Introduction

Apria Systems is a technology-based company, strongly focused to provide sustainable advanced solutions for the purification of industrial streams based on membrane and advanced oxidation technologies. APRIA's experience has allowed the development of a novel water treatment process for recirculation aquaculture systems (RAS), the ELOXIRAS® technology. ELOXIRAS® is based on electrochemical oxidation processes, which generates a mixed oxidant without the addition of chemicals, only by applying an electrical potential between two electrodes in water. The developed technology achieves high removal rates of contaminants such as total ammonia nitrogen (TAN) and nitrite, also presenting a high disinfectant efficacy.
The novelty of the ELOXIRAS® treatment system is its ability to increase the production of different marine species:

1. Allowing higher culture densities within the purification controlled limits.
2. Reducing new water intake consumption (and thus, proportional wastewater generation).
3. Removing whole key pollutants in an efficient way (>90%).
4. Increasing by a minimum of 30% the potential benefit (€/year) of the overall process.

Case Study

Figure 1. ELOXIRAS® prototype

ELOXIRAS® is a modular and versatile solution, which integrates three steps in the treatment process (figure 1): (i) pre-treatment by filtration of the water (ii) main treatment by means of an oxidation reactor for the removal of pollutants and pathogens and (iii) post-treatment for the removal of byproducts.

The ELOXIRAS® technology have been subjected to prototype validation tests under real operating conditions in marine fish hatcheries and marine fish growing farms with the aim to corroborate the efficacy of the system in terms of pollutants removal and to demonstrate its applicability to end-users.

The present case

study reports the performance of ELOXIRAS® in the validation tests that were conducted in an aquaculture facility in Spain, which involved two different species of fingerlings: Gilthead Seabream and Sea bass. The target biomass density was 20 kg/m^3 and the daily feeding rate was 2.5% of total biomass; further details regarding operating and culture conditions are summarized in table 1.

Table 1. Prototype specifications and culture conditions concerning validation tests.

Studied species	Prototype capacity	Culture conditions			
		Max. biomass density	Culture tank volume	Recirculation rate	Water renewal rate
Gilthead Seabream	Up to 50 m^3/h	30 Kg/m^3	10 m^3	13 m^3/h	0.35 m^3/h
Sea bass		21 Kg/m^3	10 m^3	13 m^3/h	0.35 m^3/h

-ELOXIRAS® technology validation.

The concentration values of the most concerning pollutants as well as other additional water quality indicators were monitored within the culture tanks during the tests. The main results obtained over the period of study are shown in table 2.

Table 2. Water quality parameters in ELOXIRAS® validation tests.

Parameter	Units	Mean value ± Standard deviation		Quality Criteria[a]	Water quality
		Gilthead Seabream	Sea bass		
pH	-	7.1 ± 0.2	7.2 ± 0.4	6.5-8.5	O.K.
Salinity	g/L	35.8 ± 1.2	35.9 ± 1.2	-	O.K.
Temperature	ºC	23.6 ± 2.1	23.7 ± 1.6	-	O.K.
Dissolved oxygen	mg O_2/L	8.4 ± 2.4	9.9 ± 2.1	> 5	O.K.
TAN	mg N-NH_3/L	0.7 ± 0.5	0.7 ± 0.5	< 3	O.K.
Nitrite	mg NO_2/L	0.02 ± 0.01	0.01 ± 0.01	< 1	O.K.
Nitrate	mg N-NO_3/L	1.0 ± 1.8	0.4 ± 0.5	0-90	O.K.
Chemical oxygen demand (COD)	mg O_2/L	< 30	< 30	-	O.K.
TSS	mg/L	24 ± 20	16 ± 3	10-80	O.K.
Oxidation-Reduction Potential (ORP)	mV	171.3 ± 90.0	171.5 ± 81.3	-	O.K.

[a]Quality criteria according to Timmons et al., 2009.

As seen in table 2, the water treated by the ELOXIRAS® technology fulfills the quality requirements for RAS proposed in the literature.

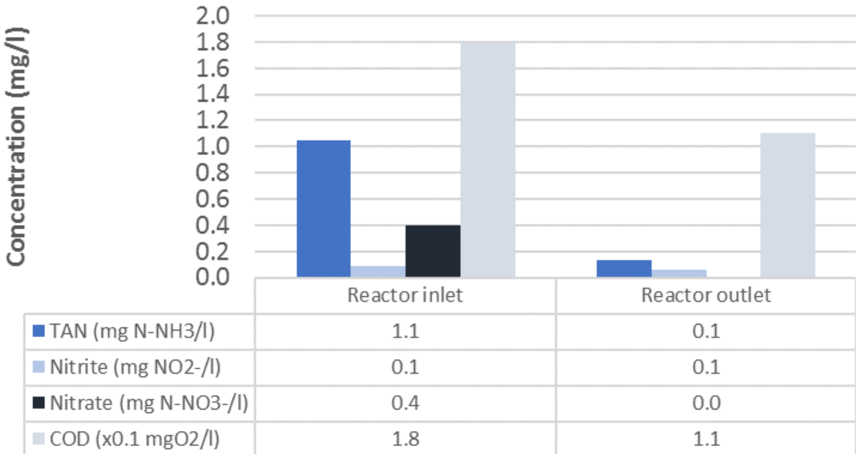

Figure 2. Experimental values of key pollutants at the inlet/outlet of the systems based on ELOXIRAS® technology.

Figure 2 reports typical values of key pollutants at the inlet/outlet of ELOXIRAS® System. These results confirm that the developed technology allows removing TAN and COD from the system with efficacies approximate to 90% and 40%, respectively. In this regard, the main removal mechanics that take place inside the reactor and that make ELOXIRAS® capable of achieving significant pollutant removal efficiencies are as follows:

a) TAN removal to nitrogen gas:

$$2NH_4^+ + 3HOCl \rightarrow N_2 + 5H^+ + 3Cl^- + 3H_2O$$

b) Nitrite removal to nitrate:

$$NO_2^- + HOCl \rightarrow NO_3^- + Cl^- + H^+$$

c) Organic matter oxidation. In-situ generated oxidants are also consumed by the organic matter

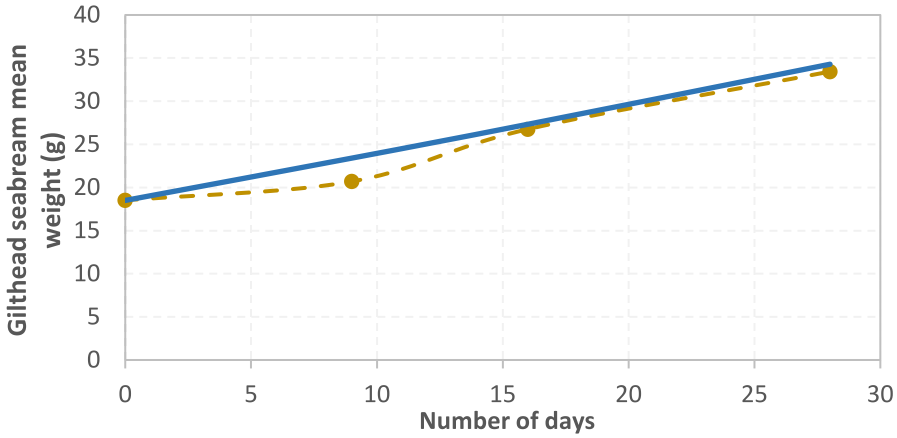

Figure 3. Experimental (--●--) and theoretical (—) Gilthead seabream mean weight (g). Theoretical values are estimated using correlations from the literature considering a salinity of 36‰ and T = 28ºC (Calderer and Castello, 2001).

The mean instantaneous growth rate in weight (G) is calculated according to the literature. The mean values for Gilthead Seabream (15-30g) and Sea Bass (10-20g) are 2.0%/day[1] and 1.6%/day[1], respectively; typical values of 2.1%/day (Gilthead Seabream) and 1.5%/day (Sea Bass) are reported by literature (Fernández Polanco and Da Silva Bichara, 2005). Figure 3 reports the mean weight evolution of Gilthread Seabream fingerlings. After 30 days, there is not a significantly influence on the weight owing to the use of ELOXIRAS® technology.

In conclusion, the ELOXIRAS® technology is able to keep pollutant concentrations under suitable values with growth rates equal to those reported by the literature under similar culture conditions.

-ELOXIRAS® technology benefits.

APRIA Systems has developed SiTELOX software to simulate the impact of ELOXIRAS® technology and its benefits. The real TAN concentration values have been compared

[1] G (percent per day) = [ln(final mass)- ln(initial mass)]/duration x 100

with theoretical evolution based on the performance of a conventional treatment using biological filters under typical culture conditions. The results obtained are summarized in table 3 and figure 4.

Table 3. Culture and operating conditions of the ELOXIRAS® validation and those considered for the simulation of TAN time evolution.

Variable	Biological	ELOXIRAS®
Culture tank biomass (Kg)	**440**	**440**
Feed consumption (kg feed/day)	**11**	**11**
Recirculation rate (R/h)	**2.0**	**1.3**
Culture volume (m^3)	**20**	**20**
Flow rate (m^3/h)	**40**	**26**
Water renewal rate (m^3/h)	**5.0**	**0.70**
Maximum resulting TAN (mg N-NH_3/L)	**2.3**	**1.5 (real) 1.6 (simulated)**

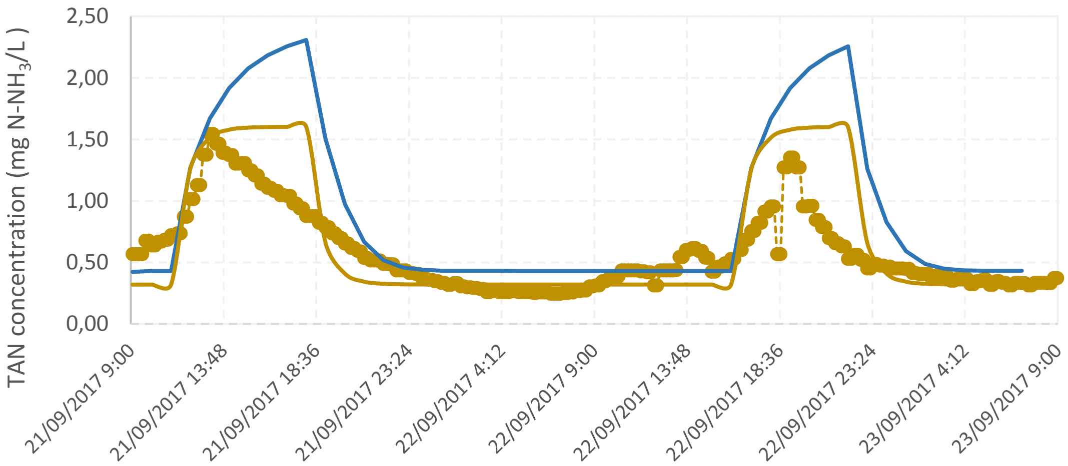

Figure 4. Comparison between experimental time evolution of TAN concentration using ELOXIRAS® (--●--) and simulated time evolution of TAN concentration using ELOXIRAS® (—) and biological filters (—) in a RAS under similar conditions over a period of 48 hours.

The main benefits of ELOXRAS® technology are: (i) TAN removal capacity is higher, being TAN maximum value at the culture tank much lower; (ii) new water intake consumption is significantly reduced; (iii) the recirculated water across the treatment systems is lower, being reduced the energy consumption associated to the pumping requirements.

References

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