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STUDY ON PHARMACEUTICALS REMOVAL BY ACTIVATED SLUDGE TREATMENT

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Abstract - **This study refers to the fate and elimination during activated sludge treatment of Permethrin and Atenolol pharmaceuticals found as pollutants in wastewaters. So, using the SimpleTreat model is estimated the pollutants removal efficiency by biodegradation in activated sludge as a function of retention time (2, 5 and 10 hours). As predicted by the model, the results are correlated with pollutants properties, i.e. biodegradation rate constant and solubility in the liquid phase.**

Keywords- **Pharmaceuticals, Simple Treat model, Aeration tank, Removal efficiency**

I. INTRODUCTION

The activated sludge treatment is carried out in wastewater treatment plants and uses bacteria digestion as the main depollution process [1-4]. As equipment for this treatment is used aeration tanks containing the activated sludge in which the wastewater is retained for a certain period of time, between 4 and 8 hours, before being transferred to the secondary clarifier for sludge settling. A schematic representation of the activated sludge process is presented in Figure 1 [2].

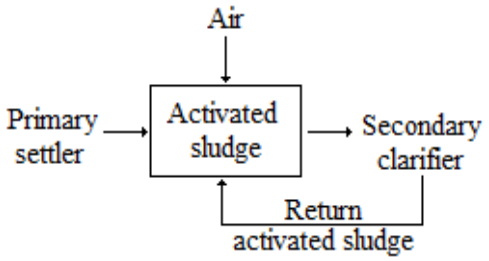

Fig. 1. Schematic representation of the activated sludge process [2]

The number of bacteria found in 1 gram of dry activated sludge is between 10^8-10^{14} cells of 5 to 8 bacteria species [1]. The addition of air from the atmosphere ensures vital processes of bacteria which consume the organic materials from wastewater and transform them into gaseous products and biomass [1-4].

This study aims quantitative estimations during biological treatment in an activated sludge tank of a wastewater treatment plant of two pollutants, i.e. Permethrin and Atenolol pharmaceuticals. As available from the SimpleTreat model [5, 6], estimates regarding removal efficiency, expressed in percentage from pollutant concentration in influent, are presented after treatment (in primary settler, aeration tank, and secondary clarifier) and also after discharge from wastewater treatment plant in effluent.

II. METHOD OF ANALYSIS AND RESULTS

The pollutants were selected due to their relative high use by humans [7-9], concentrations of approximately 0.13 µg/L of Permethrin and 1 µg/L of Atenolol were detected in municipal wastewater [10, 11]. Permethrin is a chemical classified in the pyrethroid insecticide group and is also used as a medication in the form of cream or lotion [11, 12]. Atenolol belongs to the group of beta-blockers pharmaceuticals used in treating cardiovascular disease [10]. The input data used in the SimpleTreat model are presented in reference [13]. In addition, predictions are made as a function of retention time in aeration tank of 2, 5 and 10 hours.

Figure 2 shows estimated mass flows of Permethrin (PMT) in treatment plant different basins in function of the retention time of 2 (a), 5 (b) and 10 hours (c). As the solubility of Permethrin (PMT) at 25ºC is low, about 0.006 Pa [14], it favors its adsorption on solids surface in influent, rather than dissolution into wastewater liquid phase [11]. So, estimations with the SimpleTreat model predicted that in influent Permethrin (PMT) can be dissolved in the liquid phase in proportion of about 3% and adsorbed on the suspended solids surface in proportion of about 97% (Figure 2.a-c). Therefore, an important removal of pollutant quantity occurs with sludge evacuation in the primary settler (64.6%, value independent of retention time, Figure 2.a-c), but also in the secondary clarifier (Figure 2.a-c). The hydraulic retention time influences the removal efficiency in the aeration tank, larger value is estimated after 10 hours of retention, 7.29% (Figure 2.c).

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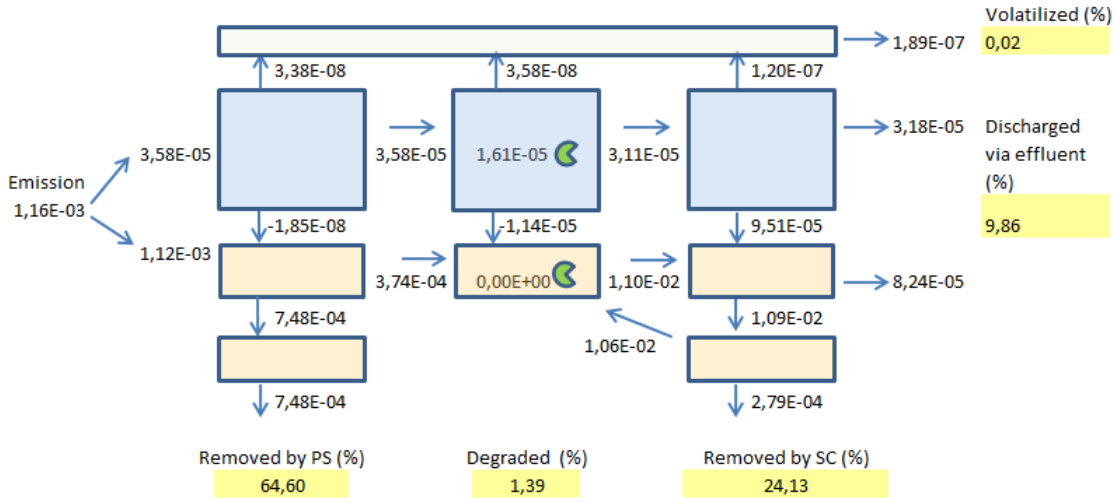
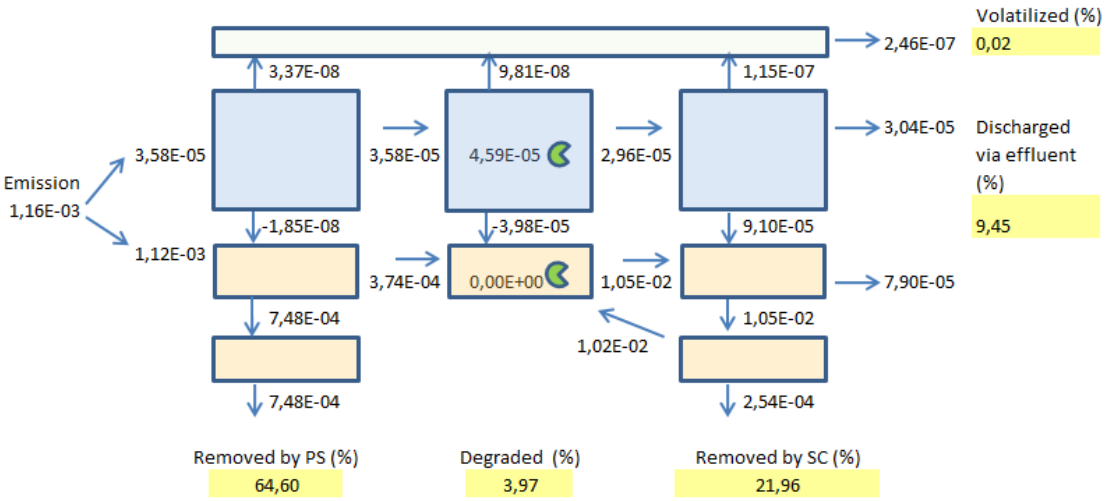
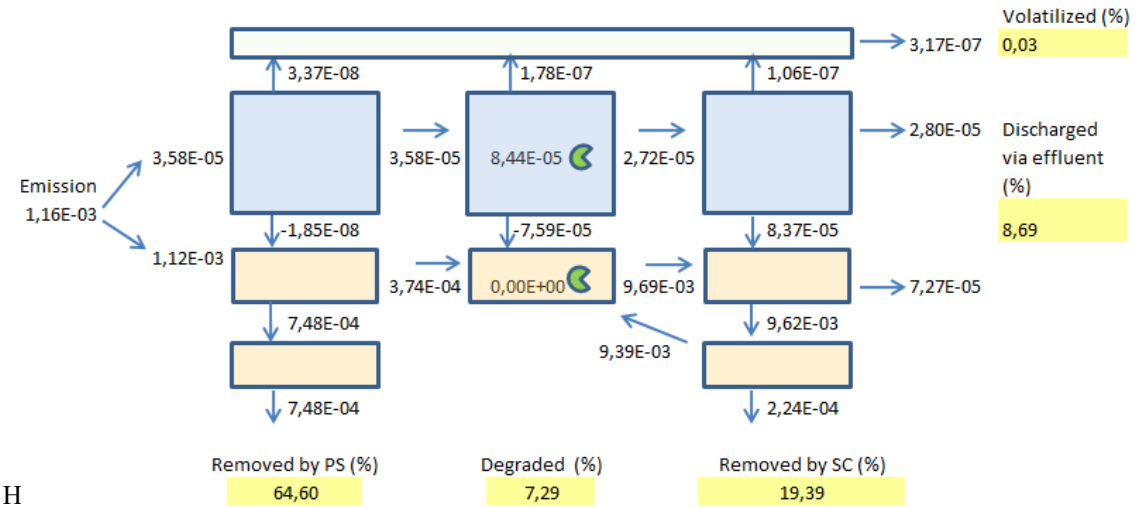


A) HRT = 2 H



B) HRT = 5H



C) HRT = 10 H

Fig. 2. Estimated mass flows of Permethrin (PMT) as a function of hydraulic retention time of 2 (a), 5 (b), and 10 hours (c)

So, although Permethrin (PMT) is a biodegradable compound, its low solubility does not favor removal by biodegradation in aeration tank (which according with the SimpleTreat model occurs only in the liquid phase [5, 6]),

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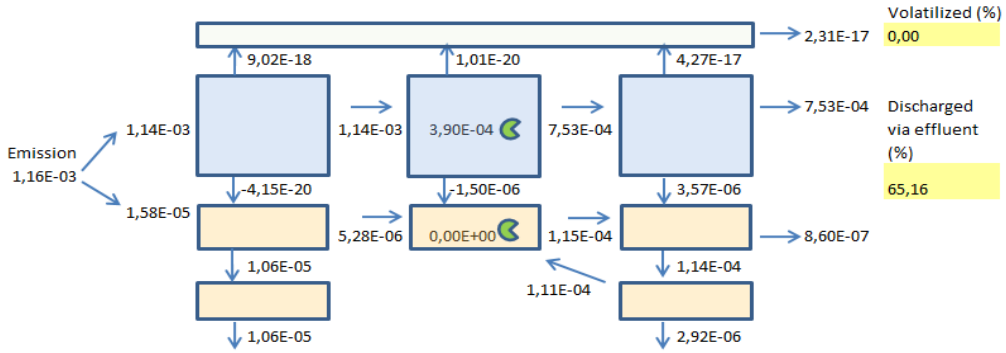
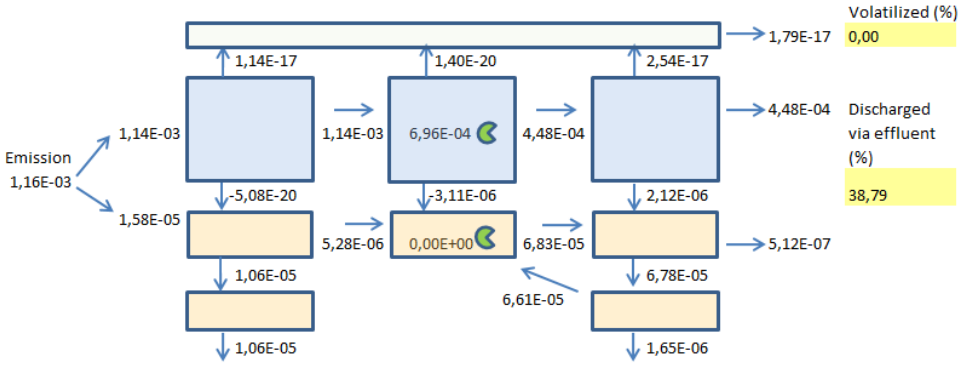
even if the retention time increases. Thus, the main mechanism of PMT removal is adsorption on sludge solids surface. However, in effluent, PMT is predicted to be found in small quantity, about 9%, with small deviation for the three retention durations (Figures 2.a-c). Therefore, PMT can be removed during wastewater treatment, in a proportion of about 90%.

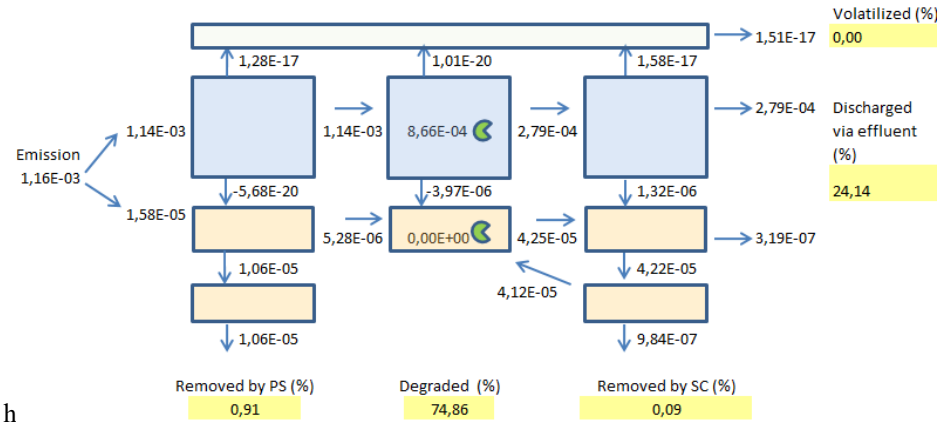
Figure 3 presents estimated mass flows of Atenolol (A) in different treatment plant basins in function of hydraulic retention time of: 2 (a), 5 (b) and 10 hours (c). Atenolol solubility at 25ºC is approximately 13300 Pa [14], which can favor dissolution in the wastewater liquid phase in high proportion.



a) HRT = 2 h



b) HRT = 5 h



c) HRT = 10 h

Fig. 3. Estimated mass flows of Atenolol (A) as a function of hydraulic retention time of 2 (a), 5 (b), and 10 hours (c)

Estimates by Simple Treat model shows that about 98% of this pollutant may be dissolved in the influent (Figure 3.a-c). Therefore, the removal by primary and secondary clarifiers is low, under 1%, the main removal mechanism being biodegradation in aeration tank (Figure 3.a-c), Also, retention time in the aeration tank influences pollutant

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removal efficiency, the estimated values being: 33.68% after 2 hours, 60.15% after 5 hours and 74.96% after 10 hours (Figure 3.a-c). Increasing the retention time, decreases the pollutant quantity discharged through the effluent, from 65.16% after 2 hours of retention to 24.14% after 10 hours of retention (Figure 3.a,c).

Figure 4 presents the variation of the SimpleTreat model estimations of biodegradation removal efficiency as a function of retention time in the aeration tank.

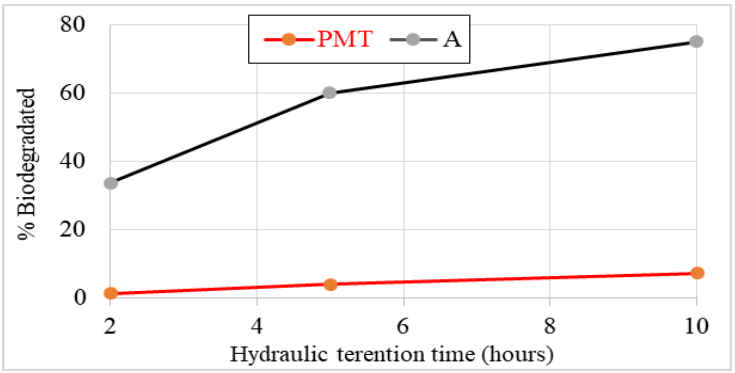

Fig. 4. Elimination of biodegradable pollutants in aeration tank in function of hydraulic retention time

As one may observe from the variation presented in Figure 4, the retention time in aeration tank helps to remove by biodegradation of the pollutant which is dissolved in the wastewater liquid phase (case of Atenolol). On the opposite, for the PMT pollutant, which has low solubility in the wastewater liquid phase, the retention time has a low influence, as removal by biodegradation in the aeration tank is a limited process.

III. CONCLUSIONS

According to predictions from the SimpleTreat model, the removal by activated sludge treatment of pharmaceuticals in wastewater treatment plants is not a complete process. Although both pollutants analyzed are biodegradable in activated sludge, the removal efficiency depends on their water solubility as estimated by the model. Further treatment for pharmaceuticals removal may involve activated carbon adsorption or membrane filtration [2, 10, 15].

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