



# Impact of paint shop decanter effluents on biological treatability of automotive industry wastewater



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## HIGHLIGHTS

- Biological treatability of paint shop wastewater was studied.
- Both COD and nitrogen removal were deteriorated with the feeding of paint shop wastewater.
- Kinetic characteristics were determined by using SBR data and respirometric test results with the aid of model simulation.
- Influence of paint shop wastewater addition on primary and secondary hydrolysis levels was much pronounced compared to the maximum growth rates.
- Biodegradation kinetics were supplied as useful data for the implementation of controlled-feeding program of paint shop wastewater to ensure a reliable waste management strategy for automotive industry.

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## ABSTRACT

A lab-scale Sequencing Batch Reactor (SBR) was implemented to investigate biological treatability and kinetic characteristics of paint shop wastewater (PSW) together with main stream wastewater (MSW) of a bus production factory. Readily biodegradable and slowly biodegradable COD fractions of MWS were determined by respirometric analysis: 4.2% ( $S_S$ ), 10.4% ( $S_H$ ) and 59.3% ( $X_S$ ). Carbon and nitrogen removal performance of the SBR feeding with MSW alone were obtained as 89% and 58%, respectively. When PSW was introduced to MSW, both carbon and nitrogen removal were deteriorated. Model simulation indicated that maximum heterotrophic growth rate decreased from 7.2 to 5.7 day<sup>-1</sup>, maximum hydrolysis rates were reduced from 6 to 4 day<sup>-1</sup> ( $k_{HS}$ ) and 4 to 1 day<sup>-1</sup> ( $k_{HX}$ ). Based on the dynamic model simulation for the evaluation of nitrogen removal, a maximum specific nitrifier growth rate was obtained as 0.45 day<sup>-1</sup> for MSW feeding alone. When PSW was introduced, nitrification was completely inhibited and following the termination of PSW addition, nitrogen removal performance was recovered in about 100 days, however with a much lower nitrifier growth rate (0.1 day<sup>-1</sup>), possibly due to accumulation of toxic compounds in the sludge. Obviously, a longer recovery period is required to ensure an active nitrifier community.

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## 1. Introduction

Because of the stringent environmental regulations, industries spent much effort to reduce or treat their wastes in a financially feasible way to achieve permissible discharge levels. In automo-

bile industry, waste streams from different processes have different characteristics. Wastewaters generated from automobile industry mostly have high suspended and dissolved solids, and high COD content [1]. Moreover, the automobile industry wastewaters contain heavy metals such as Zinc, Nickel, Lead, Copper, Chromium and Cadmium in fairly high concentrations [2–4]. In automobile industry, washing and paint shop sections are the main sources of wastewater discharges, which are rich in heavy metals and organic micro pollutants like monocyclic and polycyclic aromatic hydrocarbons used as solvents and/or additives in paints and other chemicals [5,6].

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Paint sludge is one of the automotive industry's most significant waste categories which needs a special handling. The biological treatment of paint shop wastewater is challenging due to presence of aforementioned potential toxic organic and inorganic micropollutants and high Chemical Oxygen Demand (COD) content. Due to its high toxic potential to biological system, paint shop wastewater needs chemical pre-treatment to further secondary treatment [2–4,7]. The typical COD of the paint shop wastewater reported in the range of 1.4–5.9 g/L [2,8,9] and up to 11.4 g/L [6,10], the characteristics are dependent upon the equipment, operational/cleaning processes and the type of chemicals used [6].

Although there are very few studies available in the literature on the biological treatability of paint shop wastewater, it is reported that heavy metals, particularly Cr, Ni, Cu and Zn and organic chemicals leading to high COD concentrations, can inhibit the biological system [2,6,9,11], especially nitrification process [12,13]. It is well known that, nitrifying bacteria have slow growth rate at ambient temperatures compared to the heterotrophs and they are more sensitive to inhibitors [14]. Batch respirometric tests coupled with modelling have been accepted as the pioneering practical scientific tool for providing rapid information required for the biodegradation characteristics of industrial wastewaters [15–17]. Recently, the activated sludge models have been used in kinetic evaluation for biological treatment of industrial wastewaters [18]. Modified Activated Sludge Models (ASMs) that include a larger number of biodegradation kinetics are powerful tools for the determination of COD fractionation and process parameters for carbon and nitrogen removal [15,19–21].

Due to the complex structure of the paint shop wastewater, biological treatability tests supported with the respirometric analysis together with model evaluation is therefore very important for the selection of treatment alternatives and waste management strategies for automotive industry. This study focuses on biological treatability of paint shop waste streams combined with plant (domestic and process) wastewater of a bus production factory located in Istanbul/Turkey. Paint shop sludge is considered as hazardous waste and classified according to local regulations (waste code: 08 01 13 in accordance with European Commission's 2000/532/EC ordinance). Currently, paint sludge and paint shop wastewater that is produced in the bus factory periodically transferred to a final disposal area at a high cost. The current waste management strategy of the bus factory focuses on the separate disposal of paint shop sludge and treatment of paint shop wastewater in the existing treatment plant by considering the magnitude of transfer and disposal cost. Therefore, the biological treatability of paint shop wastewater definitely has to be assessed prior to discharging into existing treatment plant. In this context, a lab scale SBR system was operated to simulate the carbon and nitrogen removal for the bus factory wastewaters. In parallel to SBR operation, respirometric analyses were conducted and biodegradation of organic carbon fingerprint is obtained by kinetic evaluation of respirogram. Finally, a long term kinetic validation was carried out for SBR system with the aid of dynamic modeling.

## 2. Materials and methods

### 2.1. Wastewater streams

In this study, a bus production factory located in Istanbul (Turkey) was studied. The bus factory currently processing 4260 buses/year (in 2015). Bus production process consisted of part production, deep phosphating, body production, e-coating, primer and top painting and body assembly. The major process wastewater is originated from cathodic coating process and treated together with domestic wastewater in the existing treatment plant after a

chemical pre-treatment. The current biological wastewater treatment plant of the factory receives about 156 m<sup>3</sup>/day of process and 348 m<sup>3</sup>/day of domestic wastewater (totally about 504 m<sup>3</sup>/day) and operated for carbon and nitrogen removal. The treated wastewater is then discharged into ISKI (Istanbul Water and Sewerage Administration) sewer line, which is further treated in municipal wastewater treatment plant.

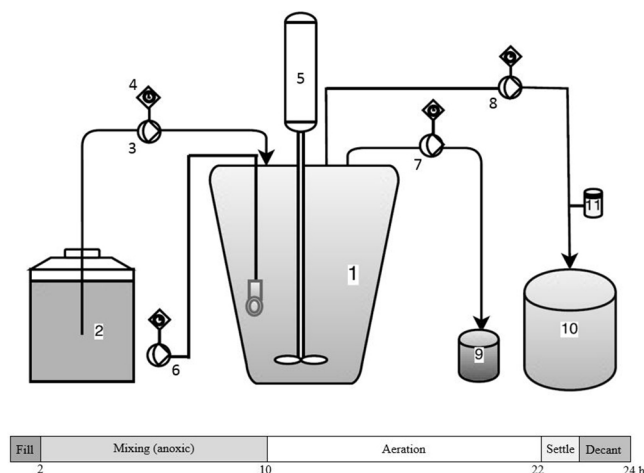
Washing and paint shop wastewater produced in water tanks that receives the paint overspray, which consists of paint particles not adhering to surface. In the paint shop, the overspray is directed via air flow to the water filled tank. Water tank receives paint overspray as long as the paint process run and has to be dampened and refilled during the annual plant shut down. Before dampening, the excess paint dropped into the water bath is separated from the liquid either by settling with addition of coagulants or floating with air flow. The paint shop produces about 1000 m<sup>3</sup> of wastewater/year and about 124.4 tones waste paint sludge/year. Paint sludge and paint shop wastewater are stored in the containers and periodically transferred to final disposal area by authorized shipping company.

### 2.2. Experimental design

A lab-scale SBR (Fig. 1) was a glass jar with a diameter of 20 cm, height of 65 cm, and a working volume of 14 L. The SBR was equipped with a mechanical stirrer and a spherical air diffuser that maintain aeration during aerobic period. The reactor was operated with a filling volume ( $V_F$ ) of 7 L and a total volume ( $V_T$ ) of 14 L ( $V_F/V_T = 0.5$ ). The total cycle time ( $T_C$ ) of SBR run was 24 h to secure 1 cycle per day and the process phase ( $T_P$ ) of the cycle consisted of a 1.75 h of anoxic filling period ( $T_F$ ), 8.25 h of anoxic (denitrification) reaction followed by 12 h aerobic reaction (nitrification) period. The process phase was followed by a 2 h of settling, decanting and idle period. Process phases are schematically illustrated in Fig. 1. Sludge was wasted daily to maintain a sludge retention time (SRT) of 18.7 days. The temperature was kept at  $20 \pm 1$  °C and pH was maintained in the range of 6.5–7.5.

### 2.3. Seed sludge

SBR was inoculated with 14 L of mixed liquor as seed sludge taken from the aerobic reactor of the full scale biological treatment plant of the bus factory. The sludge has a suspended solids concen-



**Fig. 1.** Lab-scale SBR system with mechanical agitation and the schematic representation of the cyclic operation: (1) reaction tank, (2) wastewater, (3) feed pump, (4) timers, (5) mechanical agitator, (6) air pump, (7) sludge pump, (8) effluent pump, (9) waste sludge collection, (10) treated effluent, (11) Sampling port.

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