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Original research article

Study of biodegradability for municipal and industrial Tunisian wastewater by respirometric technique and batch reactor test

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ABSTRACT

The aim of this work is to characterize biodegradability of Tunisian wastewater samples collected from a conventional, an extended aeration type activated sludge, and an industrial wastewater treatment plants (dairy, slaughter house and delicatessen). The organic loading were 0.46, 0.075 and 0.1 kg BOD d^{-1} kg^{-1} VSS respectively. The biodegradability was assessed by respirometric technique and batch reactor test. The interpretation and estimation of the chemical oxygen demand (COD) fractions were performed. The measurement of the oxygen uptake rate and evolution of soluble COD concentration, total suspended solid, pH and dissolved oxygen were carried out. The results show that the majority for the first and the third wastewater are biodegradable (56% for the first and 75% of total COD for the third). But the wastewater of the second municipal wastewater treatment plant (WWTP) is not biodegradable (48% of total COD). The readily COD fractions were strongly variable for the three Tunisian WWTP; 36% of total COD for the first, 21% of total COD for the second and 8% of total COD for the industrial WWTP.

1. Introduction

In order to respond to new legislation aimed to reducing the cost of treatment it is necessary to focus on the pivotal role of bacterial respiration in the aerobic treatment process. A global characterization of organic treated matter (chemical oxygen demand; COD and biological oxygen demand; BOD) and physical chemical separation methods (particulate, soluble, settling …) were generally used to evaluate the performance and optimization of biological process. However, deterministic tools of modeling developed for the last 20 yr (Activated Sludge Model; ASM) require a characterization which is related to the biological organic matter reactivity for describing correctly microbiological wastewater treatment plant (WWTP) processes. The global methods are used to estimate, with empirical correlation, the mean value of oxygen uptake and sludge production of the process. But, the characteristics of wastewater are more related to the type of influent, sewer and a retention time of wastewater in sewerage.

Respirometry is a widely used technique for the characterization of wastewater and activated sludge. It constitutes a well established procedure to assess the state of microbial activity and for calibration of microbial kinetic models [1]. Respirometric technique begins to generate much interest in process control. It is used to obtain bio kinetic characteristics which are one of the most important information sources in activated sludge process modeling. Munz et al. [2] applied respirometric techniques for the characterization of tannery wastewater and biomass in a pilot plant membrane bioreactor operating at high sludge age. As a result, the wastewater biodegradable COD was fractionated into four components: readily biodegradable, rapidly hydrolysable, slowly hydrolysable and inorganic. Edgardo et al. [3] used the respirometric techniques to study the effect of pH, phenol and dissolved oxygen (DO) concentrations on the phenol biodegradation kinetics by activated sludges. Cokgor et al. [4] evaluated the effect of mixing the effluent of a pharmaceutical plant producing acetylsalicylic acid with tannery wastewater on the biodegradation of the effluents using respirometric techniques. Buendía et al. [5] estimated the biodegradation kinetics and the different biologically degradable fractions (readily, slowly and inert fractions) of the organic wastes generated in a meat industry under both anaerobic and aerobic

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conditions. Caffaro et al. [6] used respirometry for evaluation of toxicity reduction of polyester manufacturing industry wastewater.

'Biodegradability' is an important parameter due to the simple fact that ecological behavior of substances and products can be better understood. Information on the degradability of chemicals may be used for hazard and risk assessment [7].

The identification of COD fractions with different biodegradation characteristics was the major achievement in this field [8], which enhanced the development of respirometry for COD fractionation and biodegradation kinetics [9,10]. This also led to multi-component models that incorporated COD fractionation and promoted the oxygen uptake rate (OUR) as the major parameter for wastewater characterization and process kinetics [11]. This approach provided a new insight to the biodegradation characteristics of domestic sewage [12]. It was successfully applied to different industrial wastewaters [13]. Mhalanga et al. [14] have characterized wastewater at the Mariannridge WWTP located in South Africa and which receives an average of 8000 m^3 d^{-1} wastewater of which about 30% industrial and 70% domestic wastewater. They have used batch respirometric test to determine the readily biodegradable fractions (S_S) and heterotrophic biomass (X_H). At the end of the test, the inert soluble substrate fraction (S_I) was determined through a flocculation-filtration procedure. The inert particulate fraction was determined from the simulation model and the slowly biodegradable COD fraction (X_S) was then determined by difference.

Mikosz [15] has performed the fractionation of COD on three different samples of industrial wastewater (Fruit processing plant) and also for municipal wastewater as 24 h flow-proportional composite samples. The S_I fraction was calculated as 90% of filtrate COD effluent. Acetate fraction (S_A) was equal to the concentration of volatile fatty acid in the collected samples of industrial wastewater. The fermentable COD fraction (S_F) was calculated by Eq. (1).

$$S_F = filtrate\ COD_{influent} - S_A - S_I \quad (1)$$

The X_H faction was determined using a maximum OUR for active X_H. The X_S fraction was deduced by Eq. (2).

$$X_S = BOD_{ultimate} - S_A - S_F \quad (2)$$

The particulate inert COD fraction (X_I) was calculated as a difference between total COD and all other fractions.

The objective of our study is the determination of biodegradable COD fractions which is necessary for dynamic simulation of the biodegradation processes and for an effective management of wastewater treatment plant. The respirometer was used for quantifying S_S and X_S fractons. Batch reactor test was used for characterizing the X_I and S_I fractions. The samples were collected from a conventional, an extended aeration type activated sludge, and an industrial wastewater treatment plants. The fractionation results were compared to the literature in order to evaluate the variability to the organic matter fractions.

2. Materials and methods

2.1. Case study

2.1.1. Description of the conventional WWTP

Fig. 1 illustrates a configuration of conventional activated sludge WWTP (load of 0.46 kg BOD d^{-1} kg^{-1} VSS), it includes a grit chamber, four rectangular primary clarifiers, eight diffusion aeration tanks and four secondary settlers treating 60,000 m^3 d^{-1} with a BOD load of 24,000 kg BOD d^{-1}.

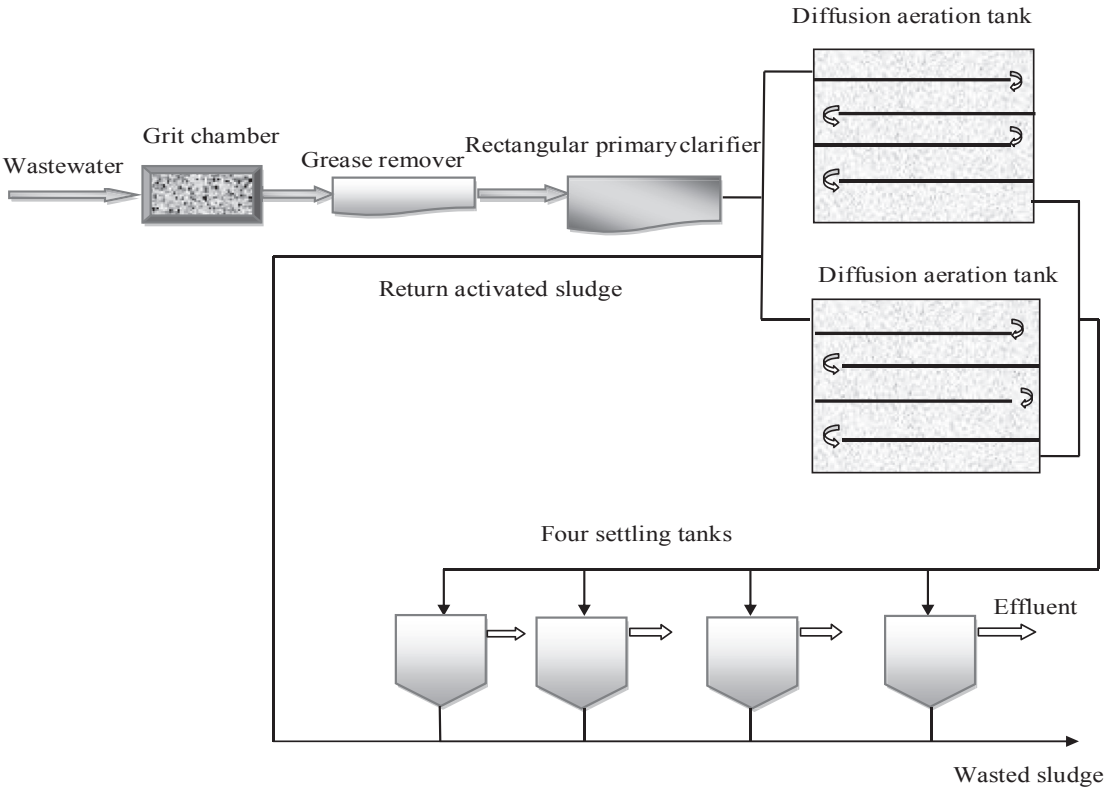

Fig. 1. Layout of conventional activated sludge WWTP.