14th WEDC Conference

Water and urban services in Asia and the Pacific

Kuala Lumpur 1988

Package treatment plant utilising RBC

Nik Fuaad Nik Abllah

ABSTRACT

In 1985, it was estimated that about 5.3 per cent of the population of Malaysia had access to centralised sewerage treatment plant. About 84.5 percent had some form of treatment while 10.2 percent had no sanitation facilities whatsoever. Especially for those in the urban or peri-urban fringes and run-down slums of large towns and cities without any proper sanitation facilities a compact package on-site domestic wastewater treatment plant could be the answer to their sanitation woes.

A full scale sewage treatment plant with primary and secondary sedimentation tanks incorporating a rotating biological contractor (RBC) as secondary treatment was employed to evaluate the process performance and to develop kinetic models when treating domestic wastewater. RBC was chosen as secondary treatment due to its carbonaceous and ammonia nitrogen removal efficiency, low power consumption, greater flexibility, low retention time, low sludge production and low mechanical maintenance requirements. The RBC was operated at different organic loading rates that ranged from 13.1 to 27.8 gCOD/m²/d. The overall carbonaceous and ammonia nitrogen removal percentages were from 84 - 92 percent and 82 - 93 percent respectively.

Steady state kinetic models for carbonaceous removal was used to obtain the kinetic constants to be used as a design aid.

INTRODUCTION

Although the government has and will be spending large sums of money in providing piped water supply to urban and rural areas, there has not been, nor is there expected to be, a similar commitment in providing central water borne sewerage system. On-site sewage disposal system is a possible alternative but is generally ineffective usually because of poor design and inadequate maintenance. The answer to this problem could possibly be to advocate the use of more effective secondary biological treatment systems. One such system is the rotating biological contactor.

The purpose of this investigation was to study the effectiveness of the package treatment plant and the process performance of the RBC so that kinetic contants could be obtained.

MATERIALS AND METHODS

A four stage full-scale RBC unit together with two rectangular sedimentation tanks were used in this study. The diagram of the package plant is shown in Figure 1.

PROCESS PERFORMANCE

The study was conducted at 4 different organic loading rates that ranged from 13.1 g COD/m²/d to 27.8 g COD/m²/d. Table 1 summarise the process performance of the plant.

The primary and final sedimentation tanks both reduced the COD of the incoming wastewater by about 19-28 per cent. In terms of suspended solids, the removal percentage was in the range 40 - 65 percent.

In the RBC, the overall removal percentage increased with increasing organic load. The overall removal percentages were 92.3, 84.2, 88.9 and 86.6 percent for organic loading rates of 27.8, 25.6, 17.6 and 13.1 respectively. More than 90 percent of the organic content of the wastewater was removed in the first stages of the RBC.

It was also observed that significant quantities of ammonia nitrogen were being converted into other forms particularly in the second and third stages. The overall ammonia-nitrogen removal percentages ranged from 85 - 95 percent for the above organic loads.

KINETIC MODEL FOR COD REMOVAL

The model developed by A. Pano (1981) was used in this study. Using the mass balances of the substrate around the attached growth and mixed liquor and by applying the total attached biomass and monod growth kinetics to the reaction rates results in the following model:-

$$[Q\,(S_o - S_1)/A_1 X_1]^{-1} = \frac{K_s}{k}\,\frac{1}{S_1} + \frac{1}{k} \qquad (1)$$

where:-

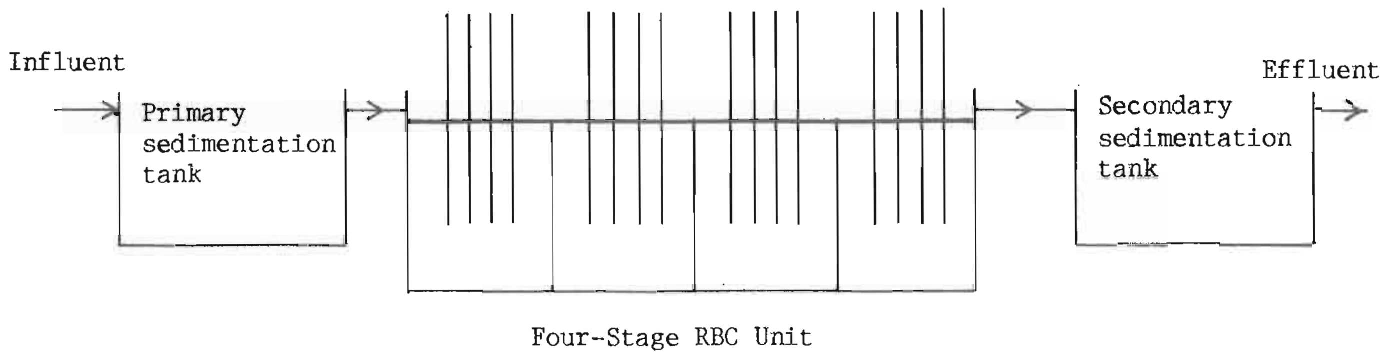

Figure 1 : On-Site Package Treatment Plant

Q – influent wastewater flow rate, m^3/d

S_o – influent substrate concentration, mg/l

S_1 – effluent substrate concentration, mg/l

A_1 – total available surface area for attached growth, m^2

$\bar{X}_1$ – attached growth per unit area, g VS/m^2

K_s – half saturation constant, mg COD/l

k – maximum reaction rate, 1/d

The kinetic constants obtained from experimental data were:-

K_s = 340.4 mg COD/l

k = 10.0 1/d

Prediction of the quantity of attached biomass uses a saturation type relationship as follows:-

$$\bar{X}_1 = \frac{k_x M_1}{K_x + M_1} \qquad (2)$$

where:-

$\bar{X}_1$ – quantity of attached biomass in the first stage, g VS/m^2

M_1 – organic load, g $COD/m^2/d$

K_x – constant, g $COD/m^2/d$

k_x – constant, g VS/m^2

TABLE 1 : Summary of Process Performance in Terms of COD

Percentage removal in primary sedimentation %	Organic load into RBC g $COD/m^2/d$	First stage RBC percentage removal %	Overall RBC percentage removal %	Percentage removal in final sedimentation %
28.0	27.8	85.6	92.3	24.1
26.2	25.6	81.9	84.2	21.6
22.7	17.6	88.3	88.9	18.8
22.2	13.1	84.6	86.6	19.7

From the experiemntal data, the constants were:-

K_x = 26.9 g COD/m^2/d

k_x = 54.4 g VS/m^2

KINETIC MODEL FOR AMMONIA NITROGEN REMOVAL

For the ammonia-N removal, the monod growth kinetics type of equation is as follows (Pano, 1981).

$$\left[\frac{Q(C_{i-1} - C_i)}{A_i}\right]^{-1} = \frac{K_N}{k_N}\frac{1}{C_i} + \frac{1}{k_N} \quad \ldots\ldots (3)$$

where:-

Q - influent flow rate, m^3/d

C_i - ammonia nitrogen concentration in stage i, mg/l

A_i - total available surface area per stage, m^2

k_N - ammonia nitrogen maximum reaction rate, g N/m^2/d

K_N - ammonia nitrogen removal half saturation constant, mg N/l

The kinetic constants obtained from the experimental data were:-

k_N = 6.25 g N/m^2/d

K_N = 7.41 mg N/l

CONCLUSION

The package treatment plant incorporating the RBC has demonstrated to be an efficient waste-water process in removal of biologically degradable carbonaceous compounds in a tropical environment. For design purposes, the kinetic constants determined in this paper can be used to calculate the required RBC surface area to meet prescribed effluent standards.

ACKNOWLEDGEMENTS

This study was supported by Universiti Sains Malaysia under the short-term research grant.

REFERENCES

1. NIK FUAAD N A. The performance and kinetics of the RBC treating domestic wastewater under tropical conditions in Malaysia. International Symposium on Small Systems for Water Supply and Wastewater Disposal, Singapore, 1987, July, 2 - 4.

2. PANO A. The kinetics of RBC treating domestic wastewater. PhD Thesis, Utah State University, 1981.

3. OPATKEN E J. An Alternative RBC design-second order kinetics. Second International Conference on Fixed-Film Biological Processes, Washington D.C., 1984.