



PHOREDOX ACTIVATED SLUDGE UNIT AT THE FIRLE SEWAGE DISPOSAL WORKS HARARE

by Mrs F C COX

INTRODUCTION

A modified activated sludge unit designed on the Phoredox principle of Barnard (ref.No.1) was installed at the Firle Sewage Disposal Works, Harare, especially to produce an effluent which would satisfy discharge standards (ref.No.2). Several similar plants are operating in other countries but, from results seen so far, not all of them are producing an effluent which would meet the high Zimbabwean standards, particularly with regard to phosphate and ammonia.

Because uncertainty still exists over the exact mechanism involved in biological phosphate removal, definite operating parameters for efficient removal have not been determined, though basic guidelines have been established.

Siebritz et al (ref.No.3) have stated that failure of the Phoredox process to remove phosphate is due to the TKN:COD of the feed being $\approx 0,08$; this means that denitrification is incomplete and the return sludge contains nitrate which causes a reduction in effectiveness of the anaerobic zone. The TKN:COD ratio at Firle is normally $< 0,08$ and, furthermore, at no time was any nitrate found in the return sludge; yet in the first few months of operation the P. removal was variable, unpredictable and usually insufficient.

However, after considerable trial and error, a pattern emerged and an operating procedure has been established which consistently produces the desired standard of effluent.

OPERATIONAL PARAMETERS

The following controls may be employed in the operation of the works:

Feed

The volume and ratio of raw to settled sewage of the feed, depending on the strength of the sewage.

Sludge Recycle Rate

A sludge recycle rate of 1:1 has been found to be satisfactory. It has been suggested (ref.No.3) that a higher recycle rate is conducive to better P removal but this would reduce the effective retention time in the anaerobic zone. Lower recycle rates were found to cause blocking of the clarifier telescopic valves.

Dissolved Oxygen Level

It was recommended that the DO level be kept at about 1 mg/l in the centre of the main aeration basin, tapering off to $< 0,5$ mg/l at the entrances to the two anoxic zones, in order to assist denitrification. Because of poor performance of the aerators and the fully-mixed aspect of the basin, this DO profile was unobtainable. In addition, the recording DO meters installed were so unreliable that control of the system by DO levels was impossible.

Solids Retention Time

Initially a SRT of 29 days was maintained but this has had to be dropped gradually to 20 days in order to keep the MLSS at a reasonable level. This short SRT does not produce a truly stable sludge, suitable for drying beds.

Mixed Liquor Suspended Solids

By keeping a constant SRT, the MLSS is supposed to vary automatically to suit the strength of the feed sewage. In fact at a SRT of 25 days the MLSS increased to over 6 000 mg/l and the aerators could not cope with this mass of sludge. With improved aeration and a SRT of 20 days the MLSS remains fairly constant at 4 500 mg/l.

Mixed Liquor Recycle

The average internal recycle rate is 2,8:1. Denitrification in the first anoxic basin is good regardless of the recycle rate, which can be as high as 4:1 if all the pumps are operable at one time.

RESULTS

Typical analysis results of the raw sewage and final effluent are given in Table 1, together with relevant discharge standards.

Nitrification-Denitrification

Nitrification began on the 20th day after commissioning and was complete by the 25th day; the final effluent having a total ammonia content of 0,24 mg/l N, temperature of the ML at this time was 19-20°C. Considerable denitrification occurs simultaneously with nitrification, mini-anoxic zones forming between the aerators. Nitrates are detected only occasionally in the main aeration basin.

Nitrification has always been good, provided the loading is kept within the capacity of the aerators. Denitrification is total on leaving the anoxic basins, even at times

when nitrate in the aeration basin rose to 6 mg/l.

TABLE 1: TYPICAL ANALYSIS RESULTS (mg/l)

Parameter	Raw Sewage	Final Effluent	Discharge Standard
4 Hour O.A.	70	8	10
C.O.D.	800	45	60
Suspended Solids	350	18	25
pH	7,0	7,6	6-9
Total Ammonia as N	32	2,4	-
Free Ammonia as N	-	0,06	0,2
Nitrite as N	-	0,04	-
Nitrate as N	-	<0,5	-
Kjeldahl Nitrogen	42	8	-
Total Nitrogen	42	<8,5	10
Soluble O-Phosphate as P	5	0,1	-
Total Phosphate as P	9	0,6	1,0
Detergent LAS	4,5	0,1	1,0

Phosphate Removal

Soluble phosphate dropped to between 1 and 2 mg/l P within a few days of start-up. After three weeks it was down to 0,2 mg/l P where it stayed for another two weeks. Then because of problems with rags, the feed was changed to settled sewage alone (COD 370 mg/l, TKN:COD 0,07) and the phosphate slowly rose over the next two weeks to a peak of 7 mg/l P.

As the Siebritz theory did not apply, it seemed to be the total COD loading that was important. In retrospect, the initial good P removal was probably due to the addition of 900 m³ raw sludge over the start-up period.

It became apparent that peaks in soluble P occurred simultaneously or about a day after peaks in DO and nitrate in the main aeration basin. P removal was found to improve on days after there had been a power cut or shut-down for repair work. The feed was therefore changed back to raw sewage alone and certain aerators were switched off, some only at night, some constantly; the number in use being determined by the ammonia level at various points. By adjusting the aeration in the main basin to get a total ammonia between 1 and 4 mg/l and nitrate <1 mg/l N, it was found possible to attain consistently high P removal rates. Soluble P is now frequently <0,1 mg/l P. The ammonia discharge standard is still reached as long as the peak total ammonia in the main aeration basin is kept below 7 mg/l N, this ammonia being further nitrified and largely denitrified in the re-aeration basin. The large clarifiers have a buffering effect on ammonia peaks. If the ammonia peak is allowed to rise above 7 mg/l N, not only is the free ammonia in the final effluent too high but phosphate uptake is reduced due to lack of oxygen.

Another useful parameter for phosphate control is the soluble P level in the anaerobic basin; if this drops below 20 mg/l, trouble

ahead is indicated. Unfortunately it is sometimes too late by then to avert the impending rise in P in the effluent.

COD Removal

Because it is necessary for good P removal to run the plant in a slightly overloaded mode, the COD of the final effluent is sometimes over the limit of 60 mg/l but on average is less than 50 mg/l.

CONCLUSIONS

Very good results can be achieved with a Phoredox type nutrient removal plant providing oxygen input is carefully balanced against oxygen demand. Sludge must be kept somewhat under-oxidized to obtain good anaerobic conditions on recycling. Satisfactory DO concentrations are barely over zero and very difficult to monitor. Recording ammonia meters would probably be more suitable than DO meters for control purposes.

REFERENCES

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