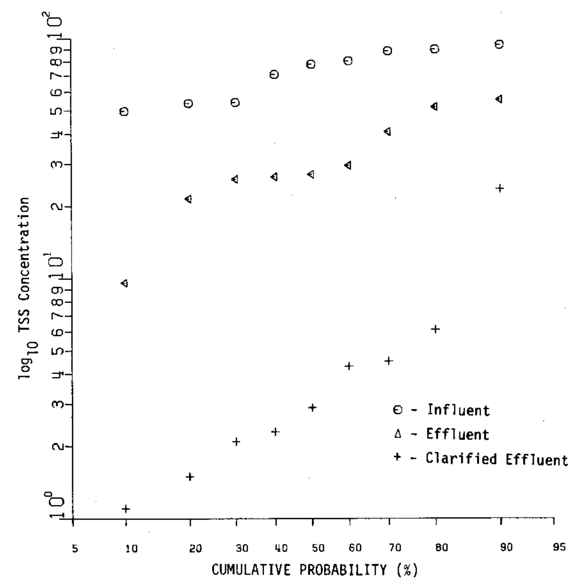

FIG. 4.—Total Suspended Solids Cumulation Probability Distribution

low influent alkalinity; however, it is not anticipated that this problem would exist with most wastewaters (see Fig. 3).

Suspended solids removal rate was lower than other removal rates, as anticipated. Mean influent suspended solids concentration was approximately 75 mg/L and was reduced to approx 25 mg/L by RBC process. Effluent suspended solids were composed primarily of biological solids synthesized in RBC unit. A further reduction to 3 mg/L was achieved in the secondary clarifier (see Fig. 4).

Analysis and Conclusion

The mean effluent qualities achieved by the RBC process were in excess of secondary effluent objectives. The effluent quality achieved with clarification greatly exceeds secondary effluent quality and approaches that obtained in many tertiary treatment plants.

The engineering significance of the results is dependent upon the local treatment requirements and local economic environments. Undoubtedly, for larger installations, the very high surface area requirements of the low loading rate make this RBC application capital intensive and uneconomical. It is anticipated that for smaller applications where a high quality, low maintenance treatment process is required, the added costs will be justified. The esthetic qualities of the effluent were excellent; the turbidity in most instances were in the range of 2 NTU–5NTU which approximates the turbidity required in California for recycled wastewaters.

The energy requirements for the RBC process at the 0.1 gal/sq ft/day loading rate are approximately the same as for small activated sludge pilot plants. This calculation was based upon high density, commercially available disc units and activated sludge pilot plants which use coarse bubble diffusers and excess dissolved oxygen (DO). The latter assumption is justified when unattended operation is needed, requiring nonclogging coarse bubble diffusers and excess DO to prevent periods of insufficient DO during high loading rate.

The results of this investigation should be considered tentative since the scale is quite small. The complete results have been reported previously (1). The problems of biodisc scale-up are not trivial and have been recently considered by Friedman, et al. (4) and Famularo, et al. (3).

Acknowledgment

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Appendix.—References

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