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The Effect of Mixed Liquor Volatile Suspended Solids and Hydraulic Retention Time on the Removal Efficiency of Chemical Oxygen Demand through Aerobic Activated Sludge Process of Textile Wastewater

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ABSTRACT: The textile industry is a major source of harmful substances that are released into the atmosphere. Dyes and chemicals are present in the effluent of these industries. They are discarded in water bodies without proper treatment. It is observed that waste water contains a high value of Chemical Oxygen Demand (COD). For real field conditions, it is essential to establish an environmentally safe and cost-effective treatment technique. Therefore, the current study was conducted to assess the ability of mixed microbial groups to remove COD from textile waste water. The capability was evaluated at various Hydraulic Retention Times (HRT) under the different MLVSS (Mixed Liquor Volatile Suspended Solids) of 2000, 3500, and 5000 mg/l and HRT (6 to 60 hours) in anaerobic activated sludge process. The findings revealed that COD removal efficiency increased with the increase in MLVSS concentrations whereas the HRT decreased. COD removal was found to be 54%, 45%, and 32% at 2000, 3500, and 5000 mg/l MLVSS, respectively. At the optimized state, the rate of reaction K 0.09436 1/hour was observed, which is 3 times higher than the 2000 mg/l of MLVSS.

Based on results it is evident that aerobic biological treatment is suitable for textile wastewater. The results are insightful in terms of the benefits of creating a greater volume of wastewater for its treatment in a shorter amount of time.

Keywords: Mixed liquor volatile suspended solids**,** Hydraulic retention times, Aerobic activated sludgeprocess,Textile wastewater.

I. INTRODUCTION

Water is a necessary component for any country's socioeconomic development. It is critical to the long-term survival of all living beings on the planet. Water is mostly used for domestic, agricultural, industrial interests [1]. The textile industry is one of the world's largest and also important industries in Pakistan. Pakistan is Asia's 8th largest cotton exporter [2]. Furthermore, around a quarter of industrial value is added by the textile industry, which is labor-consuming and occupies around 40% of the workforce. The textile industry in Pakistan is also very export-oriented and is a major source of foreign currency revenues. It accounts for an average of 55% to 60% of domestic exports.The textile industry is the major producer of wastewater because of the increased consumption of water by its various operations, especially in the wet processing unit. The entire process passes through De-sizing, squeezing, bleaching, mercerizing, teasing, printing, and finishing [3]. Textile wastewater is composed of chemicals such as acids, alkaline, dyes, hydrogen peroxide, starch, metal soaps, and surfactant dispersants [4]. In terms of environmental effects, the textile industry is thought to use more water than any other industry on the planet, and its wastewater is highly contaminated. Average fabrics consume about 200 liters of water per kilogram of fabrics processed per day [5], [6]. Textile dyeing and finishing processing are estimated to produce around 17 to 20 percent of industrial wastewater, according to the World Bank estimate [7]. In the textile wet processing industries, huge volumes of wastewater are characterized by high Chemical Oxygen Demand (COD) concentrates, suspended solids, heavy metals, and salts [8]. The highly variable nature of textile wastewater is the multiple processes such as de-sizing, scouring, bleaching, dyeing, washing, and rinsing cycle [8] Textile wastewater has become one of the ecological concerns in which toxic compounds may be accumulated in foods and also may be mixed with a groundwater aquifer [9], [10]. It is very important to choose the proper treatment method for textile wastewater with different chemicals and dyes [8, 11]. Various approaches have been implemented for the treatment of textile wastewaters, including various chemical, physical and biological treatments. Efficiency in low color removal limits physical methods such as adsorption and filtration [3]. Dyestuffs can be destroyed and degraded by chemical oxidation, but various oxidant agents, such as O_3, H_2O_2, and MnO_4, are used by these methods.Moreover, because azo dyes are stable and resistant to degradation, they cannot remove azo dyes from all wastewater completely, and these methods are not economical and produce highly toxic sludge amounts. [12]. Biological treatment processes wereselected to remove contamination from organic wastewater because they are cost-effective, non-toxic, sustainable, and environmentallyfriendly [13, 14]. All the above studies have been carried out in the field and a complex environment. The results of such studies are difficult to attribute to contributing parameters.

This experimental study evaluates the treatment of real textile wastewater with a biological treatment system under aerobic activated sludge process at laboratory scale reactor. This study thus aims to findthe suitability and significance of an adaptation protocol of aerobic biological treatment optimized under variable MLVSS and HRT for COD removal. The advantage of this experimental study is to exactly evaluate the removal efficiency of COD from textile wastewater. The removal efficiency can be evaluated precisely on a bigger scale for a large volume of wastewater.

II. MATERIAL AND METHODS

A. Activated sludge

Activated sludge samples were taken from the sewage treatment plant-II, Mahmoudabad, Karachi.

B. Textile wastewater

The Physico-chemical characteristics of textile wastewater from the Younis textile mill in Karachi's Landhi industrial zone and sludge from the activated sludge treatment plant are grouped in Table 1.

Table 1: Characterization of the sludge from the activated sludge plant.

Characteristics	Activated sludge	Textile wastewater
Moisture content %	92 ± 1.1	
Volatile solids % DS	60 ± 0.8	
pH	7.3 ± 0.3	8.6 ± 0.2
Total organic carbon µg/g	330 ± 25	
SCOD mg/l	456 ± 26	1780 ± 30
TCOD mg/l	12000 ± 450	2120 ± 95

C. Experimental detail

The experiment has been performed in a 7-inch and 10.5-inch stainless steel reactor having a design capacityof 10 liters, equipped with an online pH meterto monitor the fluctuation or variation of the experiment.Initially, pH was maintained at 6.5-7 with the addition of sulfuric acid. The aeration was maintained through an air pump and kept the oxygen concentration at 5-7 mg/l. The sludge activity test was carried out by measuring the COD before and after introducing the sludge.The reactor was operated at various MLVSS and HRT levels. The two operating parameters were chosen for the study, the MLVSS concentration and the HRT were fluctuating throughout the study, taking into account the commonly used range in the activated sludge process for industrial effluent treatment.The reactor was operatedat batch mode condition at approximately 25-30°C and MLVSS concentrations of 2000, 3500, 5000 mg/l, and HRT 6-60 hours. The reactor was operated at room temperature.

D. Analytical methods

The samples weretaken from the reactor every 6 hours, precipitating the suspended biomass separated at 10,000 rpm for 10 minutes by using a centrifuge model of the Hitech system. COD, pH, and volatile solids were determined according to the standard methods forthe examination of water and wastewater [15].

III. RESULTS AND DISCUSSIONS

A. Effect of MLVSS concentration on COD removal

The effect of MLVSS on the COD removal efficiency was evaluated at different concentrations of MLVSS (2000, 3500, and 5000 mg/l) during the aerobic activated sludge process of real textile wastewater.The results are shown in Fig. 1. According to the study's findings, the percentage of COD removal increased with the increase in MLVSS.

The initial substrate concentration was varied due to the different concentrations of microorganisms called aerobic activated sludge which is measured by MLVSS. It also contains soluble as well as suspended particles of active biomass which increased the initial COD. The initial COD for 2000, 3500, and 5000 MLVSS was 2140, 2460, and 2574 mg/l respectively. At the end of the experiment 60 hours HRT, COD removal efficiency was found to be 32%, 45%, and 58% at 2000, 3500, and 5000 mg/l MLVSS, respectively. An increase in MLVSS concentration was also associated with an increase in COD removal. The presence of more microorganisms in the aeration tank results in higher COD removal at higher MLVSS. Other studies have come up with similar outcomes [16, 17].

The maximum COD removal efficiency (54%) was achieved at the highest concentration of 5000 mg/l of MLVSS at the lowest HRT of 24 hours. It can be explainedby two possible reasons,the first reason is substratesare not completely biodegradable organics (this parameter is not considered for this study) which is not achieved through biological treatment in particular aerobic activated sludge processwhile the second reason could be due to inhibition of aerobic microorganism due to the toxicity of dye and other chemicals [18].

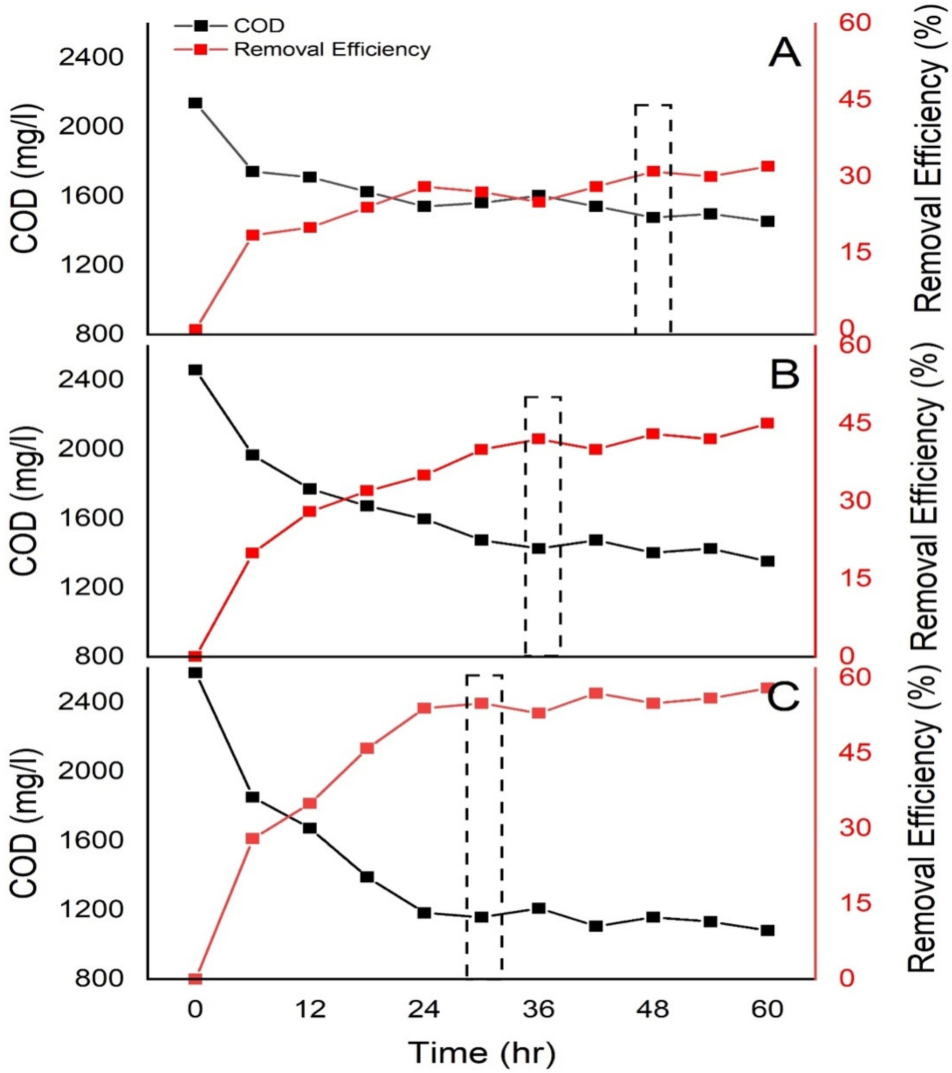

Fig. 1. COD removal at different concentration of MLVSS, (a) 2000 mg/l of MLVSS (b) 3500 mg/l of MLVSS (c) 5000 mg/l of MLVSS.

It also affects the process performance [6]. The microorganism is responsible for the activated sludge process [19]. It can be solved with dilution techniques with municipal wastewater [20]. With this approach, two different sources of wastewater at entirely different pollutant levels can compensate each other and the overall COD concentration decreases.By adopting this method, the ultimate toxicity effect of pollutant load can be overcome.

B. Effect of MLVSS concentration on HRT

To find the best-operating conditions, HRT was changing from 6 to 60 hours. HRT was found to have a stronger influence on COD removal in general [21]. Treatment efficiency (COD removal percentage) decreased with decreasing HRT, as expected, as the Food-to-Microorganism (F/M) ratio increased.In previous studies, improved COD removal efficiency was observed at higher HRTs [17]. The same trend was observed in this study, COD removal efficiency dramatically increased with the passage of HRT during the first phase of the process. The higher COD removal at higher HRT is due to the higher microorganism concentration. “Biomass growth in the activated sludge stage was limited by carbon source,” according to another study, which found that when the feed concentration of starch was reduced from 3.8 to 1.9 mg/l, the MLSS decreased from approximately 4000 to 1000 mg/l; MLSS and increased after the starch concentration was increased to 3.8 mg/l [22].

The increasing concentration of MLVSS from 2000 to 5000 shows a sharp reduction of the HRT from 48 to 30 hours.With an additional increase of 3000 mg/l of MLVSS, a further reduction of 38 percent of the total time was noted [23]. The different optimized HRT conditions wereobserved at different concentrations of MLVSS, for 2000, 3500, and 5000 mg/l of MLVSS of 48, 36, and 30 hours of HRT respectively. It is evident that MLVSS increased however the optimized HRT was decreased, one of the possible explanationsis the increasing amount of aerobic microorganisms in the system [12].

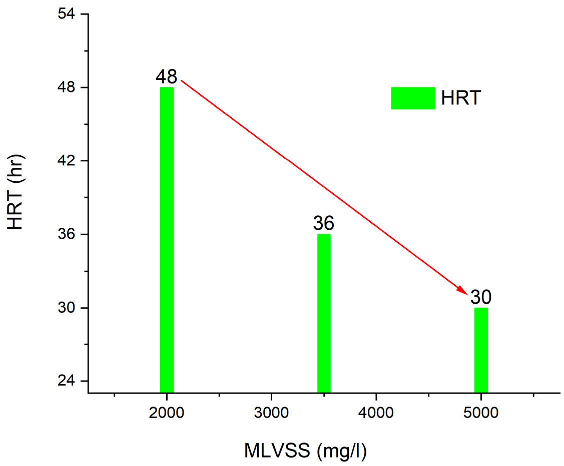

Fig. 2. Optimization of HRT at different concentrations of MLVSS.

Additional MLVSS is also beneficial for the system because it also increases the Carbon-to-Nitrogen (C/N) ratio and also boosts the pH which is favorable for the survival of aerobics microorganismsi.e Protozoa, Flagellates, and Ciliates. COD removal was roughly equivalent throughout the HRT/SRT study and the same was observed during the batch mode study. COD removal decreased as HRT decreased, as previously observed [23]. It also proves from the kinetics data, that rate of reaction (k value) increases with the increase in concentrations of MLVSS. Inverse linear co-relation between the MLVSS and HRT, and indicated in Fig. 2. The shorter HRT is beneficial forthe aerobic activated sludge process and it also influences the cost as well because it can treata large amount of textile effluent in a shorter time [24].

C. Kinetics

The aerobically activated sludge process was carried out forthe treatment of textile wastewater, the first-order kinetics was selected for the disintegration of the substrate (COD removal) [25]. The kinetic parameters determined from the experiment were applied to evaluate the biological treatability of textile wastewater [24], [26]. It is shown in Fig. 3.

$$\frac{dCOD_s}{dt} = -kCOD_s \qquad \text{...(1)}$$

After the integration applying to eq (1)

$$COD_{i=t} = COD_{i=0} * e^{-kt} \qquad \text{...(2)}$$

Where $COD_{i=t}$ the required concentration of substrate (COD) at t time. $COD_{i=0}$ initial concentration of substrate (COD), t = time (hour) and k: substrate degradation rate constant (l/hour)

The kinetics of elimination of the substrate as a function of time and the concentration of the textile wastewater is depicted in Fig. 3. The results obtained show that the removal of COD increases as the concentration of MLVSS and HRT increases. The rate of reaction K value as depicted in Fig. 4 increases with the increase of MLVSS concentration from 0.02787 to 0.09436 1/hour and 3 times the rate of reaction improved at the maximum amount of 5000 mg/l of MLVSS. The same trend was observed in one of such studies [27]. The Initial COD/Initial SSV ratios are greater than 0.5; therefore, these ratios are sufficient for bacterial growth under the operating conditions of the bioreactor [27].

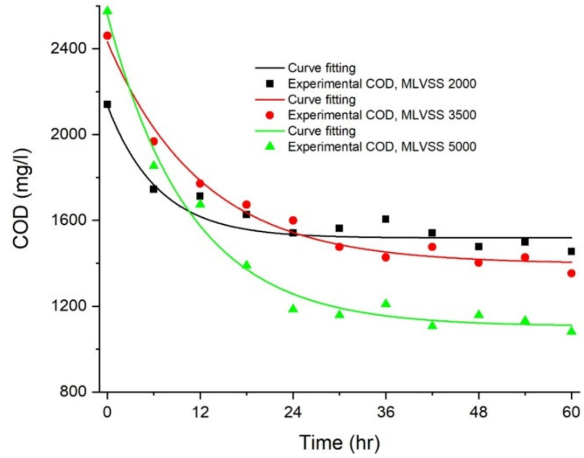

Fig. 3. First-order kinetics for COD removal under the variation of MLVSS and HRT.

Table 2: Kinetics parameters.

MLVSS	K		Statistics	
	Value	**Standard Error**	**Reduced Chi-Sqr**	**Adj. R-Square**
2000	0.02751	0.00787	2131.79	0.9731
3500	0.08161	0.00847	1943.8	0.98206
5000	0.09436	0.0093	3633.84	0.9828

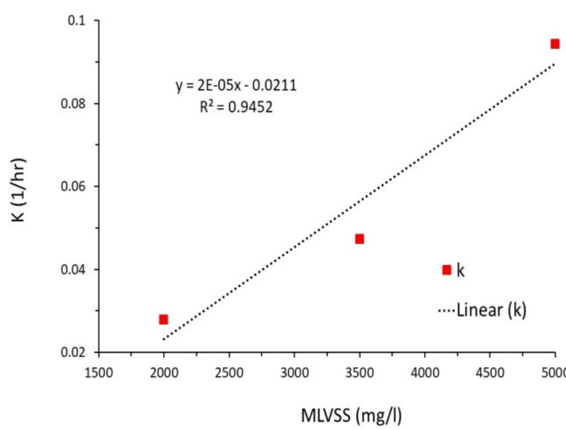

Fig. 4. Linear regression for the kinetic equation of k value at different concentration of MLVSS.

IV. CONCLUSION

The results of this study revealed that the aerobic activated sludge process is effective and suitable to improve the quality of effluent byremoving COD from textile wastewater. The MLVSS and HRT influence the performance of the aerobic activated sludge process. With the increase in HRT and MLVSS, the removal efficiency of COD has increased.The maximum removal of COD of 58%, 45%, 32%, and 5000, 3500, and 2000mg/l MLVSS was found to be 60 hours HRT respectively. At 5000 mg/l MLVSS under the 24 hour

HRT, the optimized condition of COD removal was observed at 54%. The K 0.09436 1/hour reaction rate was observed under the best possible condition and 3 times the 2000 mg/l MLVSS response rate.Based on the findings of this study, suitable wastewater treatment technology can be developed to treat textile wastewater on a commercial scale with optimized conditions.

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Conflict of interest

The authors declare that they have no conflict to complete this work.

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