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Empirical Investigation of Major Variables for Purification of Industrial Waste Water

Peyman Haghighi[1], Farshad Farahbod[2*]

[1]Department of Chemical Engineering, Marvdasht Branch, Islamic Azad University, Marvdasht, Iran
[2]Department of Chemical Engineering, Firoozabad Branch, Islamic Azad University, Firoozabad, Iran
Email: *mf_fche@yahoo.com

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Abstract

The total petroleum hydrocarbon (TPH), polycyclic aromatics (PCA), non-volatile suspended solids and volatile suspended solids besides other important parameters, total hardness, calcium hardness, CO_2 content, total dissolved solids, electrical conductivity, sedimentation time, chemical oxygen demands, biochemical oxygen demands, pH value after sedimentation and pH after coagulation in aerobic treatment are surveyed due to the changes in fast mixing rate. The experimental results show the TPH removal percentage and PCA removal percentage increases from 53.5% to 62.8% and 43.8% to 46.3% with increasing of nano dosage from 1 gr to 2.5 gr, respectively.

Keywords

Wastewater, TPH, PCA, Temperature, Fast Mixing, Oxygen, pH, Hardness

1. Introduction

The scientists have been developing impellers and various head constructions for years to efficiently cope with most processes and to ensure extended reliability of the mixers. 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] [2] [3] [4] [5]. Water and wastewater mixers are critical components of the multi-step process of water and wastewater treatment [6] [7] [8]. Water treatment requires precise control at each stage in its process—from rapid flash mixing to polymer and chemical addition [9]. 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 [10] [11] [12] [13] [14]. While some chemicals simply need to be dissolved, others, such as lime slurries, require that solids be kept in suspension. Similarly, floc/agglomerated particles formed in a flocculation 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 [15] [16] [17] [18]. One of the famous treatment methods to reduce suspended solids and turbidity is the coagulation and flocculation. Coagulation uses salts such as aluminum sulfate (alum) or ferrous 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 flocs that are heavier than water, which settles out in a clarifier [19] [20] [21]. Scientists 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 [22] [23] [24] [25]. Chemical treatment of wastewater containing these solids results in the precipitation of chemical agents which cause flocculation and rapid settling [26] [27] [28] [29]. 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 [30] [31] [32] [33]. Researchers studied mixing, coagulation and flocculation process with a standard jar test procedure with rapid and slow mixing of a kaolin suspension (aluminum silicate), at 150 rotate per minute and 30 rpm, respectively, in which a cation 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, cation 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% [34] [35] [36] [37]. Other scientists 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 [38] [39] [40] [41]. 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 [42] [43]. The researchers studied treatment of wastewater discharged from four car washes by sedimentation and coagulation. The effect of the coagulants Servical P (aluminum hydroxychloride), Servican 50 (poly (diallyldimethyl ammonium chloride)), aluminum sulfate and ferric chloride was evaluated. The achieved removal using sedimentation was 82%, 88%, 73% and 51% for oils, total suspended solids, COD, and turbidity, respectively [44]-[49]. 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 [50]-[61]. Some researchers studied the treatment of tannery wastewater through coagulation-flocculation-sedimentation. They investigated the occurred coagulation process by mixing rate of mixers [62]-[69]. They stated that alum was used as a coagulant with cationic and anionic polymers as a coagulant aid. The results were compared with those when alum was used alone for the treatment [70]-[81]. 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 [82]-[93]. The researchers 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 [94]-[103]. 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 [50]. It appears that aluminum sulfate was more effective than ferric chloride based on the chemical dosage and removal efficiency [51]. The addition of 200 mg/L was sufficient to reduce the optimum dosages of both chemicals by 200 mg/L [27]. Some scientists performed a study to evaluate the efficiency of cationic polymers as a suitable replacement for metal salts for the treatment of local tannery wastewater [31] [49]. Eleven cationic polymers of varying molecular weights (MW) and charge densities (CD) were examined using jar test apparatus [33] [38]. The results demonstrated that treatment of tannery wastewater with cationic polymers is a viable and economical option when compared with metal salts [41] [44]. The aim of the present study is to investigate the optimum coagulant dose and type of coagulants to be used to reduce the strength of the wastewater and improve its biological treatment. The experimental parameters used in this study include mixer shape. Undoubtedly, the effect of shape on the total hardness, (T.H.), suspended solids, (S.S.), turbidity, and 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. This has led to a marked increase in the general use of mixers for mixing and contacting operations in the treatment units. The objective of this work is evaluation of NVSS and VSS parameters of effluent waste water of aerobic treatment unit by usage of mineral nano coagulant in pre-treatment unit. This will be happen using coagulation, flocculation and sedimentation process, respectively. Components like aluminum sulfate, Ferric sulfate and Ferric chloride are three common commercial nano coagulants which are applied in this experimental study. Some of related reactions are presented by relations (1), (2) and (3).

$$Al_2(SO_4)_3 + 3Ca(HCO_3)_2 \leftrightarrow 2Al(OH)_3 + 3CaSO_4 + 6CO_2 \quad (1)$$

$$Fe_2(SO_4)_3 + 3Ca(HCO_3)_2 \leftrightarrow 2Fe(OH)_3 + 3CaSO_4 + 6CO_2 \quad (2)$$

$$FeCl_3 + 3/2\,Ca(HCO_3)_2 \leftrightarrow Fe(OH)_3 + 3/2\,CaCl_2 + 3CO_2 \quad (3)$$

6-liter waste water, Sodium Hydroxide and Sodium Carbonate with the used coagulant is added in this reactor.

3. Results and Discussion

The results are shown in this section. The basic parameters are evaluated in the below parts.

The chemical oxygen demands of wastewater in an aerobic lagoon are important to describe the performance of treatment briefly. Addition of ferric sulfate introduces the oxygen ions if the sulfate ions don't react with the hardness ions. Also all carbonate and sulfate may be hydrated and releases the oxygen. The decrease in the amount of COD from 25.2 ppm to 19 ppm is obtained by the increase in the amount of fast mixing rate from 50 rpm to 120 rpm. Then the increase in the COD value to 25 ppm is obtained by the increase in the amount of fast mixing rate to 200 rpm. So, comparing the results of contaminant elimination with Figure 1 shows that the lowest amount of TH, calcium hardness, CO_2 and EC value between 90 rpm and 120 rpm occurs not only since of formation of complexes with oxygen but also other ions are interpreted in formation of flocs.

Figure 2 shows the value of BOD versus the values of fast mixing rate. Biochemical oxygen demands are one criterion to show the amount of microorganisms in the wastewater. This value may lead to the amount of volatile compounds. The best value of a fast mixing rate, which obtains 6.5 ppm as a minimum amount of BOD is 120 rpm. The decrease-increase trend in BOD values is obtained. Lowest amount of BOD may show the higher amount of microorganisms which trapped in the flocs. This leads to the more stable condition in wastewater. Although, the values of 8 to 9 ppm are obtained at 60 to 90 rpm.

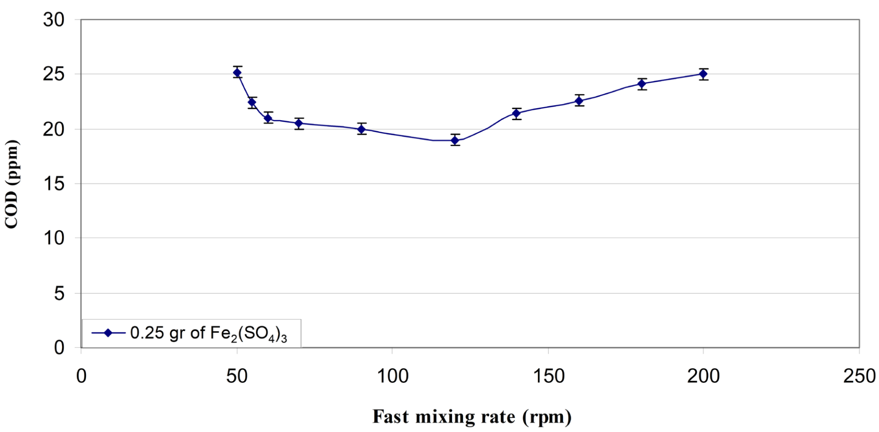

Figure 1. Value of COD versus fast mixing rate.

The total petroleum hydrocarbon of wastewater through amount of nano coagulant is shown in Figure 3. With increasing of nano dosage from 1 gr to 2.5 gr the TPH removal percentage increases from 53.5% to 62.8%. Passing time increases the amount of TPH removal percent. So, nano coagulant shows the best performance in removal of total petroleum hydrocarbon.

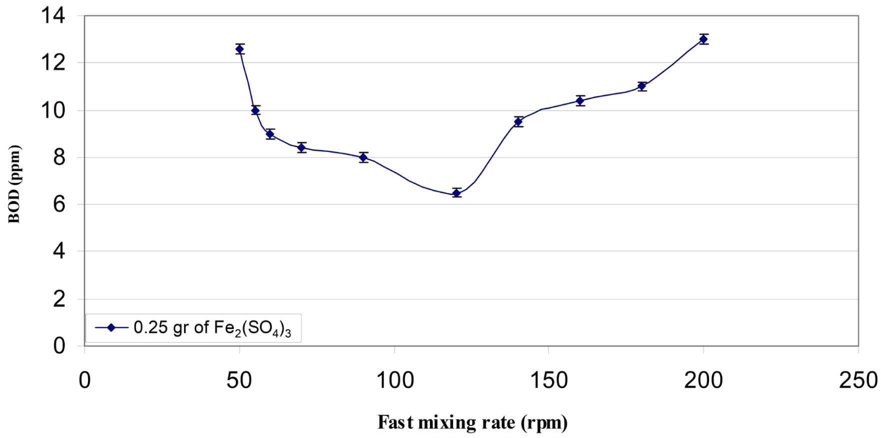

Figure 2. Value of BOD versus fast mixing rate.

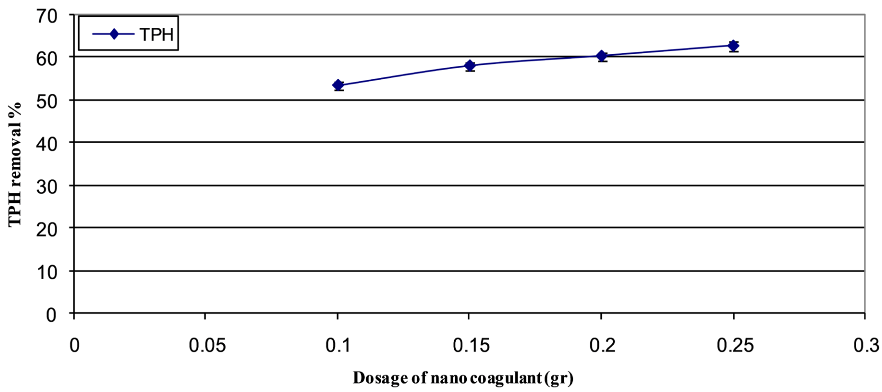

Figure 3. Amount of total petroleum hydrocarbon removal versus amount of nano coagulant.

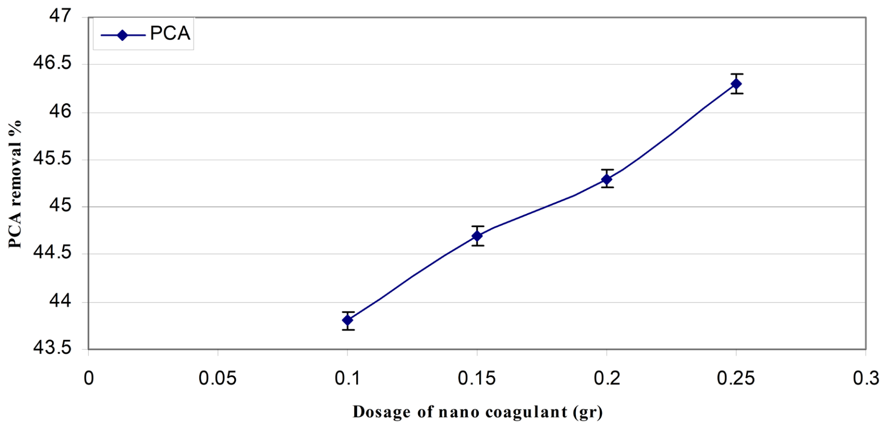

Figure 4. Amount of polycyclic aromatic removal versus amount of nano coagulant.

The effect of nano coagulant amount on the amount of polycyclic aromatic is shown in **Figure 4**. With increasing of nano coagulant from 1 gr to 2.5 gr the PCA percentage increases from 43.8% to 46.3%. Passing time decreases the amount of PCA of wastewater.

4. Conclusion

The effluent waste water from petrochemical complex is considered in this research. The usage of nanometal oxides is considered in recent years in treatment processes. In this research, the application of nano ferric oxide as a mineral coagulant is studied to treat the wastewater in an aerobic lagoon. Experimental tests are conducted in two series tanks. Experimental results show with increasing of nano dosage from 1 gr to 2.5 gr the TPH removal percentage increases from 53.5% to 62.8%. Passing time increases the amount of TPH removal percent. Moreover, the empirical results illustrate with increasing of nano coagulant from 1 gr to 2.5 gr the PCA percentage increases from 43.8% to 46.3%. Passing time decreases the amount of PCA of wastewater.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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