**Development of a hybrid biological process for oilfield produced water treatment.**

Nicolas Lusinier1, Isabelle Seyssiecq2, Cecilia Sambusiti3, Matthieu Jacob3, Nicolas Lesage4 and Nicolas Roche1,\*

*1 Aix-Marseille Univ, CNRS, IRD, INRA, Coll France, CEREGE, Aix en Provence FRANCE ; 2 Aix-Marseille Univ, CNRS, Centrale Marseille, M2P2, Marseille France ; 3 TOTAL SA, PERL – Pôle d’Etudes et de Recherche de Lacq, Pôle Economique 2, BP 47 – RD 817, Lacq, France ; 4 TOTAL SA, CSTJF, Avenue Larribau, Pau, France*

*\*Corresponding author: nicolas.roche@univ-amu.fr*

**Highlights**

* Amount of produced water from oil exploration and production is increasing.
* A hybrid biological process was developed to treat oil produced water.
* Enhancement of oxygen transfer occurs in the presence of a packing material.

**1. Introduction**

Crude oil extraction leads to the production of produced water (PW). PW flowrate increases with oil field lifetime, up to more than 20 times the flowrate of crude oil. Since the regulations regarding PW disposal becoming more stringent, there is a big challenge in developing efficient treatment processes (i.e. physico-chemical and/or biological treatments). Among them, biological treatments (i.e. conventional activated sludge processes) are commonly installed in the industrial sector, due to cheaper operation costs and higher removal efficiencies of biodegradable compounds compared to those obtained by chemical treatments. However, critical parameters, such as the PW composition (i.e. salinity and low biodegradability of some compounds) and technology compactness for offshore implementation, have to be taken into account. Hybrid processes defined here, as the combination of two biotreatment processes (i.e. fixed and suspended microbial biomass in the same reactor) showed promising performances in terms of oxygen transfer [3]. Furthermore, this combination enhances treatment efficiencies as both, the biomass concentration and the microorganisms variety increase in the bioreactor [4]. Thus, this study relates the development of a hybrid biological process for oilfield produced water treatment.

**2. Methods**

Experiments were carried out by using a laboratory pilot plant, consisting of two bioreactors (30 L of working volume) and two clarifiers (5 L of working volume) in parallel (Figure 1). Reactor columns have an inner diameter of 19 cm and a total height of 107 cm. The aeration is supplied by compressed air flowing into a membrane to provide fine bubbles. The packing material, confined into the bioreactors, is made of cylindrical solid rings (AnoxKaldnes®). The air flowrate is controlled by a flowmeter. Preliminary experimental tests were conducted to determine the oxygen transfer rate (KLa) on clear water and on a physico-chemical Newtonian suspension (i.e. 3g/L bentonite suspension), by varying the air flow rate (4-10-16 L/min) and the packing height (0-17-34 cm). The oxygen transfer measurements were carried out by using the disulfite deoxygenation method followed by a re-oxygenation phase [3].

**

**Figure 1.** Experimental set-up of the two packed-bed bioreactors.

**3. Results and discussion**

Concerning the oxygen transfer, results showed that, in the presence of the physico-chemical Newtonian suspension (bentonite suspension) oxygen transfer is reduced compared to clear water at a same packing height and/or air flowrate (figure 2a and 2b). Furthermore, figure 2b shows that the oxygen transfer coefficient increases with the air flowrate (up to 60 %) but also with the packing height. Indeed, the presence of the packing bed is thought to induce a decrease in bubble coalescence, inducing in turn an increase in specific exchange area, thus of the KLa coefficient (up to 30 %).

|  |  |
| --- | --- |
|  |  |

**Figure 2.** Evolution of oxygen transfer coefficient as a function of air flowrate and packing height for clear water (a) and bentonite suspension (b)

**4. Conclusions**

Results showed that the presence of the packing bed induce a 52-64 % increase in oxygen transfer for both clear water and bentonite suspension and for an identical energy input (constant air flow rate) due to the presence of the packing bed inducing a decrease of bubbles coalescence along the column. Further studies of oxygen transfer will be performed with a non-Newtonian bioflocs suspension, as well as biotreatment studies to assess the treatment efficiency of such a process for a synthetic produced water. During acclimation test, first results showed that the COD of produced water can be removed with high treatment efficiencies (>95 %).

**References**

1. P. Baldoni-Andrey, P. Pedenaud, P.L. Dehaene, B. Segues, Society of Petroleum Engineers (2006).
2. P. Pedenaud, P. Baldoni-Andrey, A. Breton, B. Segues, A. Demangel, M. Jacob, Society of Petroleum Engineers (2018).
3. K. Zerari, I. Seyssiecq, D.E. Akretche, N. Roche, Journal of Chemical Technology & biotechnology 88 (2013) 1007-1013.
4. V.S. Ruys, K. Zerari, I. Seyssiecq, N. Roche, Journal of Chemistry (2017) 1-7.