Upgrade of an Oxidation Ditch Using Bio-Mass Carriers

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The Problem

Oxidation ditches (OD) are very popular wastewater treatment processes for small to medium sized municipalities that have to meet stringent water quality standards in terms of BOD and nitrogen removal. However, when an upgrade is required due to increase in wastewater quantities or due to stricter regulations, there is usually a need to increase the OD volume in order to comply with the new quality standards. Introduction of biomass carriers into an existing OD is a potential method of enhancing the treatment capacity of the system without increasing its footprint. The advantage of biomass carriers over activated sludge-based systems becomes more prominent especially at low temperatures when an increase in nitrification capacity is required. This approach, however, cannot be implemented in a straightforward manner due to the unique hydraulic patterns within the oxidation ditch.

Goals of Presentation

This paper presents a case study of an OD upgrade in Spain by introducing biomass carriers and performing some internal structural and hydraulic changes in the existing ditch. The performance of the upgraded OD module has been compared to an existing OD module at the same site that had not been upgraded.

A Case Study

The existing OD was operating with two parallel modules at a total flow rate of 1,100 m^3/d, exhibiting very poor nitrification capacity. The wastewater characteristics and the required effluent quality are presented in Table 1. It was required to upgrade one of the two existing modules in order to double its inflow rate to 1,100 m^3/d, while improving the OD treatment capacity in terms of organic matter and nitrogen removal.

The process configuration chosen to upgrade the treatment capacity of the system was IFAS (Integrated Fixed Film Activated Sludge; Figure 1). The IFAS configuration allows simultaneous removal of BOD by the suspended biomass and efficient nitrification by the fixed biomass upon the carriers. The original aerobic zone was separated from the anoxic zone by vertical partitions and filled with Aqwise Biomass Carriers (ABC), possessing a protected surface area of ~650 $m^{2/}m^3$ carriers (Figure 2). Additional structural changes included installation of wedge wire screens on the installed partition to retain the biomass carriers within the aerobic zone and rearrangement of diffusers on the floor of the aerobic zone to enable carriers' mixing.

Since the installation of the vertical partitions resulted in a change in the original OD mixed liquor flow pattern, the liquid was transferred from the anoxic to aerobic zone by means of air-lift pumps at a rate of ~ 300 m^3/h. Several coarse bubble diffusers were placed in several regions within the anoxic zone in order to prevent sludge sedimentation.

The two modules were operated at an average flow rate of 550 m^3/d in order to compare between their performances.

Results and Discussion

Figures 3 to 5 present the effluent qualities in the original and upgraded modules in terms of total N, ammonia and nitrate during one month of operation. It can be clearly seen that N removal was excellent in the upgraded module, reaching the required effluent quality of <15 mg/L (Figure 3), while in the original OD the effluent levels were as high as 35 mg/L.

The ammonia and nitrate results (Figures 4 and 5, respectively) clearly demonstrate the advantages of the IFAS configuration over the original design at low temperatures. The effluent concentrations remained stable and low, as the water temperature went down from ~23^{o}C in summer to ~ 17^{o}C in the beginning of November, demonstrating excellent nitrification and denitrification capacities of the system. On the other hand, nitrification has been steadily inhibited in the original module with decrease in the temperature, resulting in ammonia effluent levels as high as 30 mg/L in the beginning of November. Absence of nitrate in the effluent also implied that ammonia oxidation was not taking place in the original OD. Table 2 presents the values of the quality parameters averaged over a period of one month in the two modules. It can be seen that the performance of the upgraded module is better than the performance of the original one in terms of organic matter and nitrogen removals.

The performance of the upgraded module under increasing flows and loads at temperatures lower than 17^{o}C is being tested these days.

Table 1. Wastewater characteristics and effluent requirements.

Parameter	Units	Design value
INFLUENT		
Flow rate	m^3/d	1,090
Temperature	^oC	10 - 22
COD^T	mg/l	440
BOD_5^T	mg/l	220
TSS	mg/l	145
TKN	mg/l	52
TP	mg/l	8
EFFLUENT REQUIREMENTS		
COD^T	mg/l	< 125
BOD_5^T	mg/l	< 25
TSS	mg/l	< 35
TN	mg/l	< 15

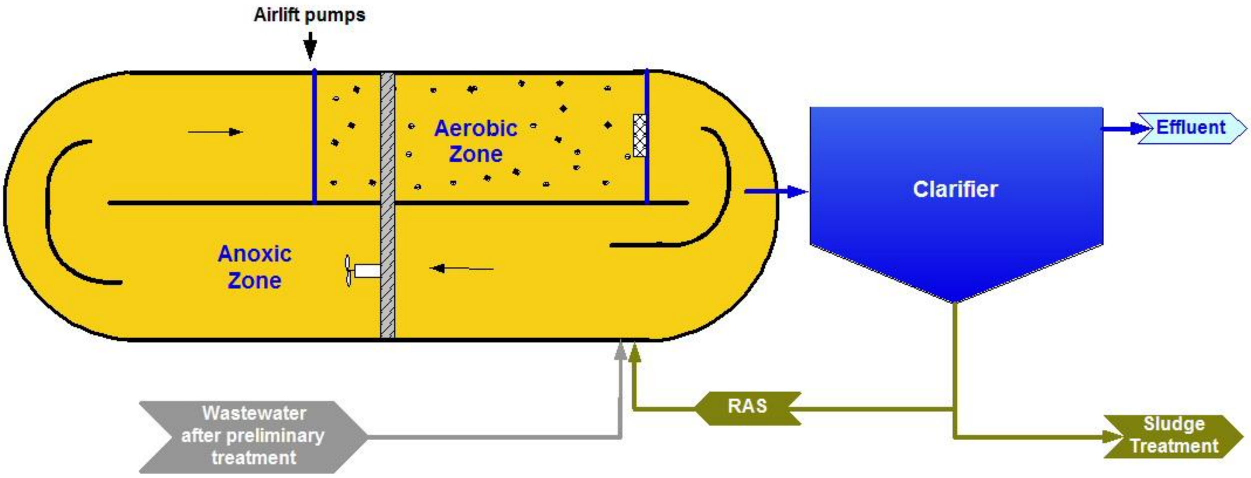

Figure 1. A schematic representation of the upgraded OD

Figure 2. ABC (Aqwise Biomass Carriers) used in the upgrade of the OD

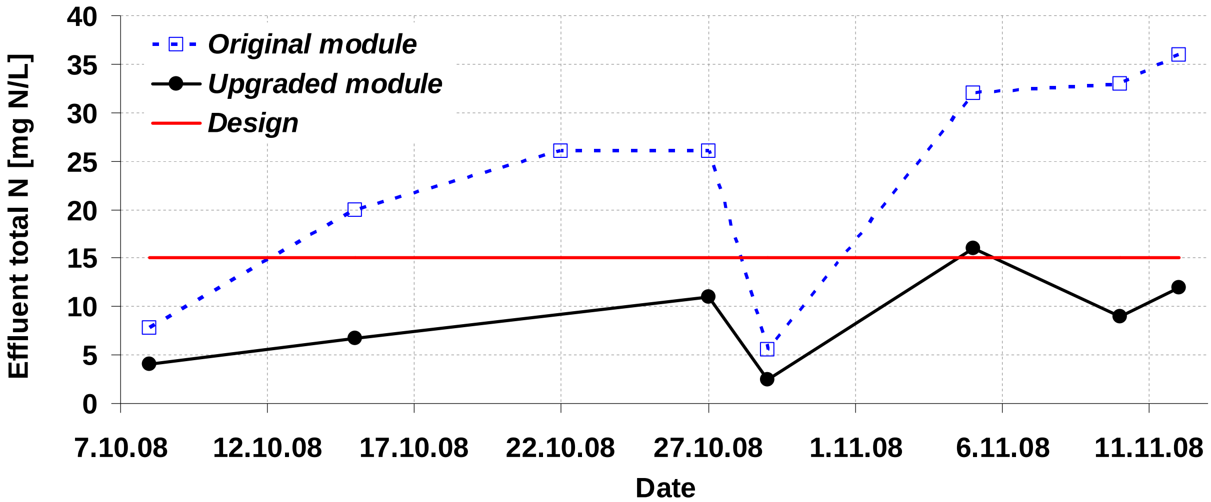

Figure 3. Comparison between effluent total N levels in the upgraded and original modules

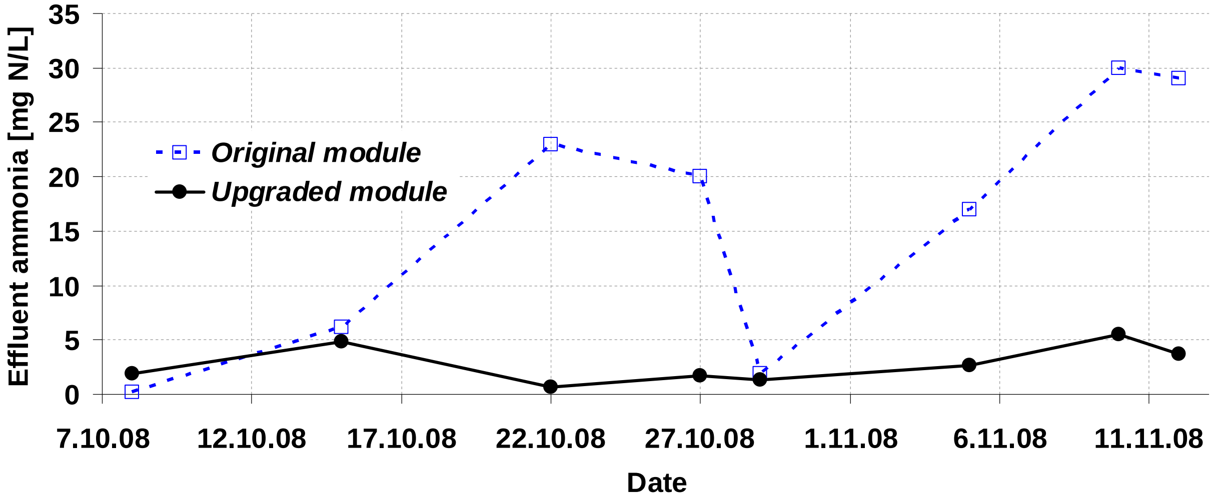

Figure 3. Comparison between effluent ammonia levels in the upgraded and original modules

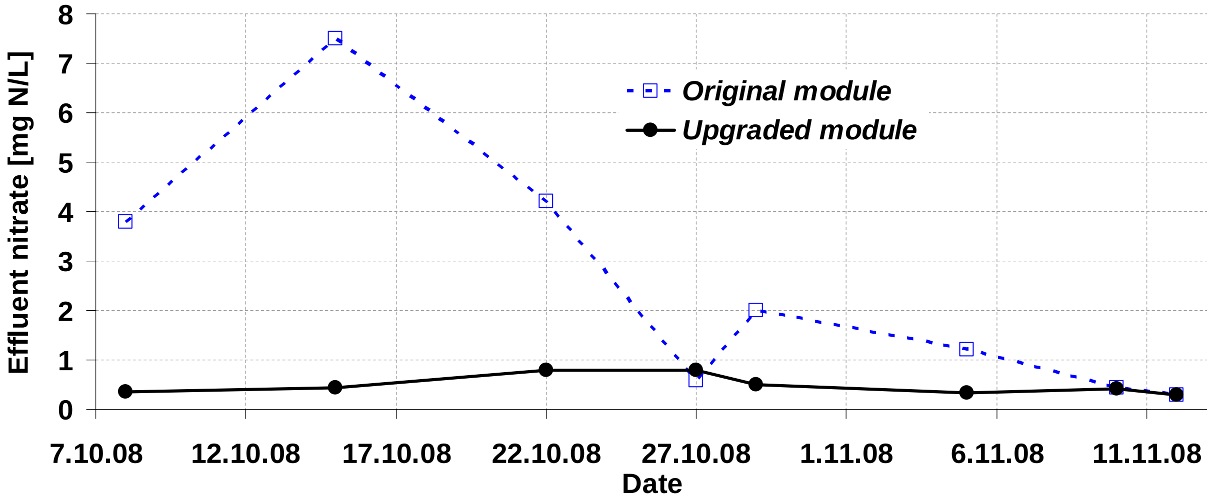

Figure 3. Comparison between effluent nitrate levels in the upgraded and original modules

Table 2. Effluent quality parameters in the two modules averaged over one month of operation.

Parameter	Requirement	Original	Upgraded
TN	15	23.3	8.8
NH_4^+-N	-	15.9	2.8
NO_3^--N	-	2.5	0.5
BOD_5^T	25	16.8	11.0