Bioscience and Bioengineering
Vol. 2, No. 1, 2016, pp. 8-12
http://www.aiscience.org/journal/bio
ISSN: 2381-7690 (Print); ISSN: 2381-7704 (Online)

Investigation of Mixing Type in Pre-Treatment Unit Reactors; Biological View

Sahar Barghpeyma[1, 2], Farshad Farahbod[3, *]

[1]Department of Chemical Engineering, Sirjan Branch, Islamic Azad University, Sirjan, Iran
[2]Department of Chemical Engineering, Sirjan Science and Research Branch, Islamic Azad University, Sirjan, Iran
[3]Department of Chemical Engineering, Firoozabad Branch, Islamic Azad University, Firoozabad, Iran

Abstract

Wastewater from the desalination unit of petrochemical industry is used in treatment tanks. Experiments are held with three different types of impellers in the treatment tanks and the amounts of chemical oxygen demands, biological oxygen demands, turbidity of the clear solution, CO_2 and sedimentation time are measured in each runs. Mixers are composed of a mechanical part called the head and hydraulic part called the impeller which is the core of the mixer.

Keywords

Wastewater, Mixing, BOD, COD, CO_2, Treatment

Received: November 2, 2015 / Accepted: November 11, 2015 / Published online: February 16, 2016

1. Introduction

Agitators are mostly installed in the following applications such as; Petroleum storage, refined product, bioethanol fermentation, edible oil storage, bitumen, alcohol storage, pulp and paper [1]. Water and wastewater mixers are critical components of the multi-step process of water and wastewater treatment [2]. Water treatment requires precise control at each stage in its process – from rapid flash mixing to polymer and chemical addition [3]. This control requires specific wastewater mixers designed by engineers focused on this process and industry. Mixing solutions for water and wastewater treatment must address the intricacies of our processes, from G value specifications to tank and baffle geometries [4]. While some chemicals simply need to be dissolved, others, such as lime slurries, require that solids be kept in suspension. Similarly, flocc / agglomerated particles formed in a flocculator tank are highly sensitive to shear. That's why it's critical to have a low shear polymer mixer that creates an axial flow pattern that won't damage the particles [5]. One of the famous treatment methods to reduce suspended solids and turbidity is the coagulation and flocculation. Coagulation uses salts such as aluminium sulphate (alum) or ferrous of ferric (iron) salts, which bond to the suspended particles, making them less stable in suspension, i.e., more likely to settle out. Flocculation is the binding or physical enmeshment of these destabilized particles, and results in floccs that is heavier than water, which settles out in a clarifier [6]. Scientifics stated that removal of very small particles by gravity sedimentation requires excessively long retention periods. Typically these solids are bacteria, viruses, colloidal organic and fine mineral [7]. Chemical treatment of wastewater containing these solids results in the precipitation of chemical agents which cause flocculation and rapid settling [8]. In addition to solids removal, chemical treatment can help the reduction of organic pollution. A study was made to determine the effectiveness of various mixers on the removal of organic pollutants [9]. Researchers studied mixing, coagulation and flocculation process with a standard jar test procedure with rapid and slow mixing of a kaolin suspension (aluminium

* Corresponding author
E-mail address: saharbarghpeyma@yahoo.com (S. Barghpeyma), mf_fche@iauf.ac.ir (F. Farahbod)

silicate), at 150 rotate per minute and 30 rpm, respectively, in which a cat-ion Al (3+), acts as a coagulant and pectin acts as the flocculent and found that maximum flocculating activity and turbidity reduction are in the region of pH greater than 3, cat-ion concentration greater than 0.5 mM, and pectin dosage greater than 20 mg/L, using synthetic turbid wastewater within the range. The flocculating activity for pectin and turbidity reduction in wastewater is at 99% [10]. The other Scientifics investigated the feasibility of mixing rate and ferric coagulant recovery from chemical sludge and its recycle in chemically enhanced primary treatment (CEPT) and found that the efficiency of coagulant recovery had a linear relationship with sludge reduction [11]. Experiments verify that it would be a sustainable and cost-effective way to recover ferric coagulant from coagulation sludge in water treatment and chemical wastewater treatment and then recycle it to CEPT, as well as reduce sludge volume [12]. The researchers studied treatment of wastewater discharged from four car washes by sedimentation and coagulation. The effect of the coagulants Servical P (aluminium hydroxyl chloride), Servican 50 (poly (diallyldimethyl ammonium chloride)), aluminium sulphate and ferric chloride was evaluated. The achieved removal using sedimentation was of 82%, 88% 73% and 51% for oils, total suspended solids, COD, and turbidity, respectively [13]. In the treatment by coagulation we achieved average efficiencies nearly to 74% for COD removal, greater than 88% in the case of total suspended solids removal and 92% in the case of turbidity and except the performance of Servican 50 greater than 90% in oil removal [14]. The some researchers studied the treatment of tannery wastewater through coagulation- flocculation-sedimentation. They investigated the occurred coagulation process by mixing rate of mixers [15]. They stated that alum was used as coagulant with cationic and anionic polymers as coagulant aid. The results were compared with those when alum was used alone for the treatment [16]. The comparison revealed that the use of coagulant aid reduced sludge volume by 60-70% and cost of chemicals by 50% for comparable removal efficiencies [17]. The Scientifics studied the waste activated sludge (WAS) as a coagulation and sedimentation aid in the coagulation-flocculation process with ferric chloride or aluminum sulfate as a coagulant for the treatment of wastewater collected from the aforementioned industry [18]. Without the WAS addition, the concentrations of 800 mg/L aluminum sulfate at the optimum pH value of 8 and 2208 mg/L ferric chloride at the optimum pH value of 12 were the optimum chemical dosages [19]. It appears that aluminum sulfate was more effective than ferric chloride based on the chemical dosage and removal efficiency [20]. The addition of 200 mg/L was sufficient to reduce the optimum dosages of both chemicals by 200 mg/L [21]. Some investigator performed a study to evaluate the efficiency of cationic polymers as a suitable replacement of metal salts for the treatment of a local tannery wastewater [22]. Eleven cationic polymers of varying molecular weights (MW) and charge densities (CD) were examined using jar test apparatus [23]. The results demonstrated that treatment of tannery wastewater with cationic polymers is a viable and economical option when compared with metal salts [24]. The aim of the present study is to investigate the optimum coagulant dose and type of some coagulants to be used to reduce the strength of the wastewater and improve its biological treatment. The experimental parameters used in this study including mixer shape. Undoubtedly, the effect of shape on the total hardness, (T.H.), suspended solids, (S.S.), turbidity, total dissolved solids (T.D.S.) is very basic. So, the effect of three types of mixers is investigated in this paper.

2. Materials and Methods

In the field of water treatment, mixing and contacting are important unit operations having a fundamental influence on the performance of individual process stages or even on the results of the complete process itself. The ever increasing demands on water quality call for continuous improvement of the cleansing processes.

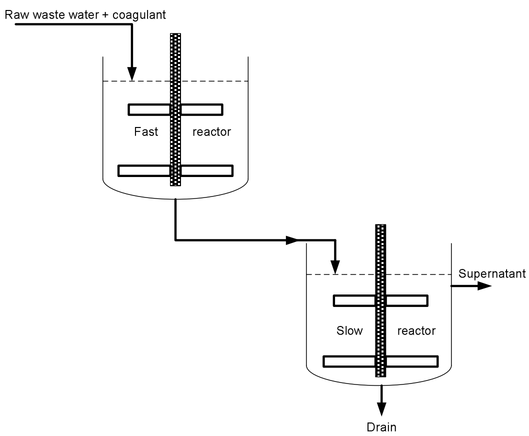

Figure 1. A schematic of two series tanks.

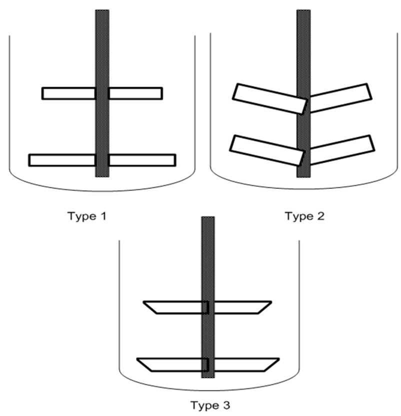

Figure 2. Three types of impellers used in the experiments.

Figure 1 and 2 shows a schematic of the applied series tanks and types of investigated impellers. The produces supernatant is the product of the treatment unit. All analyzes are done on samples from supernatant.

Table 1. Component assay of wastewater.

Composition	Unit	Brine outlet line
Ca++	ppm as $CaCO_3$	14616.3
Mg++	ppm as $CaCO_3$	36080
Fe++	ppm	Trace
Ba++	ppm	Trace
SO_4 --	g/l	5.25
HCO_3 -	g/l	0.185
Total hardness	ppm as $CaCO_3$	50320
Salinity	Percent	20
Silica	ppm	0.1
Specific Gravity at 15 c		1.25
pH		10.11
Viscosity (Kinematic)	mm2/s	1.2
TSS	g/l	Trace

Three different types of mixers are applied in experiments to investigate the effect of blade shape on the coagulation and flocculation process. Mechanical parts of mixer are equipped with two rows of blades with two different lengths which are on a 30 cm metallic rod. Two longer blades (10 cm) are located 5 cm from the end of rod. Two shorter blades (7 cm) are 15 cm higher than longer blades on the rod. Each blade has 1.5 cm thickness at the side which joint on the rod. Blades in type 1 are all in rectangular shape and are jointed with angle of 90 on the rod. In type two, blades are rectangular too but are jointed with angle of 60 from the vertical line on the rod. Blades in type 3 are jointed with 90 from the vertical line on the rod, but have free sides with angle of 60 from the horizon. Table 1 shows analysis for samples from MED of Mobin petrochemical complex. Measurements from experiments are done when the turbidity of clarified water reaches to 0.3 NTU.

3. Results and Discussion

A submersible mixer is a mechanical device that is used to mix sludge tanks and other liquid volumes. Submersible mixers are often used in sewage treatment plants to keep solids in suspension in the various process tanks and/or sludge holding tanks. The submersible mixer is operated by an electric motor, which is coupled to the mixer's propeller, either direct-coupled or via a planetary gear-reducer. The propeller rotates and creates liquid flow in the tank, which in turn keeps the solids in suspension. The submersible mixer is typically installed on a guide rail system, which enables the mixer to be retrieved for periodic inspection and preventive maintenance. Results which are reported as bar type of graphs don't obey the usual arrangement of X values and the amounts of X values are presented as the arrangement of experiment which is done.

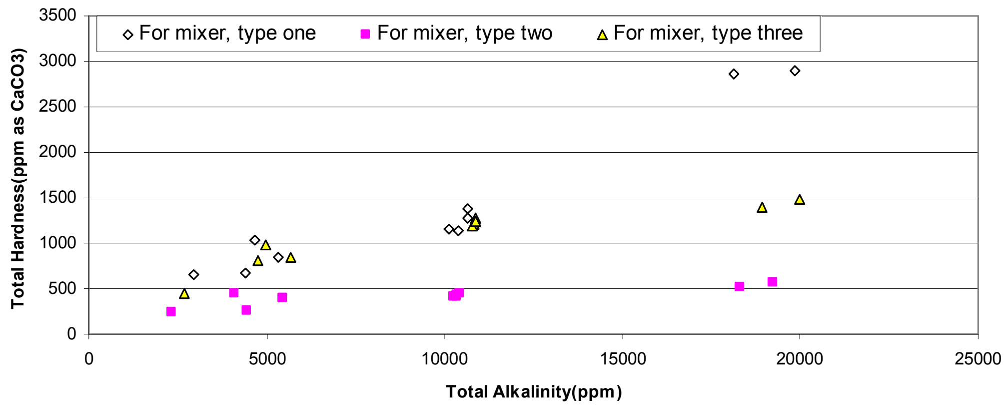

Figure 3. Total hardness versus total alkalinity.

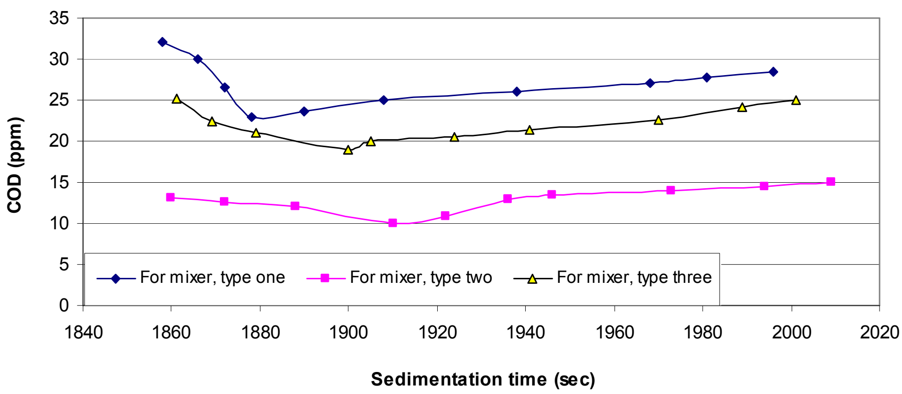

Figure 4. The effect of sedimentation time on the COD.

The effect of three types of mixers on the total alkalinity and total hardness is illustrated in Figure 3. Type two shows the effective elimination in the amount of total hardness in the range of different alkalinity. This may since of the better coagulation which is obtained by blades type 2 which removes the magnesium and calcium in form of coagulants. Also, according to the definition of alkalinity (summation of carbonate, bicarbonate etc) and total hardness (salt of divalent ions like Mg^{+2} and Ca^{+2}) this can be concluded that the brine solution contains a lot magnesium and calcium salts. SO, the similar trend of decrease and increase in the amounts of total alkalinity and total hardness are obtained. The higher amounts of alkalinity are obtained in the higher amounts of total hardness.

There are chemicals which react with oxygen other than suspended solid and hardness in the brine. The effect of coagulation – flocculation mechanism on the elimination of this chemical is shown in Figure 4. Relation between the sedimentation time and the amount of COD is obtained in Figure 4. The mixer type 2 shows the lowest amounts of chemical oxygen demands (in the range of 10 ppm to 15 ppm) at all related sedimentation times. This may be since of the best effect of mixer blades in flocculation mechanism. So, the compounds which react with oxygen are trapped between floes and sediments.

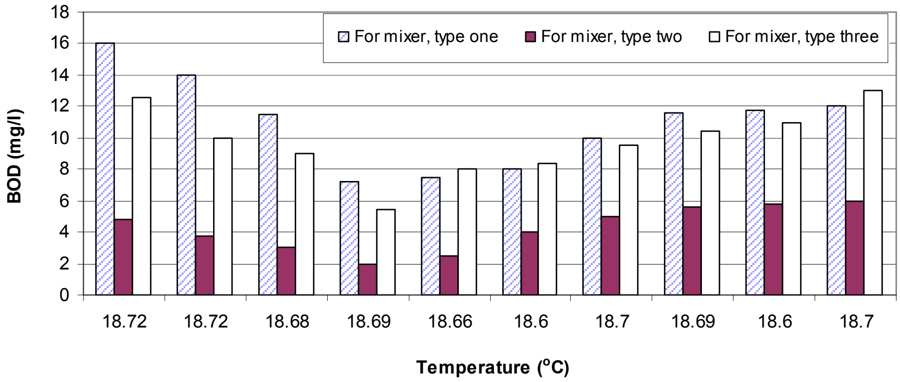

Figure 5. The effect of temperature and mixer shapes on the amount of BOD.

The effect of temperature and mixer shapes on the amount of BOD is investigated in Figure 5. Biological oxygen demand is the major criteria in wastewater treatment. The mixing phenomenon by mixer type 2 increases the temperature of reactor to 21 C. The range of BOD values for 18.5 C to 21 C are changed between 2 mg/l to 6.2 mg/l, respectively. Temperature distribution is not considerable with mixer type 1, however mixer type 3 and type 2 shows wide temperature distribution, comparably. According to the results in Figure 5, the mixer type 2 removes BOD effectively. So, at the adjusted temperature, the smaller amount of BOD is obtained, after using type 2. This may relates to the best effect of blades in mixer type 2 on the coagulation and flocculation of organic compounds. Temperature of environment doesn't show any clear effect in the BOD elimination.

4. Conclusion

In this study, the effect of mixer blades and the number of blades on the amount of major parameters of treatment process are investigated. Drainage of petrochemical desalination plant makes environmental emissions and treatment of effluent wastewater is considered in this research. The relations between important parameters such as turbidity, CO_2 , total hardness, alkalinity, chemical oxygen demands and biochemical oxygen demands are presented based upon the results of experiments. The results can be applied in process manufacturing and equipment design. The following observations and conclusions can be drawn: Using mixer with different shapes leads to different coagulation and sedimentation efficiencies. Results show the mixing phenomenon by mixer type 2 increases the temperature of reactor to 21 C. Also, the range of BOD values for 18.5 C to 21 C is changed between 2 mg/l to 6.2 mg/l, respectively.

References

[1] A. Malakahmad, A. Hasani, M. Eisakhani, M. Hasnain Isa, Sequencing Batch Reactor (SBR) for the removal of Hg^{+2} and Cd^{+2} from synthetic petrochemical factory wastewater., J. Hazard. Mater., 191, (2011) 1–3, 118-125.

[2] A. Thill, S. Moustier, J. Aziz, M.R. Wiesner, J.Y. Bottero, Flocs restructuring during aggregation: experimental evidence and numerical simulation, J. Colloid Interface Sci. 243 (1) (2011) 171–182.

[3] B. Xie, S.B. Liang, Y. Tang, W.X. Mi, Y. Xu., Petrochemical wastewater odor treatment by biofiltration. Biores. Techn., 100, (2009), 7, 2204-2209.

[4] C.C. Kan, C.P. Huang, J.R. Pan, Coagulation of high turbidity water: the effects of rapid mixing, Water Sci. Technol.: Water Supply 51 (2002) 77–85.

[5] C. K. Lin, T.Y. Tsai, J.C. Liu, M. Ch. Chen, Enhanced biodegradation of petrochemical wastewater using ozonation and bac advanced treatment system Water Res., 35, (2001), 3, 699-704.

[6] C. Li, Sh. Zhong, L. Duan, Y., Song. Evaluation of PetrochemicalWastewater Treatment Technologies in Liaoning Province of China Proce. Environ. Sci. part C, 10, (2011), 2798-2802.

[7] D.H. Bache, C. Johnson, J.F. McGilligan, E. Rasool, A conceptual view of flo in the sweep floc domain, Water Sci. Technol. 36 (1997) 49–56.

[8] D. Teresa Sponza, R. Oztekin, Removals of PAHs and acute toxicity via sonication in a petrochemical industry wastewater. Chem. Engin. J., 162, (2010), 1, 142-150.

[9] E. Vaiopoulou, P. Melidis, Alex. Aivasidis, Sulfide removal in wastewater from petrochemical industries by autotrophic de nitrification. Water Res., 39, (2005), 17, 4101-4109.

[10] F. Ma, J.-bo Guo, L. jun Zhao, Ch.chi Chang, D. Cui, Application of bioaugmentation to improve the activated sludge system into the contact oxidation system treating petrochemical wastewater. Bioresource Tech., 100, (2009), 2, 597-602.

[11] H. Patel, D. Madamwar. Single and multichamber fixed film anaerobic reactors for biomethanation of acidic petrochemical wastewater-systems performance Process Biochemistry, 36, (2001), 7, 613-619.

[12] H. Zhang, Y. He, T. Jiang, F. Yang. Research on characteristics of aerobic granules treating petrochemical wastewater by acclimation and co-metabolism methods. Desalination, 279, (2011), 1–3, 15, 69-74.

[13] J. Duan, J. Gregory, Coagulation by hydrolyzing metal salts, Adv. Colloid Interface Sci. 100–102 (2003) 475–502.

[14] J. Gregory, Polymer adsorption and flocculation, in: C.A. Finch (Ed.), Industrial Soluble Polymers, Royal Society of Chemistry, London, 1996, 62–75.

[15] J.L. Lin, C.P. Huang, C.J.M. Chin, J.R. Pan, Coagulation dynamics of fractal flocs induced by enmeshment and electrostatic patch mechanisms, Water Res. 42 (2008) 4457–4466.

[16] J.L. Lin, C.P. Huang, J.R. Pan, D.S. Wang, Effect of Al (III) speciation on coagulation of highly turbid water, Chemosphre 72 (2008) 189–196.

[17] K. Ebie, Y. Azuma, Reducing turbidity and coagulant residue in treated water through optimization of rapid mix condition, Water Sci. Technol.: Water Supply 2 (2002) 103–110.

[18] K.J. Ives, The Scientific Basis of Flocculation, The Netherlands, Alphnvan der Rijn, 1978.

[19] K. Lin, H.T. Hsu, Y. Ko, Z.X. Shieh, H-L. Chiang, Pyrolytic product characteristics of biosludge from the wastewater treatment plant of a Chiang petrochemical industry, J. Hazard. Mater. 171, (2009), 1–3, 208-214.

[20] L.Ch. Wang, I.-Ch. Wang, J.E. Chang, S.O. Lai, G. P. Chang-Chien, Emission of polycyclic aromatic hydrocarbons (PAHs) from the liquid injection incineration of petrochemical industrialwastewater., J. Hazard. Mater., 148, (2007). 1–2, 296-302.

[21] L. Wang, S. Barrington, J.W.Kim, Biodegradation of pentyl amine and aniline from petrochemical wastewater. J. Environ. Manage., 83, (2007) 2, 191-197.

[22] M. Aliabadi, A. Aroujalian, A. Raisi, Removal of styrene from petrochemical wastewater using pervaporation process**.** Desalination, 284, (2012), 116-121.

[23] M. Anbia, S. Ershad Moradi. Removal of naphthalene from petrochemical wastewater streams using carbon nanoporous adsorbent. App. Surf. Sci., 255, (2009), 9, 5041-5047.

[24] M.A. Yukselen, J. Gregory, The effect of rapid mixing on the break-up and reformation of flocs, Chem. Technol. Biotech. 79 (2004) 782–788.