II-443 FAECAL COLIFORM REDUCTION IN FACULTATIVE PONDS

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Introduction

A follow up of a research on pilot scale ponds at the University of Dar es Salaam reported by Mayo (1989) and Mayo (1988) was made. University of Dar es Salaam waste stabilization pond units with the daily flow rate of 840 m^3/d were chosen for the research. The effect of solar intensity, pond depth and hydraulic detention time was investigated and is hereby presented. Samples were collected between 1987 and 1991 and analysis of faecal coliform density was carried out in accordance the standard methods (APHA, 1985). Solar intensity was measured by Linke-Feussner pyrheliometer with the sensor wavelength of 0.3 to 5 μm manufactured by Kipp and Zonen. Values for solar radiation were printed automatically at 1 h intervals.

Results and Discussion

Effect of Pond Depth and Solar Intensity on Faecal Coliform Mortality Rate

The data collected from pilot scale studies in 1987/88 and reported by Mayo (1989) were combined with those collected from the full scale waste stabilization ponds between 1989 and 1991 for plotting figure 1, which shows the effect of pond depth and solar intensity on faecal coliform mortality rate. Each point in figure 1 represent the mean faecal coliform mortality rate in each unit in full scale ponds and in two pilot scale ponds of similar operational conditions (same pond depth and hydraulic retention time). The bacterial mortality rate k, in vertically mixed ponds is given by (Qin et al., 1991):

$$k = k_d + (k_s S_o [1 - l_e] [1 - e^{-KH}])/ (KH) \qquad \text{.... eq. 1}$$

where k_d = bacterial die-off rate constant in the dark (d^{-1}), k_s = bacterial light mortality term constant (cm^2/cal), K = light attenuation coefficient (m^{-1}), H = liquid depth in the pond (m), S_o = daily average solar intensity received at the pond surface (cal/cm^2 d) and l_e = the surface layer effect coefficient.

The term e^{-KH} in equation 1 has earlier been reported by Sarikaya et al.(1987) to be negligible for the pond depths greater than 1.0 m. The term l_e was also reported by Qin et al. (1991) to range from 0 to 0.03. The effect if these parameters if neglected will not cause a gross error of more than 3%. Because of these reasons Sarikaya et al. (1987) reduced equation 1 to:

$$k = k_d + (k_s S_o/KH) \qquad \text{.... eq.2}$$

The relationship shown in equation 2 was used for data obtained from pilot scale and full scale waste stabilization ponds for plotting figure 1. Results closely comparable to those from pilot scale reported by Mayo (1989) were obtained. FC mortality rate obtained from the combined data obtained from field scale and pilot scale ponds was found to be represented by equation 3:

$$k = 0.12 + 5.5 \times 10^{-4} [S_o/H] \qquad \text{...... eq. 3}$$

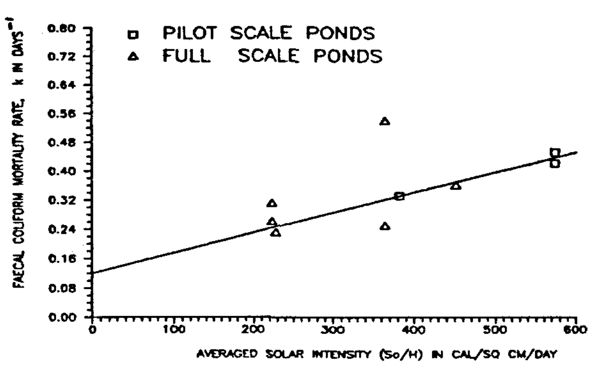

Fig. 1: Effect of solar intensity and pond depth on faecal coliform mortality rate.

This means with the average daily solar intensity of 550 cal/cm^2 d received at the pond surface in Dar es Salaam, the contribution of the solar intensity is about 72% and 63% for the pond depth of 1 m and 1.5 m respectively.

Effect of Retention Time and Temperature on the Bacterial Mortality

The influence of hydraulic retention time on the feacal coliform reduction was also investigated. The total hydraulic retention time, t, at each pond effluent with respect to influent in series was compared with the respective faecal coliform log reduction as shown by figure 2. The data from pilot scale ponds appears to fit well with those collected from full scale ponds. As shown by figure 2, faecal coliforms were reduced by 4.42 $\log_{10}$ scales in 27.2 days and follows the behaviour described by equation 4. The mean faecal coliform reduction of 99.995% was achieved after 27.2 d hydraulic retention time infull scale ponds.

$$\text{log reduction} = 0.067 + 0.16\,t \qquad (R^2 = 0.940) \qquad \dots \text{eq. } 4$$

The data collected by Mayo (1988) in pilot scale ponds shows that faecal coliforms were reduced by an average of 4.1 and 3.3 $\log_{10}$ scales in a 1.0 m and 1.5 m deep ponds respectively after a total hydraulic retention time of 22.4 d in two ponds in series (11.2 d in each unit). Within the duration experimental studies, the waste water temperature was 26.2~31.7°C taken between 9.00 and 10.00 a.m. Because of the high temperature at the University of Dar es Salaam ponds, the faecal coliform reduction rate reported in this study were higher than those reported by Saqqar and Pescod (1990) in Jordan's Al-Samra stabilization ponds at 12~15°C. To achieve an equivalent reduction in faecal coliforms Al-Samra requires about 40 d hydraulic retention time which is nearly 1.5 times the retention time required for ponds in Dar es Salaam operating at 26~32°C.

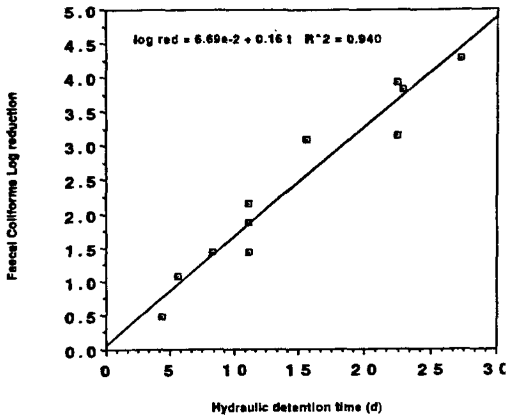

Fig. 2: Effect of hydraulic retention time on faecal coliform mortality.

Conclusions

There appears to be a strong influence of solar intensity, pond depth and hydraulic retention time and temperature on faecal coliform mortality rate.

References

1. Mayo A.W. ; 1988. "Bacterial Die-Off in Waste Stabilization Ponds Receiving Domestic Waste Water in Dar es Salaam, Tanzania". Masters of Science Thesis, *Tampere University of Technology*, Publication No. A36, Tampere, Finland, 60p.
2. Mayo A.W.; 1989. "Effect of Pond Depth on Bacterial Mortality Rate". *Journal of Environmental Engineering Division*, American Society of Civil Engineers, Vol. 115, No. 5, pp. 964-977, New York, U.S.A.
3. American Public Health Association, American Water Works Association and Water Pollution Control Federation, 1985. "Standard Methods for the Examination of Water and Waste Water". 16th Edition, APHA Publications, Washington, D.C., U.S.A.
4. Sarikaya H.Z. and Saatci A.M.; 1987. "Bacterial Die-Off in Waste Stabilization Ponds". *Journal of the Environmental Engineering Division*, American Society of Civil Engineers, Vol. 113, No. 2, pp. 366 - 382, New York, U.S.A.
5. Saqqar M.M. and Pescod M.B.; 1991. "Microbiological Performance of Multi-stage Stabilization Ponds for Effluent Use in Agriculture". *Proceeding of the Fifteenth Biennial Conference of The International Association on Water Pollution Research and Control*, 29 July- 3 August, 1990, pp. 1525-1534, Kyoto, Japan.
6. Qin D., Bliss P.J., Barnes D. and FritzGerald P.A.; 1991. "Bacteria (Total Coliform) Die-Off in Maturation Ponds". *Proceedings of the Fifteenth Biennial Conference of the International Association on Water Pollution Research and Control*, 29 July - 3 August, 1990, pp.1517-1524, Kyoto, Japan.