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THE REDUCTION OF CHEMICAL OXYGEN DEMAND AND TOTAL SUSPENDED SOLIDS FROM FOUR DOMESTIC WASTEWATER DISPOSAL SUBURBS BY USING COAGULATION AND FLOCCULATION PROCESSES: A CASE STUDY IN BABYLON PROVINCE, IRAQ

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Abstract

Coagulation and flocculation treatment processes are vital processes to remove the organic materials that contain pollutants and heavy metals. This study was conducted to investigate the coagulation and flocculation removal efficiency for COD and TSS in wastewater disposal in open canals at four suburbs located in Hilla, Iraq. Twenty-four samples were analyzed from the wastewater disposal in suburbs (Al-Muhandessen, AL-Askari, Al-Akrameen, and Al-Tohmaziaa). Jar test experiments were utilized in this study with the addition of two Alum concentrations 250 and 500 mg/L. The findings revealed that the highest COD removal efficiency in Al-Muhandessen recorded at 73.68%. Furthermore, the removal of TSS in the six samples at this suburb is considered to be high with ranging from 82.6% to 94.4%. In the Al-Askari suburb, the highest COD removal efficiency was 86.18%. TSS removal efficiency was between 65.1% and 86%. In the third suburb, Al-Akrameen, COD particularly recorded the highest removal percentage at a range from 83.33% to 91.24%. The samples from Al-Tohmaziaa suburb recorded the lowest COD removal efficiency which was because of the wastewater characteristics such as chemical contents as well as the effectiveness of TSS removal efficiency. Overall, TSS removal efficiency was high in all samples at the four suburbs with increasing pH, that was because of the noticeable floc destabilization which was observed during the experiments. COD recorded the better-removing results with pH ranging from 6 to 8.

***Keywords*:** Chemical Oxygen Demand; Total Suspended Solids; Coagulation; Flocculation; Iraq.

Introduction

Water is considering as an essential resource for living creatures after the air. It disposed into the environment as a form of wastewater after it been consumed Spellman (2013), and Hami *et al.* (2007). Wastewater is regarded as a holder of various hazardous products such as chemical oxygen demand (COD). COD is defined as a measurement of organic matter presents in aqueous solution. Several studied have been conducted through the past decade to remove the content of COD in wastewater by employing various treatment methods. COD is one of water quality criteria and the high organic matter content, indicates a low water quality Zhang *et al.* (2007), Zheng *et al.* (2008), Ademiluyi *et al.* (2009), Dubber *et al.* (2010), and Syafalni *et al.* (2012). Thus, Organic matter is considered as a pollution indicator of wastewater which can be predicted through measuring COD. Removing Chemical oxygen demand is regarded as an overall material reduction in a sample Zhao. (2017). The Coagulation step in water and wastewater treatment plants resulted in the destabilizations with chemicals [coagulants] of charged suspended solids and colloids. This will help to ease the aggregation and floc formation in subsequent processes. Two types of coagulants are mainly employed in this process such as Al(III) or Fe(III) salts and sometimes they combined with calcium salts and the utilization of polymers as flocculants. The distribution of coagulant uniformly is occurred by using flash mixing which its characteristics depend on the raw water quality, coagulant and subsequent process S. Kawamura, (2000). The standard concentration of coagulants in domestic wastewater treatment such as alum ($Al_2(SO_4)_3.18H_2O$) is varying in the literature and ranging from 250–2000 mg/L and 150–600 mg/L Meriç *et al.* (2000), (2002), and Delgado *et al.* (2003). In terms of drinking water treatment, the used coagulant is raging from 10- 150 mg/L ML Davis (2011) and 20-60 mg/L of alum L. Rizzo *et al.* (2005), and Volk, Bell *et al.* (2000). Wang and his colleagues (2016) stated that any increase of Al dose in drinking water is correlated with the probability of increasing the neurological disorders. Furthermore, the selection of these coagulants is largely depended on different factors such as the concentration and type of particulates, natural organic matter (NOM), water temperature, effluent quality Crittenden *et al.* (2012). There is no specific process to incorporate these variables in the selection method. Therefore, the process of the jar test is needed for this purpose. It is necessary to know when a mechanism of sweep flocculation is employed as a method of coagulation, for example, in the cause of low turbidity of waters, this does not rely on the particles type. Therefore, the same quantity of coagulant is needed for sweep floc formation independently of particle type that could appear Crittenden *et al.* (2012). Coagulation / flocculation can be defined as physical –chemical method in which a coagulant will be added to the sample in order to stabilize the collided materials and transform the small particle into large settable flocs Ayguna, and Yilmaz (2010).

This study aims to determine the removal efficiency of chemical oxygen demand and total suspended solids by adding alum with two different concentrations to coagulation /flocculation processes at four suburbs in Hilla City, Babylon, Iraq. The study was taken into a consideration four suburbs to determine the COD and TSS concentrations in illegal wastewater disposal. The selected locations are residential areas which contain all the necessary basic infrastructure such as schools, health centers, shopping malls, electricity as well as drinking water networks. Although there is currently a wastewater treatment plant near these four suburbs, there is still no sewer networks available. The domestic wastewater in these suburbs which represent 80%

of the total consumed water is discharged in open drains which creates a serious health hazard.

Materials and Methods

Twenty-four samples in total were analyzed in this study. They were collected from four different suburbs in Hilla city at Babylon province, Iraq (Figure 1). The locations are from untreated wastewater that been disposed of regularly at these locations. The samples coded as illustrated in Figure 2 and as following Al-Muhandessen (A1 … A6), AL-Askari (B1… B6), Al-Akrameen (C1...C6) and finally Al-Tohmaziaa (D1…D6). The samples were collected in glass bottles from these four suburbs, delivered to the laboratory within 30 minutes and preserved in 5 C to avoid further biodegradation.

The processes of coagulation and flocculation were accomplished in this study with a standard jar-test apparatus. The device is consisting of six paddle motors (24.5mm x 63.5mm). The Jar Tester Model CZ150 consists of 6 beakers of 1-liter volume. After that, the collected samples were coagulated at 150 rpm form about 3 minutes. Then, they were stirred for 20 minutes at 30 rpm and left for 30 minutes for the settlement process. Two different dosages of coagulant were added to the samples (250 and 500) mg/l of $Al_2(SO_4)_3 \cdot 18H_2O$ with PH reengaging from 4-10 S. Meriç *et al.* (2002). The pH was measured in this study by pH meter Cyberscan 20. The twenty-four samples were filters through 0.45 µm GF/C Whatman filter papers. The analysis was accompanied according to the standard method to measure COD and TSS in the samples American water Works Association (1998). This was employed by using Double beam UV/visible spectrophotometer, (6800 UV- Jenway Type).

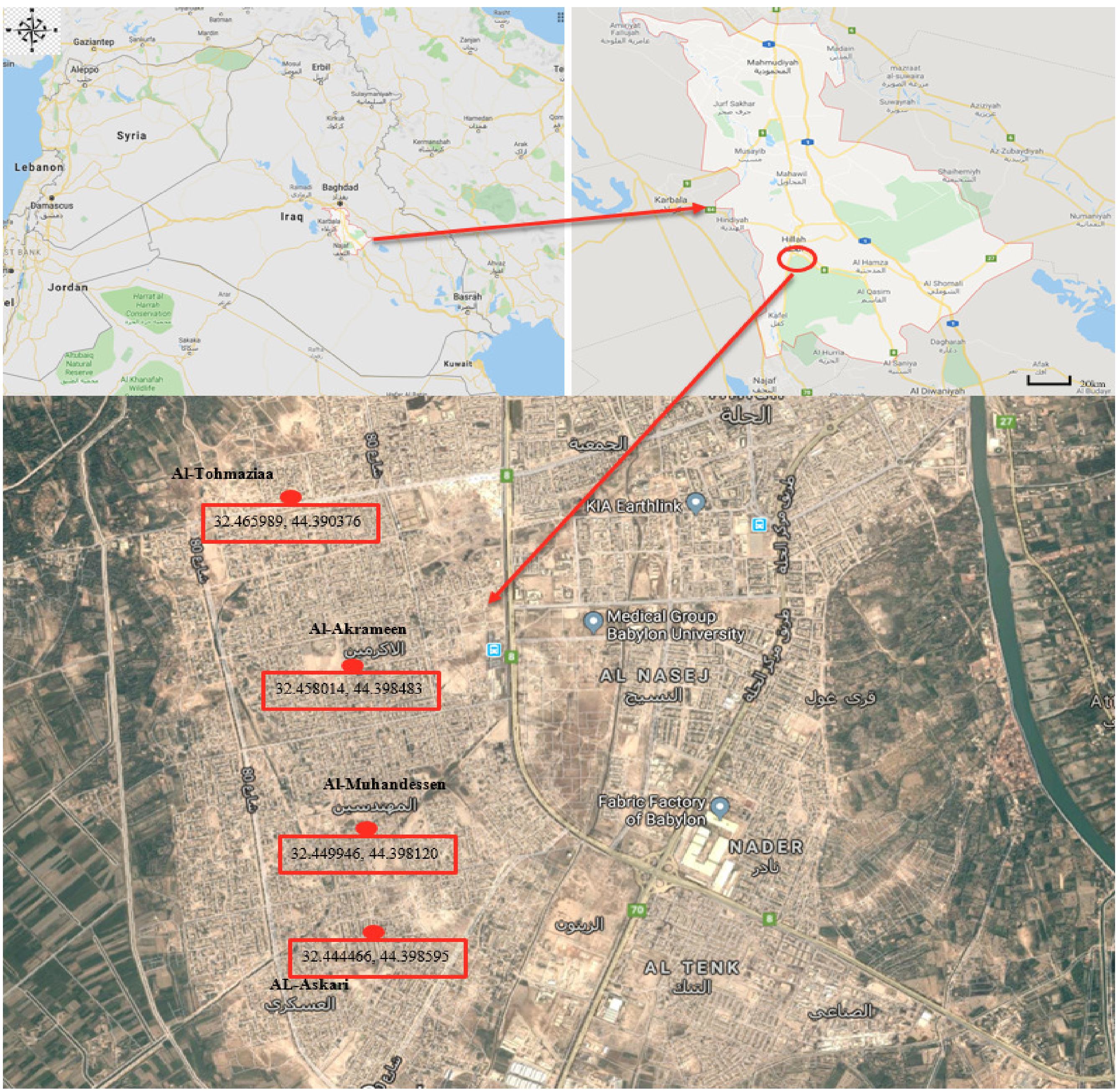

Fig. 1 : Four suburbs samples locations (sourced from Google Maps)

Results and Discussion

The COD and TSS concentrations for selected four suburbs are represented in Figure 2. The findings revealed that the higher COD concentration in the sample was recorded at Al-Muhandessen (Sample A5). TSS at the same location recorded an average of 233.8 mg/L. On the other hand, the collected samples in Al-Akrameen suburb were having less COD and TSS concentrations with an average of 223.5 mg/L and 200.3 mg/L respectively. Al-Askari and Al-Tohmaziaa have an average of COD concentration of 427.2 mg/L and 295.8 mg/L respectively and an average of TSS concentration 252 mg/L and 229.3 mg/L respectively.

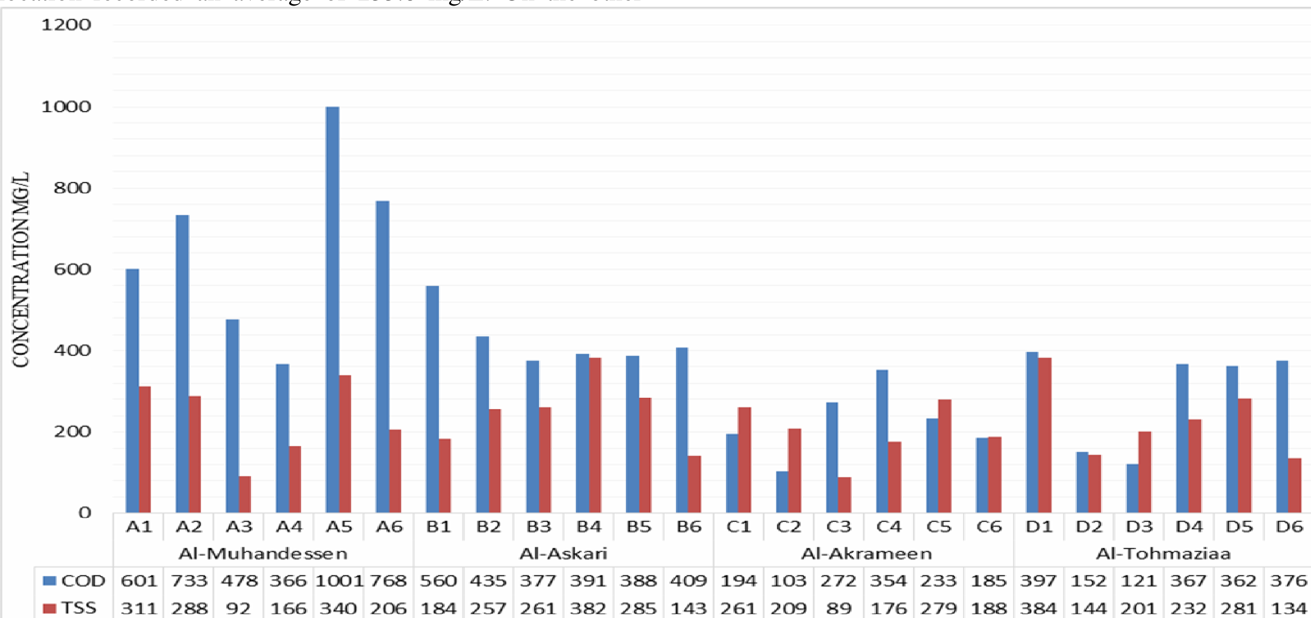

Fig. 2 : Samples characteristics

After the implementation of the coagulation and the flocculation process, the results show that the COD removal efficiency in Al-Muhandessen recorded 73.68% at pH 5 with the addition of 500 mg/L of alum. This represented the higher removal efficiency in this location. Still, with the same alum amount, it can be observed from the Figure 3 that there was a dramatic decrease in terms of removal efficiency toward the increase of pH number with a recording of 49.39% of COD removal efficiency at pH 10 with adding 500 mg/L of alum. In the two cases of alum addition, the lowest removal efficiency was recorded at 41.83% when added 250 mg/L of alum at pH 9. Regarding TSS at Al-Muhandeseen suburb, 94.4% was recorded as the highest removal efficiency in the sample code A6. This was when added 250 mg/L of alum at pH 10. However, the removal of TSS in all the six samples at this suburb is considered high with ranging from 82.6% to 94.4% with slightly better removal performance when adding less amount of alum as it can be clearly noticed in Figure 3.

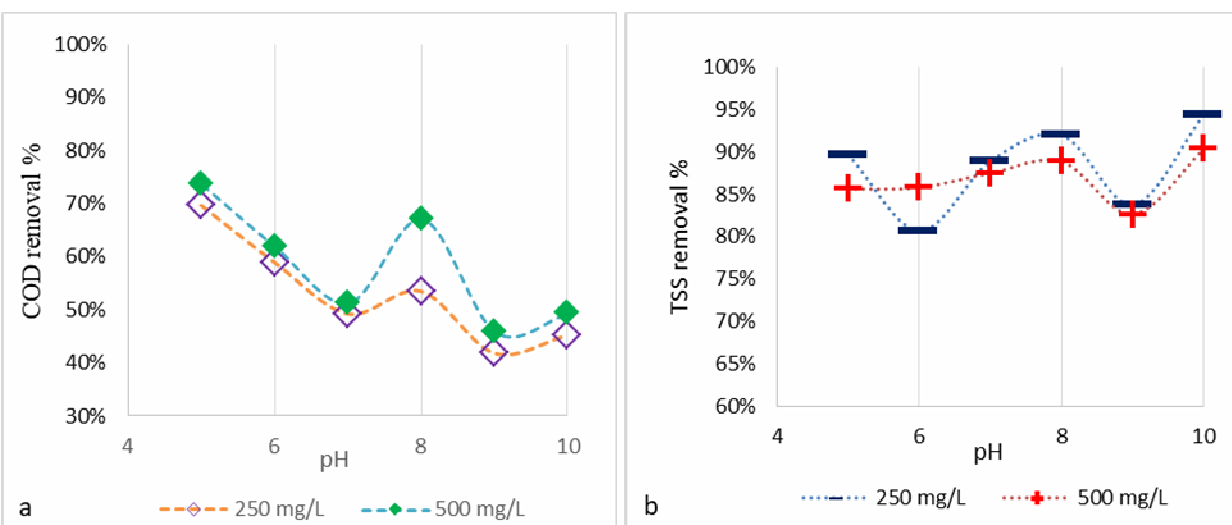

Fig. 3 : The removal efficiency of (a) COD and (b)TSS in Al-Muhandessen samples

In Al-Askari suburb, it can be seen from the Figure 4 that the highest COD removal efficiency when adding 500 mg/L of alum was 86.18% at pH 7 which is slightly more than the removal efficiency when 250 mg/L of alum added (81.62%) under the same pH. TSS removal efficiency was between 65.1% to 86% with better removal performance with pH ranging from 6 to 8.

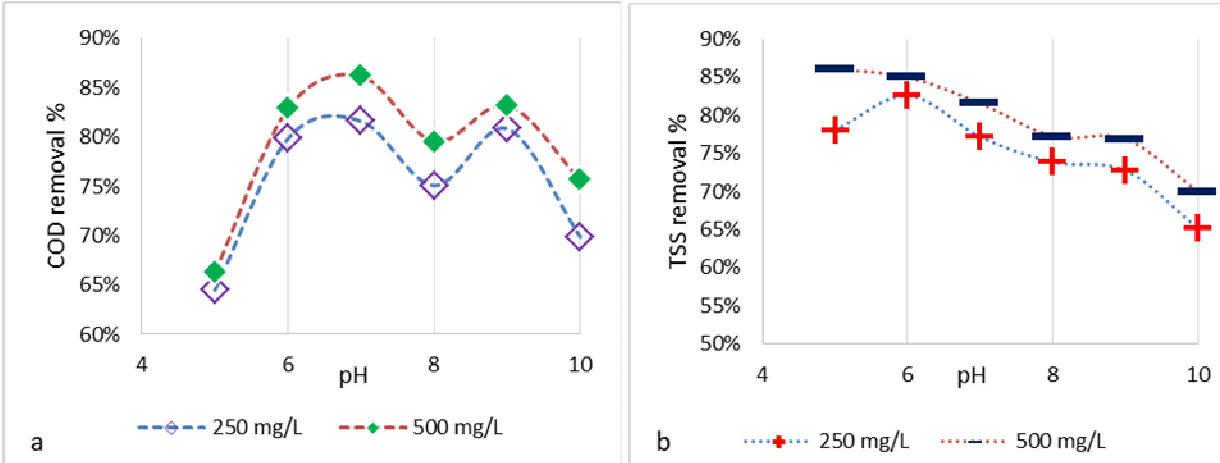

Fig. 4 : The removal efficiency of (a) COD and (b) TSS in Al-Askari samples

Regarding COD removal efficiency in Al-Akrameen (Figure 5), C5 recorded the highest one which was 91.24% at a pH of 9 with adding 500 mg/L alum. Moreover, the removal efficiency in this location particularly has been measured highest COD removal when adding 500 mg/L of alum at a range of 83.33% to 91.24%. Furthermore, COD removal at 250 mg/L of alum also recorded an optimum elimination with ranging from 77.09% to 84.52%. TSS also showed high removal efficiency, especially when adding 500 mg/L of alum.

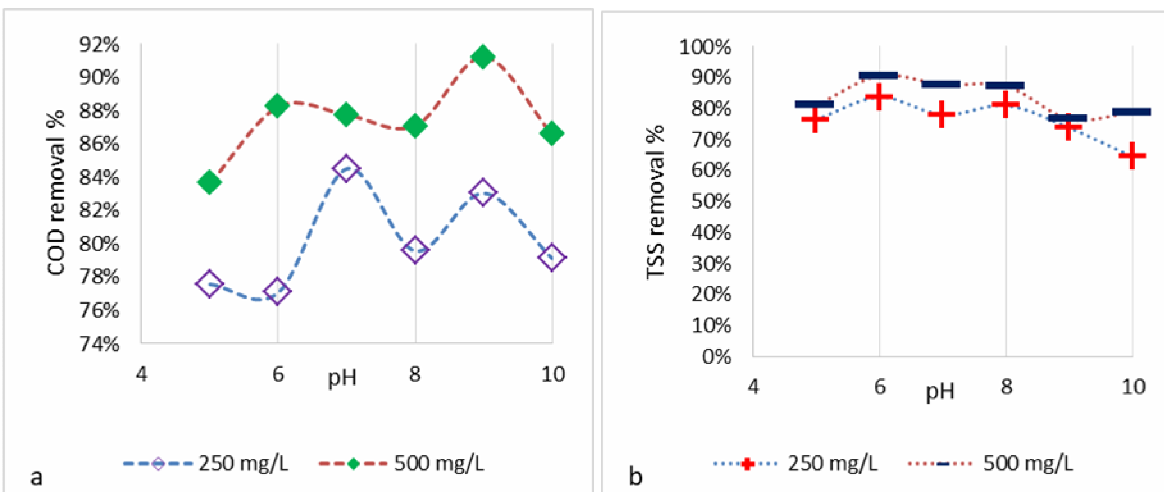

Fig. 5 : The removal efficiency of (a) COD and (b) TSS in Al-Askari samples

The samples have been taken from Al-Tohmaziaa suburb recorded the lowest COD removal efficiency as it can be seen from Figure 6. This is mainly due to the wastewater characteristics such as chemical contents as well as the effectiveness of TSS removal efficiency.

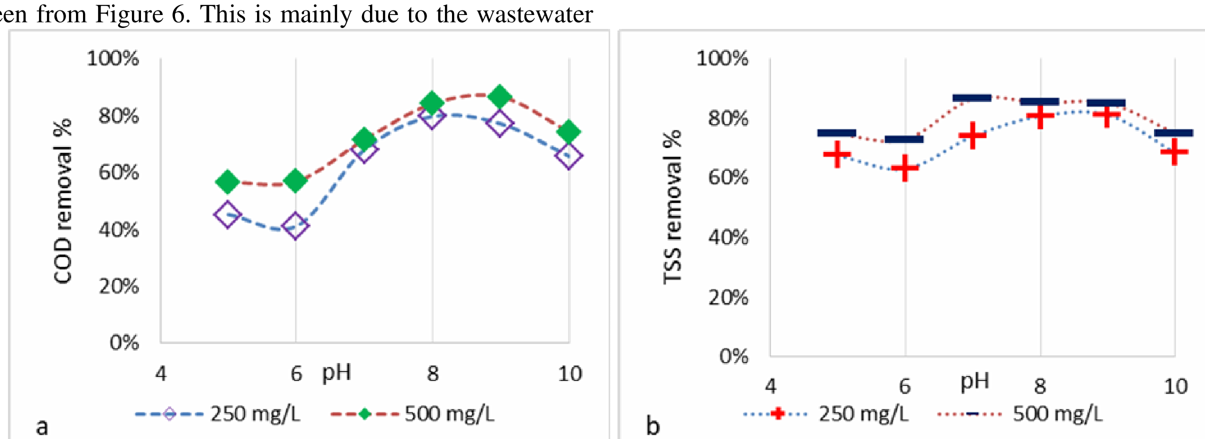

Fig. 6 : The removal efficiency of (a) COD and (b) TSS in Al-Askari samples

TSS removal efficiency was high in all samples at the four locations with increasing pH, that because of the noticeable floc destabilization which was clearly seen during the experiments.

Conclusion

Wastewater requires a reduction of organic substances, suspended solid as well as inactivation of pathogens. The coagulation and flocculation steps are applied in four different suburbs in Hilla city, Iraq. With the focusing mainly on the organic materials contains COD and TSS removal efficiencies. In selected suburbs, all the wastewater which represent 80% of the total consumed water is disposed of in open canals as there are no available sewer networks. Twenty-four samples were analyzed in these suburbs as followed Al-Muhandessen, Al-Askari, Al-Akrameen, and Al-Tohmaziaa. The effect of pH with ranging from 5 to 10 and two alum concentrations (250 and 500 mg/L) were investigated. The removal of TSS in Al-Muhandessen is high with ranging from 82.6% to 94.4% and the COD removal efficiency recorded 73.68% at pH 5 with the addition of 500 mg/L of alum. In Al-Askari suburb, the COD removal efficiency when adding 500 mg/L of alum was 86.18% at pH 7. TSS removal efficiency was between 65.1% to 86% with better removal performance with pH ranging from 6 to 8. The third suburb, Al-Akrameen, COD has been recorded the highest removal percentage at a range of 83.33% to 91.24% especially when adding 500 mg/L of alum. Finally, Al-Tohmaziaa suburb recorded the lowest COD removal efficiency which was because of the wastewater characteristics such as chemical contents as well as the effectiveness of TSS removal efficiency. Overall, TSS removal efficiency was high in at the four suburbs with increasing pH, that because of the noticeable floc destabilization which was clearly seen during the experiments. COD recorded the better removing results with pH ranging from 6 to 8.

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