CHAPTER 7
CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER WORK

7.1 Conclusions

Based on the experimental data from the operation of the three pilot-scale primary facultative ponds in UK climatic conditions, the following conclusions can be drawn:

1. The pilot-ponds had excellent removal for BOD, for which the optimum surface BOD loading was between 116-169 kg/ha.d. BOD removal did not require facultative conditions.

2. SS removal was also excellent, independent of surface BOD loading, and did not require facultative conditions. Removal was better in winter than summer when it was affected by algae entering the effluent and sludge feed-back.

3. Ammonia removal was variable: at loadings of 107 kg BOD/ha.d and below, ammonia removal was found to be strongly dependent on season: with better performance in summer than winter. Ammonia removal was related to pH and temperature, both were higher in summer than winter. The data from the second year showed good agreement with the model of Pano and Middlebrooks (1982).

4. Facultative conditions were not maintained at any of the test loadings during the winter; therefore, either the maximum surface BOD load to maintain facultative conditions is less than 63 kg/ha.d, or facultative conditions cannot be maintained at any surface BOD loading on primary facultative ponds during the UK winter due to light limitation. If facultative conditions cannot be maintained at any loading during the winter, the recommended optimum is 80 kg/ha.d. A loading of 63 kg/ha.d combined with a more sheltered location led to widespread algal predation effects during the summer.

On small ponds, serving less than around 10 people, some surface movement should be provided to avoid odours during winter and break up algal scums during the summer.

5. The pond loaded at 80 kg BOD/ha.d produced an effluent quality which met the EC Urban Waste Water Treatment Directive (1991) standard of <25 mg filtered BOD/l and 150 mg SS/l, at all times.

6. The volume of sludge accumulated was 1.46-1.83m^2 over 20 months, equivalent to 10-20% of the incoming solids. There was evidence of sludge digestion throughout the year. After 20 months, the dry sludge was 42% VS by weight compared to 62% in the incoming settleable solids. The predicted desludging interval was more than 7 years.

7. The contribution of algae to the effluent BOD and SS was: 100 µg Chlorophyll-a ≡ 6.8 mg SS and 5.8 mg BOD.

8. Primary facultative ponds have excellent BOD removal, SS removal and very low rate of sludge accumulation. Thus they are a very useful option for wastewater treatment for small communities in the UK.

7.2 Recommended further work

In light of the data from the pilot-ponds, further work is needed as follows:

1. The loadings to the pilot-ponds should be reduced to 40-60 kg/ha.d during the winter to test the US recommendations for the maintenance of facultative conditions. The loading regime should be randomised across the ponds, thus removing the effect of relative location.

2. The hydraulic retention time should be reduced to around 30-40 days for all the ponds and partitioned from the surface BOD loading by diluting the incoming wastewater.

3. The loadings should be increased to 80 kg/ha.d during the following summer, at hydraulic retention times of less than 40 days, with one or more ponds receiving assistance. This regime should be continued during the following winter.

4. The sludge accumulation should be measured every 6 months to the point of desludging. It would be useful to also measure the volume and composition of the gas coming from the sludge layer at different times of the year.

5. To establish a mass balance for nitrogen removal, organic nitrogen, ammonia, nitrate and nitrite should be measured on the influent, effluent, pond water and sludge. Further controlled experiments are also required determine the actual mechanism for ammonia removal: for example, pH buffering the pond water to test the effect of algal uptake without volatilisation; the measurement of ammonia gases lost through volatilisation. This will enable pond design to be enhanced to improve ammonia removal.

6. Dissolved oxygen, redox and chlorophyll-a measurements should be logged every hour at a number of depths. There should also be odour monitoring on site to correlate DO, redox, chlorophyll-a and weather conditions with odour events. This will enable failure criteria based on DO, redox or chlorophyll-a to be established and to determine the critical environmental factors for failure.

7. New ponds should be built with a deeper inlet area (around 2 m or more) to allow extra sludge storage capacity to test the effect of increasing the isolation of the sludge from the pond water.

8. Testing should be done on the operation of secondary facultative ponds, which would receive the effluent from an anaerobic pond or septic tank, to compare their performance with that of the primary ponds.