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Reducing Pollutants in Wastewater by Coagulation and Flocculation as a Pre-Treatment Process for Environment Protection

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Abstract: Wastewater treatment is an urgent necessity to reduce environmental pollution resulting from it and preserve water resources. There are various techniques in wastewater treatment, one of which is chemical pretreatment to reduce pollutants in wastewater. Alum, lime, and ferrous sulfate heptahydrate were used as coagulants for wastewater during the coagulation and flocculation processes. The wastewater properties were studied after removing the causes of turbidity from the suspended materials to determine the extent of reducing various pollutants through the parameters BOD, COD, TSS, phosphate, Turbidity, O&G and NH4+, then compared with their values before coagulation and flocculation. It has been proven through this study that the process of coagulation and flocculation as a pre-treatment process has an effective role in reducing pollutants in wastewater.

Keywords: Wastewater, Pre-treatment, Coagulation and Flocculation, Jar test, Pollutants, BOD, Phosphate.

1. Introduction

Chemical treatment methods for industrial wastewater include the addition of chemicals. To trigger chemical reactions to get rid of pollutants or convert them into easily separated materials, the chemical treatment processes that are most often carried out are chlorination, absorption, and chemical precipitation. Chemical processes are either pre-treatment of water and wastewater such as coagulation and flocculation. Either the chemical processes are in other stages of treatment, such as the chlorination process, which is the final step for water and wastewater treatment[1]. Coagulation and flocculation are essential processes in several diverse fields and Specialties, including water and wastewater treatment. In 1757 alum was used as a coagulant in water treatment in England, and more formally for water treatment in the year 1881. Coagulation and flocculation are still essential in modern water and wastewater treatment[2]. Coagulation is a well-known wastewater treatment process to remove suspended particles from water. Most suspended solids in water carry a negative charge and therefore repel each other. This repulsion prevents the particles from clumping, causing them to remain suspended. Coagulation occurs in sequential steps designed to overcome the settling force of suspended particles allowing for particle collision and mass growth, which can then be accelerated and removed by sedimentation or filtration[3]. Flocculation is the process by which unstable molecules, or molecules that form as a result of instability, are stimulated to come together, come into contact, and thus form larger agglomerates. It is a gentle mixing stage that increases the particle size of submicroscopic fine clumps to remove visible suspended particles. Through the slow mixing process, the micro-clumps come into contact with each other, and the collision of microscopic cluster particles joins them to produce larger "visible clumps". Cluster size continues to build and grow through additional collisions and interaction with the coagulant. When the lumps have reached the optimum size and strength, the water is ready for the separation process by sedimentation[4]. In addition to removing turbidity from water, coagulation and flocculation are useful in other ways in removing many bacteria suspended in water and decolorizing, pollutants in wastewater present in a colloidal form such as organic matter, metal oxides, insoluble toxic compounds, and emulsifiers[5]. Mixing conditions have a very big effect on the performance of coagulants and flocculants. It is that the additive be distributed uniformly between commentary and this must be It is achieved through a form of rapid mixing. particles then you need to collide to form rubble and this process can be greatly aided through some form from stirring, either in upside down tanks or in some form through the flow unit. In the case of a neutral charge or polymer bridging, rapid mixing is particularly important since then Poor mixing can lead to local overdose and re-settlement of some particles. with hydrolysis mineral salts, forming hydrolysis products[6]. Then the mixing is converted into slow mixing. The basic function of slow mixing is to Keep the particles in suspension so that collisions occur between them particles occur. Moreover, slow mixing can provide a velocity gradient for collisions between particles of similar size to larger ones. It happens very quickly and competition processes[7]. Generally, the development of flocs formation involves several steps occurring sequentially[8]: dispersion of the coagulants in the solution, diffusion of the coagulants towards the solid-liquid interface, adsorption of the coagulants onto the surface of the particles, collision of particles carrying adsorbed coagulants with other particles, adsorption of the coagulants onto other particles in order to form micro flocs, and growth of the micro flocs to larger and stronger flocs by successive collision[8][9]. The efficiency of the coagulation and flocculation process depends on many variables: Coagulant dosage, turbidity, type of coagulant used, intensity and duration of mixing at rapid mix stage, final pH, velocity gradients during the sintering phase, and Temperature[2]. The coagulation process is characterized as: Simplicity and Efficiency, it separates many types of particles from water and wastewater, it uses abundant, low-cost chemicals, and the added doses of coagulants can be controlled so that they do not negatively affect the turbidity and pH of the water and wastewater[10]. The coagulation and flocculation process has proven good efficiency in reducing pollutants in the wastewater as a pre-treatment process[11]. This process occurs after the wastewater passes through filters to get rid of large waste and garbage. Wastewater is collected in coagulation tank. Coagulants are added to it after determining the appropriate dose according to the degree of turbidity of the wastewater. These tanks must contain special mixers to complete the sintering process. The speed of the mixers is controlled because they are at a high speed at the beginning of the process, then the speed is reduced to a lower degree, and the emulsion leaves. Stirring for at least half an hour to complete the flocs formation, then the mixers stop and the wastewater is left for at least an hour until the flocs sedimentation process is completed quietly. Then the clear wastewater is withdrawn and transferred to the biological treatment tank or the physical treatment tank according to the design of the treatment plant. Through the process of coagulation and flocculation, pollutants in wastewater are reduced to the largest possible extent, which reduces loads on WWTPs, improves the treatment process, and guarantees treated wastewater with good properties and quality that can be reused with the least possible harm to living organisms and the environment. There are many chemicals used as coagulants in the coagulation and flocculation process of wastewater, including alum, slaked lime, and ferrous sulfate heptahydrate. Aluminum sulfate is a soluble salt that is found in nature, is a white crystal or white powder with a molecular formula of $Al_2(SO_4)_3.16H_2O$. It is not volatile or flammable. It has a low pH when combined with water which makes it capable of burning skin or corroding metal, and is water soluble and able to hold water molecules. When added to water, it forms aluminum hydroxide $Al(OH)_3$ in the form of a precipitate, where aluminum hydroxide is an insoluble (gelatinous) substance that slowly precipitates through the water, and when it descends pulls suspended materials with it. The list of uses of aluminum sulfate is long, and its most important uses are to purify water and wastewater from impurities. When it is added to water, it begins to agglomerate microscopic impurities according to the principle, so it is often used in swimming pools to reduce water turbidity. The chemical reaction between it and the pollutants causes the pollutants to solidify and filter out[12]. Ferrous Sulfate heptahydrate (Copperas) Also known as iron (II) sulfate it is a blue-green crystal with the formula $FeSO_4.7H_2O$. It contains 19.5% iron (Fe). Produced as a natural by-product of the titanium dioxide (TiO_2) manufacturing process. Ferrous Sulfate Heptahydrate, commonly known as Copper is a green acidic salt, soluble in water, well used in many chemical, industrial and medical applications as it is used as a source of iron in the treatment of iron deficiency anemia, fertilizers, pesticides, radiation dosimeters, Writing ink, process engraving, lithography, leather dyeing, aluminum engraving, Ferrous Sulphate Heptahydrate can be used directly in water and wastewater treatment plants to improve coagulation and remove pollutants such as phosphorus[13]. It is the preferred coagulant for many industrial and wastewater treatment applications, due to its high coagulation efficiency, removal of suspended solids and color, and reduction of BOD and COD values[14]. Calcium hydroxide commonly referred to as slaked lime is described with the chemical formula $Ca(OH)_2$. It is an inorganic compound that has a fine white appearance in its solid state. However, $Ca(OH)_2$ has a colorless appearance in its crystalline form. It is prepared by mixing water and calcium oxide. It is very insoluble in water and its solubility decreases with increasing temperature, but it is completely soluble in glycerol and acids. $Ca(OH)_2$ is used in the paper industry and as a pH modifier due to its alkalinity. It is also used in pesticides, hair care products, and the manufacture of ebonite. It is used medically in dental fillings to fill cavities in human teeth. Calcium hydroxide has many uses In the wastewater treatment process, it used as a coagulant agent. Lime has many advantages including pH control, neutralization of acidic wastewater, reduction of the concentration of oxidized organic pollutants, filtering, and sedimentation of dissolved pollutants well as flocculation and coagulation of colloidal particles[15]. The doses of alum, lime, and ferrous sulfate heptahydrate added to water and wastewater to be purified from impurities are not a random process but are determined according to the turbidity of the water and the number of impurities it contains[16]. The dose of coagulants is estimated by using the Jar test is a method of simulating a large-scale water treatment process. The jar test can be used to help determine the doses of chemical additives that will work best in your water treatment. Jar testing entails adjusting the doses of chemicals added and the sequence in which it is done for wastewater samples kept in jars or jars glasses. Then the sample is stirred It can be seen as if it were in the complete treatment plant. Flocs is formed when chemicals are added to react with impurities in water and clump together. Then A series of additives are added and the pH and turbidity values are measured for each jar for comparison and optimum dosage for each treatment plant. A test jar can produce critical information quickly, inexpensively, and the data is directly applicable to plant design, modification, and operation Through it, the ideal time for slow and fast mixing can be determined[17]. The characteristics of wastewater are subject to certain criteria to determine the efficiency of treatment, and these parameters are subject to specific environmental determinants that show the possibility of reusing wastewater, whether for industrial purposes, irrigation of crops, or pouring into water sources with the least possible negative harm to the environment and living organisms. These parameters are measured through laboratory tests and pollutant concentrations are estimated before and after wastewater treatment. Among the most important of these criteria: Biochemical oxygen demand (BOD_5) is the amount of oxygen consumed by bacteria and other microorganisms during the decomposition of organic matter under aerobic conditions, BOD is measured using a refrigerated incubator and the test takes 5 days. Chemical Oxygen Demand (COD) is defined as the oxidation reactions of organic compounds under controlled chemical conditions by adding oxidizing substances such as potassium permanganate[18].Turbidity is a measure of the relative clarity of a liquid. It is an optical property of water and is a measurement of the amount of light that is scattered by a substance in water when light is shined through a water and wastewater sample. The higher the intensity of the scattered light, the higher the degree of turbidity[19]. Total Suspended Solids (TSS) is a quantitative estimate for suspended particles in the wastewater. Although the turbidity and TSS complement each other, each parameter has its role, as the turbidity test gives immediate and quick results in the field, but the TSS test gives the calculation of sedimentation rates despite being more complex[20]. Oils and Grease (O&G) contain toxic substances such as petroleum hydrocarbons, phenols, and polycyclic hydrocarbons, which inhibit the growth of animals and plants in the aquatic environment, and human carcinogens[21]. The high concentrations of oils lead to the failure and disruption of biological treatment units as a result of their accumulation on them, and it is an insulating surface that reduces the percentage of dissolved oxygen in the sewage water necessary for the life and reproduction of aerobic bacteria that decompose the organic matter contained in wastewater[22][23].Phosphate (PO_4^{-3}) one of the pollutants in wastewater. Although phosphorous is a nutrient that increases the growth of plants, it has negative effects on aquatic systems because it promotes the growth of plants on the growth of other wildlife, such as the growth and reproduction of algae, some of which produce toxins harmful to animals and humans[24]. Most of the sources of phosphorous in wastewater are human and animal waste and detergents and rainwater drains, and agricultural fertilizers[25][26]. Ammonium, Nitrite, and Nitrate Nitrogen sources in wastewater, it is in the form of organic nitrogen, either urea, amino acids, fecal matter, and through the hydrolysis process turns organic nitrogen into ammonia or ammonium. And the entry of sewage into WWTPs turns organic nitrogen into ammonium, by ammonification is the natural process in which organic N is mineralized to NH_4^+ by microorganisms[27]. Then the nitrification process occurs which is the biological conversion of ammonium to nitrogen nitrate, which is A two-step process. In the first step, aerobic bacteria known as Nitrosomonas are transformed from ammonium to nitrite. Another group of aerobic bacteria called Nitrobacter terminate convert nitrites to nitrates and finally to nitrogen gas[28].Hydrogen Sulfide (H_2S) is formed in wastewater when aerobic bacteria consume all available oxygen during the decomposition of organic matter[29]. Therefore, anaerobic bacteria grow and become active, converting sulfur compounds, such as sulfates, into sulfides, SO_2. It combines with hydrogen to produce hydrogen sulfide gas with an unpleasant smell similar to the smell of rotten eggs, which is the characteristic smell of sewage water. Hydrogen sulfide gas is very toxic and has an unpleasant odor. The oxidation of H_2S forms sulfuric acid, which leads to the corrosion of concrete and steel structures in lifting stations and wastewater treatment plant.

2. Materials and Methods

The current study applied a quantitative and descriptive assessment of pollutants in wastewater, where samples were collected from wastewater from WWTP based on the activated sludge process and no chemicals were used in wastewater treatment only physical biological treatment. The concentration of pollutants was estimated before and after adding alum, lime, and ferrous sulfate heptahydrate, depending on the coagulation and flocculation processes, and by using a jar test to determine the appropriate doses for these coagulants depending on the degree of turbidity of the wastewater.

2.1 Samples

Wastewater samples were collected from the Mahmoudiyah wastewater treatment plant on the outskirts of Baghdad, the capital of Iraq. This wastewater treatment plant is based on two phases, physical and biological treatment only. The samples were preserved by acidification and cooling according to the sample collection instructions to ensure the accuracy of the laboratory results.

2.2 Chemical Solutions

1 g of aluminum sulfate hexahydrate ($Al_2 (SO_4)_3.16H_2O$) was weighed and dissolved in a minimum volume of distilled water and transferred to a 1000 mL volumetric flask then completed with distilled water for determination. The concentration of alum solution is 1000 ppm (mg/L) which every 1 ml of solution contains 1 ppm (1mg/L). In the same way, standard solutions of lime and ferrous sulfateheptahydrate were prepared.

2.3 Optimal Coagulants Dosage

The turbidity and pH of the samples were measured before the start of the experiment. The beakers were filled with 1000 mL of untreated WWTPs-introduced wastewater per beaker. The beakers filled with wastewater samples placed the device and operated the device's stirring tools at a speed of 100 revolutions per minute, then the standard alum solution was added by pipettes to the second beaker of 5 ml, the third beaker of 10 ml, and the beaker of 15 ml, the fifth of 20 ml and the sixth of 25 ml. The suspension is coagulated by the added alum[30]. As for the sample in the first beaker, the alum solution was not added to it.Then reduce the speed to 30 rpm as the filament forms and leave it for 20 minutes . Then the engine was turned off and the samples were left for half an hour to precipitate and precipitate the impurities after coagulation and flocculation. A volume of 5 mL was taken by pipette of the clear solution to each beaker and turbidity was measured with a turbidity meter.A volume of 50 mL of pure solution was taken with a pipette from each beaker and the pH was measured with a pH meter.All the above-mentioned work steps were repeated by adding the standard lime and ferrous sulfate solutions, and the turbidity of the wastewater did not decrease as much as required. Therefore, the examination was re-examined by increasing the added volumes of lime and ferrous sulfateheptahydrate solutions, as the additions were 10ml, 20ml, 30ml, 40ml, 50ml, and 60ml, respectively.

2.4 Laboratory Tests

After the completion of the coagulation and flocculation process and the sedimentation of the coagulant, the clear wastewater was withdrawn to conduct laboratory tests, and to identify and determine the characteristics of the wastewater. And compare them with the characteristics of wastewater before the coagulation and flocculation process to find the percentages of pollutant reduction before and after adding coagulants. Contaminants in wastewater are estimated using quantitative analysis methods, which is a method of determining the absolute or relative amount with respect to the concentration of one or more substances present in a sample or compound. Quantitative analysis techniques include gravimetric analysis and volumetric analysis. Instrumental methods of analysis are also used to estimate the amount of pollutants in wastewater due to the speed and accuracy of obtaining results. Performance evaluation is the derivation of a comparative calculation between reducing pollution before and after treatment operations, in addition to distinguishing between its efficiency according to the following equation:

$$\text{Pollutant removal (\%)} = \frac{Ci - Cf}{Ci} \times 100$$

Ci = Initial reading of parameter before treatment

Cf = Final reading of parameter after treatment

3. RESULTS

Additions of alum, lime, and ferrous sulfate standard solutions to untreated wastewater samples from the Mahmoudiyah WWTP whose turbidity was 153 NTU according to the jar test using the coagulation and flocculation process as shown in Table 1 where the first column shows the added doses of the standard alum solution for each Wastewater sample, and the second column shows the turbidity values after each addition. The third column shows the doses added from the standard lime solution, and the fourth column shows the turbidity after each addition. The fifth column shows the added doses of ferrous sulfate solution, and the sixth column shows the turbidity after each addition. The ideal dose for alum was 20 mg/L, for lime 40 mg/L, and ferrous sulfate 50 mg/L.Appropriate doses of coagulants were added to the special wastewater samples for laboratory tests, and after the completion of the coagulation and flocculation process, the pure wastewater was withdrawn and14 laboratory tests were carried out.

Table 1. Optimum Alum, lime and ferrous sulfateheptahydrate Dosage for Sample of the wastewater

No.	alum			lime			ferrous sulfate heptahydrate		
	Vol. of S.S	Turbidity	PH	Vol. of S.S	Turbidity	PH	Vol. of S.S	Turbidity	PH
1	0	141 NTU	6.8	10 ml	113 NTU	6.81	10 ml	105 NTU	6.79
2	5ml	96.7 NTU	6.8	20 ml	78 NTU	6.92	20 ml	84 NTU	6.76
3	10ml	60.2 NTU	6.79	30 ml	31 NTU	6.95	30 ml	68 NTU	6.72
4	15ml	29 NTU	6.78	40 ml	22.8NTU	7	40 ml	31 NTU	6.69
5	20ml	12 NTU	6.6	50 ml	30 NTU	7.1	50 ml	18NTU	6.65
6	25ml	18 NTU	6.53	60 ml	32.8 NTU	7.3	60 ml	21 NTU	6.62

Laboratory test results are listed in Table 2, where the first column shows the wastewater parameters along with the environmental determinants of each parameter. The second column contains the values of laboratory test results for wastewater before the coagulation and flocculation process and without the addition of coagulants. The third column shows the results of laboratory tests after adding alum and performing the coagulation and flocculation process for sewage samples. The fourth column is after adding lime and the fifth column is after adding ferrous sulfate. Coagulation is a chemical process that neutralizes the charge on suspended particles. Flocculation is a physical process that enables particles to bind together, making them larger, so that they can be more easily separated from wastewater.Solids suspended in water have a negative charge and because they have the same type of surface charge, they are repel each other when they come close. Therefore, suspended solids will remain in suspension and will remain. It does not clump together and settle out of the water unless appropriate coagulants and flocculation are used. Coagulation and flocculation occur in successive steps, allowing particle collision and bulk growth. This is then followed by sedimentation.The coagulation and flocculation process also proved effective in reducing the organic compounds as evident by the decrease in the values of BOD and COD. The reduction of organic matter in the wastewater follows two different mechanisms: charge neutralization and adsorption. Organic matter organic anions during coagulation with mineral salts. The molecules in the effluent coordinate with the metal cations present in the coagulants to date. It forms neutral and insoluble products present in the masses resulting from the coagulation and flocculation processes. Neutral organic mattes can form larger clumps by van der Waals attractive forces and these larger clumps then stabilize. Phosphate is one of the most pollutants present in wastewater affected by the coagulation and flocculation process, as its concentration has decreased in large proportions.

Table 2. Laboratory test results of the wastewater

Parameters	Without coagulants	After adding alum	After adding lime	After adding ferrous sulfate
BOD(40mg/L)	350 mg/L	110 mg/L↓	134 mg/L↓	145 mg/L↓
COD(100mg/L)	365 mg/L	123 mg/L↓	144 mg/L↓	151 mg/L↓
TSS(40 mg/L)	204 mg/L	28 mg/L↓	36 mg/L↓	38mg/L↓
SO_4^{-2}(400mg/L)	430 mg/L	278 mg/L	225 mg/L↓	292 mg/L
Cl^{-}(600mg/L)	311 mg/L	185 mg/L↓	192 mg/L↓	205 mg/L↓
NH_4^{+}(5mg/L)	48 mg/L	13.6 mg/L↓	22 mg/L↓	24 mg/L↓
PO_4^{-3}(3mg/L)	3.8 mg/L	0.95 mg/L↓	1.2mg/L↓	1.1 mg/L↓
O&G(10 mg/L)	48 mg/L	13 mg/L↓	16 mg/L↓	18 mg/L↓
PH(6.4-8)	6.8	6.6	7	6.95
Temp.(20-35)°C	24° C	25° C	25° C	25° C
Turbidity 10NTU	153 NTU	12 NTU↓	16.8 NTU↓	18 NTU↓

The Phosphate removal process in wastewater treatment with Me coagulant is simultaneous particle destabilization in the colloidal system. The coagulation mechanism of P removal by using Me salts leads to the direct formation of insoluble MePO4 and Me-hydroxyl-phosphate complexes. When Me is salt dosed into water, a range of Me-hydrolyzed species are formed, and hence the species that can react with the PO4 ions will be a range of hydrolyzed products, including the metal hydroxide, rather than the simple Me ions.Addition of aluminum sulfate, ferrous Sulfate, and Calcium hydroxide to phosphate-containing waste water the following reactions results:

$$Al_2(SO_4)_3 + 2PO_4^{3-} \rightarrow 2AlPO_4 + 3SO_4^{2-}$$

$$3FeSO_4 + PO_4^{3-} \rightarrow Fe_3(PO_4)_2 + 3SO_4^{2-}$$

$$Ca(OH)_2 + PO_4^{3-} \rightarrow Ca_3(PO_4)_2 + 2OH$$

For ammonium, the coagulation and flocculation process and the addition of alum, lime and ferrous sulfate as coagulants had a limited effect in reducing it from wastewater by no more than 30% due to the fact that it is a highly water soluble compound. Part of NH_4^+ can become a surfactant with negatively charged colloidal particles by electrostatic attraction but the remainder dissolves in wastewater due to hydrogen bonds.Even if reducing the concentration of ammonium in wastewater by small percentages, it is a positive factor that enhances the process of biological treatment of nitrogen compounds through aerobic and anaerobic bacteria by the nitrification process, ammonium is converted to nitrite with the addition of anaerobic bacteria and oxygen and then to nitrate in the second stage. Laboratory tests of wastewater taken from the entrance of the wastewater treatment plant showed no nitrates or nitrates, indicating that the wastewater was newly contaminated with ammonium and that the nitrification process had not yet begun. Oils and grease decreased in the wastewater samples after the coagulation and sintering process and the use of alum, lime, and ferrous sulphate as coagulants, as can be seen in Figure1, which shows the difference in the values of the wastewater parameters before and after the coagulation and flocculation process.

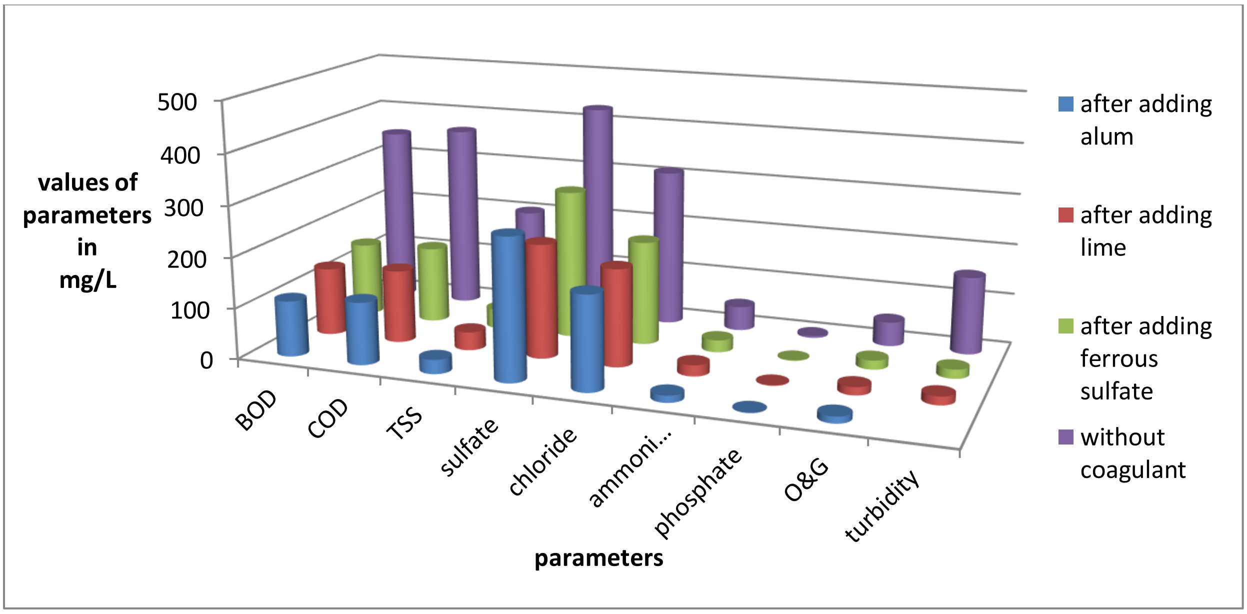

Figure1. The difference in the values of wastewater parameters before and after the coagulation and flocculation process

The fact that oils and grease float on the surface of the wastewater is one of the causes of its turbidity and is difficult to treat. The coagulation and flocculation process involves rapid mixing of mineral salts and water to destabilize charged colloid materials, slow mixing to promote aggregation of unstable particles and emulsion of oil droplets, and separation of particles by sedimentation. Using chemicals that are effective in breaking down the stability of emulsions and reducing the amount of oil in the water. It sticks to the sediment, which makes it a suspended material and coagulant, and settles with it. It is considered a successful primary treatment method for wastewater in reducing wastewater in WWTPs. The efficiency of the coagulant and flocculation process in reducing pollutants from wastewater was evaluated according to the type of coagulant used and in general according to Table 3.

Table 3. Evaluation the efficiency of coagulation and flocculation

Parameters	% alum efficiency	%lime efficiency	%ferrous sulfate efficiency
Turbidity	92%	89%	88%
BOD	69%	62%	59%
COD	66%	61%	59%
TSS	86%	82%	81%

NH_4^+	72%	54%	50%
PO_4^{-3}	75%	68%	71%
O&G	73%	67%	63%

Reducing the turbidity of wastewater to these high percentages due to the coagulation and flocculation process is evidence of the reduction of all various pollutants, which has a positive role in preserving the environment, especially the aquatic environment. Organic compounds are substances whose basic structure is carbon atoms, and most of them are stable because they remain in the environment with their components of air, water, and soil for long periods extending over years and decades, and do not dissolve or decompose. Reducing the amount of wastewater through continuous coagulation and flocculation helps protect the aquatic environment, the soil that uses wastewater for irrigation, and human health. Direct and indirect exposure to organic pollutants causes serious diseases in humans and various living organisms. The high percentage of suspended solids in water or wastewater has an impact on both the environment and human health, causing digestive problems or even death. TSS can reduce the normal content of dissolved oxygen in the water and increase the water temperature, preventing young fish from surviving, TSS can also block sunlight, affecting plant survival. Reducing total suspended solids in wastewater after treating it with the coagulation and flocculation process means fewer bacteria, pathogens, and heavy metals, which has a positive impact on protecting the environment from pollution. Ecosystems naturally cycle nitrogen from the air into the soil and water as bacteria break down nitrogen-containing compounds in dead plants and animals and release nitrogen gas into the atmosphere, the effectiveness of the coagulation and flocculation process in reducing nitrogen compounds has an environmental impact in maintaining this balance. If a disruption occurs in this ecosystem, this will cause serious environmental problems. For example, the leakage of nitrogen compounds into the seas causes an increase in the proliferation of toxic algae, which kills marine life, and the death of many organisms such as fish and others. Not only that, the effects of this imbalance include a long list of air pollution, disruption of the delicate balance of the atmosphere, acid rain, soil acidification, and more. Reducing the concentration of phosphate in wastewater helps prevent abnormal growth of algae and lichens in the water because it is an element an important nutrient for aquatic plants, it also affects the concentration of dissolved oxygen in the water, which has a positive effect on preserving the aquatic environment.

CONCLUSION

It has been proven through this study that the process of coagulation and flocculation is successful as a chemical pre-treatment of wastewater and has an effective role in reducing pollutants in wastewater. According to the turbidity of the wastewater and using the jar test, appropriate doses were determined for each of the standard solutions of alum, lime, and ferrous sulfate that were added as coagulants. Through the flocculation process, clumps containing suspended materials are formed and separated from wastewater by sedimentation. By testing the wastewater from which the blocks were separated, it was found that the greatest effect of coagulants is to reduce the turbidity of the wastewater, and this is evidence of reducing the total suspended matter in good proportions, which improves the wastewater treatment process. Where the concentration of phosphorus compounds decreased in high proportions. The organic matter concentration in the wastewater decreased its concentration according to the BOD and COD values, which in turn reduces the organic loads on the wastewater treatment plants. The same applies to the O&G concentration, which according to laboratory results was reduced to more than half of its concentration before coagulants were added to the wastewater. In general, even if the effect of the coagulation and flocculation process is simple, this is considered a positive effect on wastewater, as it reduces the pollutants present in it, which improves the treatment process and guarantees treated wastewater of good quality and can be reused with minimal harm to the environment and living organisms. It also reduces pollutant loads on WWTPs and improves their performance.

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