Activated Sludge Systems

FIXED BIOMASS CARRIERS IN ACTIVATED SLUDGE PLANTS

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ABSTRACT

To upgrade existing activated sludge treatment plants, the effect of submerged elements in the aeration basins was verified. In a full scale unit, one complete section of the plant fitted with biofilter packing was operated in parallel with a similar unmodified section as reference. The volume occupied by the fixed beds was varied between 20 and 40% of the tank. The biofilm evolution and hydraulic behaviour of the packing was followed. No significant change in sludge settleability was observed, but fixed biomass addition reduced sludge production. The submerged elements improve removal efficiency at higher loads. Effluent quality can be maintained even though loadings are increased. Existing treatment plants can thus be adapted to higher loads without additional basin volume. For a constant loading, the basins with biomass carriers improved residual pollution values. Higher purification standards can thus be met without increasing plant capacity.

KEYWORDS: activated sludge, fixed biomass, sludge volume index, plant rehabilitation, effluent upgrading.

INTRODUCTION

Although submerged surfaces to enhance biological growth in activated sludge plants have been in use for more than 50 years (HUANG, 1982), only recent improvements with air diffusers and plastic contact materials have raised new interest (RUSTEN, 1984).

With the same aim to increase biomass content in activated sludge plants, floating foam pads acting as porous support particles have been proposed (HEGEMANN, 1984; HEGEMANN, 1986; COUPER, 1984; BOYLE, 1986). Advantages claimed are better removal rates, more stable operation due to a reduced sludge volume index, and increased air transfer efficiency. Similar results were reported on submerged biofilter media (BOYLE, 1986; HIROSE, 1983; EBERHARDT, 1984; SCHLEGEL, 1986). Doubts have been raised as to the development status of the "pseudo-fluidized" foam beds (BOYLE, 1986). The directly aerated plastic supports have been shown to be colonized by biomass grazing organisms and protozoa which led to a lower contribution to the substrate removal than expected (EBERHARDT, 1984; SCHLEGEL, 1986).

All these experiences were carried out at low BOD loadings (less than 1 kg BOD / m³ d) with the primary objectives to eliminate bulking problems or to enhance nitrification. Fine bubble diffusers, placed at the bottom of the activated sludge basins directly under the carriers, were used. At a highly loaded plant, a comparison between mobile foam cubes and fixed biomass carriers (ROGALLA, 1987) showed that both allow the extension of existing treatment plants without additional basin volumes. In a plant where medium bubbles were injected close to the surface the treatment capabilities were extended without changing aeration equipment or adding tankage volume.

In the continuation of this work, the aim of the presented research was to confirm the feasibility of adapting an overloaded activated sludge treatment plant to a desired load and treatment objective. We tried to find a relationship between the quantity of fixed biomass added and treatment efficiency.

EXPERIMENTAL ARRANGEMENT

The possibility to compare different treatment systems was given at a 40 000 m³/d activated sludge plant serving 250 000 inhabitants in Le Mans (France). Two aerated basins and one pure oxygen unit (UNOX) are installed on the site. Sludge is treated thermally, and concentrated heat treatment liquor is sent back to the head of the plant after anaerobic digestion to lower the return load (GUEGAN, 1982).
The aeration equipment installed consists of a grid injecting coarse air bubbles 80 cm below the surface on one half of a basin (INKA systems). A submerged median wall enhances a spiral flow in the U shaped basin (Figure 1). This configuration is representative for a large number of plants built in the 70ties when investment costs were preponderant to running costs in systems selection.

A complete section of the plant consisting of primary settling tank, aeration basin (650 m³) and clarifier with sludge return was available for the study of the biomass carrier addition. A conventional basin of 1200 m³ was operated in parallel, with the objective of having comparable loads and functioning parameters on both units. The UNOX system could accept all surplus load, so that parameters on the two test basins could be varied over a wide range.

The BIOFIX system consists of modular corrugated cross-flow type plastic media with a specific surface area of 100 m²/m³, allowing a good penetration of the spiral flow. The media is attached to a support structure below the aeration grids, filling about 20 % of the tank volume (Period 1). To increase fixed biomass, up to 40 % of the basin volume could be packed by placing submerged elements on both sides of the circulation wall (Period 2).

Biomass weight measurements were taken from an easily removable pilot element having a known weight and a volume of 0.6 x 0.6 x 0.33 = 0.12 m³. This element was periodically removed and washed until its weight reached the initial value. Dried biomass and volatile content was then measured by the usual MLSS method.

On all basins, 24 hour composite samples were analysed for Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Suspended Solids (SS) and Ammonia. Dissolved Oxygen (DO), Mixed Liquor Suspended and Volatile Suspended Solids (MLSS, MLVSS) as well as Sludge Volume Index (SVI) were analyzed periodically. Flows of air, water and excess sludge were monitored. Three months of measurements were compared on each system after a one month seeding period.

RESULTS

BOD Removal

Monthly averages of BOD concentrations, removal efficiency and loads are listed in Table 1. As with SS, the BIOFIX system shows consistently better BOD removal efficiencies at higher loading rates. Even though F/M ratios based on free biomass were sometimes double the values in the conventional unit, efficiency was superior in the carrier systems.

The improved removal performances are confirmed in the load-efficiency curves (Figure 2). Whereas the efficiency of conventional suspended biomass units decreases steadily with increased F/M ratio, the decline is less steep if 20 % packing is added. At 40 % packing and within the ranges tested, the BOD removal seems independent of the load. Even if fixed bacteria had been taken into consideration when calculating F/M ratio, the load-efficiency curves would show a higher removal capacity.

To allow the calculation of acceptable loads on the basin in relation to treatment objectives, the residual BOD after clarification was related to the volumetric load accepted by the unit. Effluent BOD values are drawn in Figure 3 as a function of daily pollution mass per basin volume. The beneficial effect of the fixed biomass becomes more evident at high loadings beyond the nominal load of the conventional plant. With 20 % packing, the plant is upgraded from a 30 mg/l BOD effluent to 20 mg/l BOD at the same load. For 40 % media addition, the effluent quality becomes independent of the load and stabilizes around 20 mg/l. As discussed above, a unique design curve for both the conventional and the modified basins is difficult to obtain due to influent quality variations.

COD Removal

The COD results reflect the BOD removal results. The modified units obtained increased efficiencies at much higher loads. As shown in Figure 4, the COD mass per day and reactor volume to reach the same effluent quality (French discharge standard at 90 mg COD/l) could be extended by 1.5 kg COD/m³ d with 20 % packing. The same value was gained by adding 40 % media, but at a lower level due to deteriorated water biodegradability. The percentage gain in acceptable load thus varies between 30 % improvement at 20 % packing and 50 % load increase at 40 % added media volume.

During period 2, the conventional unit hardly ever produced acceptable COD levels below 90 mg/l, even though the average BOD was close to the discharge standard of 30 mg/l. The addition of biomass carriers could mitigate the upset conditions and maintain effluent quality at the required level. Addition of submerged elements can thus help to overcome seasonal or momentary shock loads.
CONCLUSION

The addition of fixed biomass carriers to existing activated sludge basins has been shown to be a feasible remedy for overloaded plants. Plant capacity can be extended by about 30 to 50% without supplementary basin volume. The efficiency increase by additional biomass is highly dependent on initial treatment quality. The beneficial effect is proportional to overloading conditions. The relationship between performance and added media volume could not be clearly demonstrated, even though a higher fixed biomass content gave more stable treatment results. Other work to assess nitrification capacity of submerged biomass carriers is in progress.

ACKNOWLEDGEMENTS

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REFERENCES


FIGURE 1 Schematic view of biomass carriers in activated sludge basin
Table 1 Monthly averages of BOD removal performance

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<th>Month 2</th>
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<td>BIOFIX</td>
<td>INKA (ref.)</td>
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<td>BOD mg/l INFLUENT</td>
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<td>EFFICIENCY %</td>
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<td>LOAD kg/d</td>
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<td>EFFICIENCY %</td>
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<td>VOLUME/m³</td>
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Figure 2 BOD removal efficiency during Period 1 (20% packing) in relation to load on suspended biomass

Figure 3 Effluent quality during Period 1 (20% packing)

Figure 4 Residual COD during Period 1 (20% packing)