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Treatment of pharmaceutical waste water using Coagulation method

Yeddla. Gangadhar Reddy[1], Dr. T. Bala Narsaiah[2], B. Venkateswar Rao[3]
[1]Research Scholar, Centre for Chemical Sciences & Technology, IST, JNTUH, Hyderabad.
[2]Associate Professor, Department of Chemical Engineering, JNTUACEA, Anantapur.
[3]Research Scholar, Centre for Environmental Sciences, IST, JNTUH, Hyderabad.

Abstract:- Attempts were made in this study to examine coagulation process for the treatment of pharmaceutical wastewater. The studies were carried out as functions of contact time, dosage of coagulant and influent pH for coagulation process using aluminum sulfate ($Al_2(SO_4)_3 \cdot 18H_2O$) as coagulant. COD reduction was found to be extremely depend on effluent pH. The total COD reduction was depending on coagulation pH. In addition, optimal parameters of coagulation process were determined. When treated effluent was controlled at pH 7.0, the pollutants could be further removed by sedimentation process. The analytical parameters monitored include COD, BOD, TOC, Hardness and Total solids (TS).

Keywords:- Coagulants, COD, Pharmaceutical Wastewater, Treatment process.

I. INTRODUCTION

Pharmaceutical industry consumes considerable volume of water for various manufacturing processes of drugs production. Water was also used and required for steam generation and other general purposes. The wastewater discharged was highly polluted in nature with highly variable characteristics such as temperature, colour, total solids, chemical oxygen demand (COD), biochemical oxygen demand (BOD), total organic carbon (TOC) and hardness [1]. Due to highly polluting nature, it is not possible to discharge treated and untreated waste either into water course or on land without causing great damage. They pose a great problem for environmental engineers. Due consideration was also given to the comparison of effluent characteristics parameters of effluent treatment plant with the State Pollution Control Board Effluent Quality standards discharged in different receiving bodies as per IS: 2490 (Part-I) 1974 and standards for liquid effluent for Pharmaceutical Industries. Toxicity tests were also done on treated effluent to study the effects of treated waste effluent on ecological environment before disposal [2].

Coagulation is an essential process in water and industrial wastewater treatment. In the area of potable water treatment, clarification of water with coagulating agents were practiced since ancient times, using a variety of substances the most notable among them being crushed seeds [3]. The Egyptians, as early as 2000 BC, used almonds smeared around a vessel to clarify river water. The early Romans were also familiar with alum, though it may not have been for water treatment [3,4]. Nevertheless, its use of a coagulant by the Romans was mentioned in ca. 77 AD. By 1757, alum was used as a coagulant in water treatment in England, and more formally for the treatment of public water supplies in 1881. In modern water treatment, coagulation and flocculation are still essential steps in the treatment processes [4].

Coagulation is one of the most important physicochemical operations used in wastewater treatment can be achieved by chemical and electrical means [5,6]. Coagulation and flocculation occur in successive steps intended to overcome the forces stabilizing the suspended particles, allowing particle collision and growth of floc. Coagulation was defined as the addition of a positively charged ion of metal salt or catalytic polyelectrolyte that results in particle destabilization and charge neutralization. Coagulation targets the colloid particles of size 10^{-7} to 10^{-14} cm in diameter. The colloid particles exhibit Brownian movement through the water; their surface is negatively charged so they repel one another, and they form a stable dispersed suspension [7]. If colloid particles or ions of positive electric charge were added it neutralizes the electric negative charge. Flocculation refers to the successful collision that occurs when destabilized particles are driven toward each other by the hydraulic shear force in the rapid mix and flocculation basin. It agglomerates of a few colloids then quickly bridge together to form microflocs which is turned into visible floc masses [8], which is shown in Fig.1.

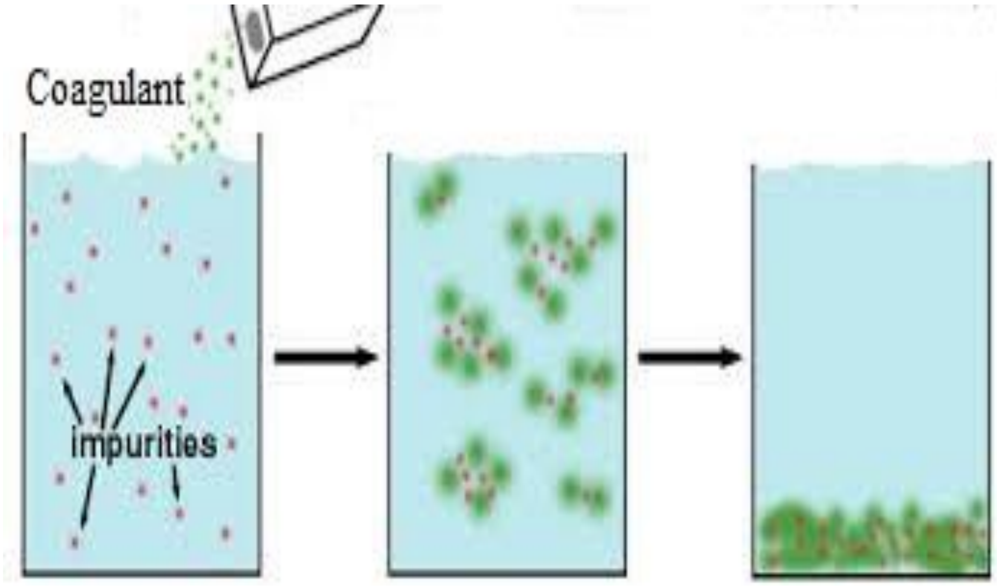


Fig.1: Coagulation process

In the present study the pharmaceutical wastewater will be treated using coagulation process and the successive method will be evaluated.

II. MATERIALS AND METHODS

Coagulant: Industrial grade alum and ferric chloride Chlor Pars Company, Mumbai.

II.A. Wastewater Samples

Wastewater was obtained from the wastewater treatment plant in Hyderabad Industrial area. This wastewater was a mixture of organic and inorganic compounds. The wastewater was collected and sent directly to our lab and stored at 4°C and was equilibrated to room temperature before use. The main characteristics of the wastewater were presented in Table 1.

Table. 1: Initial characterization of the pharmaceutical sample

S. No.	Parameters	Concentration (mg/l)
1	**pH**	**7.2**
2	**COD**	**1700**
3	**TOC**	**1200**
4	**BOD**	**940**
5	**TS**	**1940**

Treatment tests were carried out with Industrial Grade alum. A known amount of industrial grade alum was taken in a 500-ml flask with working volumes of 250ml. The flocculator was used for constant mixing of alum, over a period of time and sample filtered with Whatman No. 41 Filter paper [9]. The pH of the solutions at the beginning and end of the experiments were measured, and the average values were reported. The treatment time studied up to 60min at dosage range 100mg/l-500mg/l and pH studied at 6, 7 and 8.

II.B. Analytical analysis

The pH, Total solids, Hardness, Chemical oxygen demand (COD) of the samples was measured by Standard methods for the examination of the water and waste water 21 th addition 2005 APHA, were repeated for getting the reproducibility of results [10, 11, 12].

The instrumental analysis was carried using Double beam Shimadzu UV 2450 UV–visible Spectrophoto meter and TOC-L CPH E 200 for TOC estimation.

$$\%\text{Removal of the pollutant} = \frac{C_i - C_f}{C_i} \times 100$$

Where, C_i is the initial pollutant concentration (mg L^{-1}) and C_f is the final pollutant concentration (mg L^{-1}).

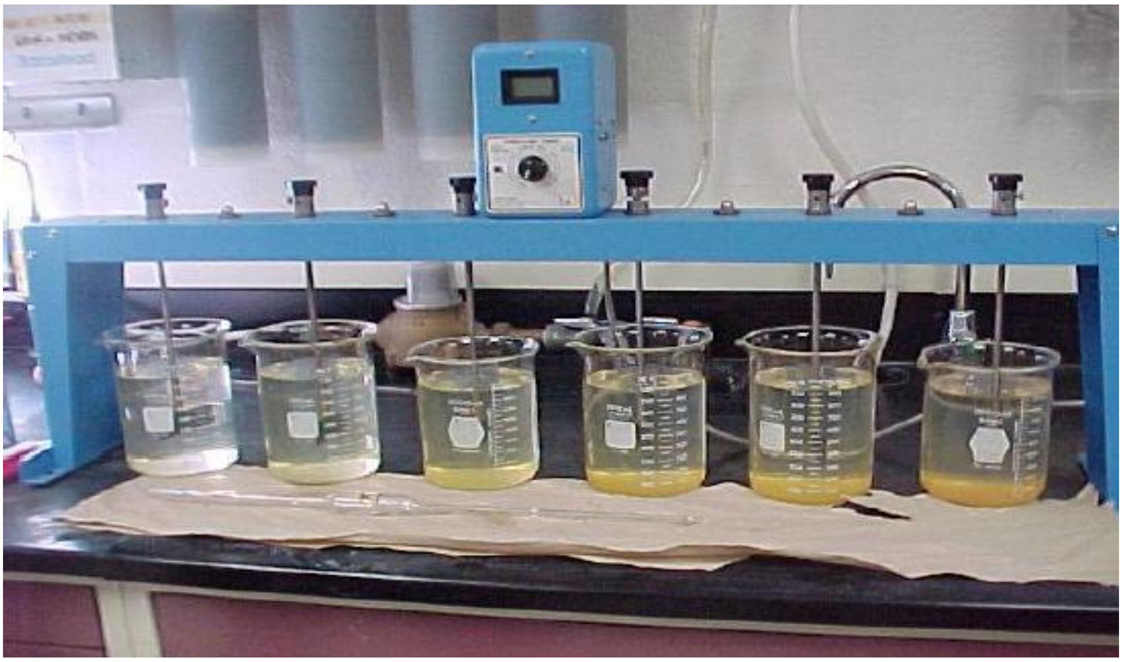


Fig.2: Coagulation test in jar operators

III. RESULTS AND DISCUSSION

III.A. COAGULANT SELECTION:

The objective of this study is to compare the two coagulants, i.e., aluminium and iron based coagulants that can be used to coagulate the suspension particles in the pharmaceutical wastewater. It was found that the behaviour of coagulant may change from wastewater to another according to many factors including pH, kind of coagulant and different constituents of wastewater [11, 13]. Fig. 3 shown the removal efficiencies for alum had more efficiency in % removal colour compared with iron coagulant at the specified conditions and reaction given below [16].

$$Al_2(SO_4)_3 + 3Ca(HCO_3)_2 \rightarrow 2Al(OH)_3 + 3CaSO_4 + 6CO_2$$
$$Fe_2(SO_4)_3 + 3Ca(HCO_3)_2 \rightarrow 2Fe(OH)_3 + 3CaSO_4 + 6CO_2$$
$$FeSO_4 + Ca(HCO_3)_2 \rightarrow Fe(OH)_2 + CaSO_4 + 2CO_2$$
$$2FeCl_3 + 3Ca(HCO_3)_2 \rightarrow 2Fe(OH)_3 + 3CaCl_2 + 6CO_2$$

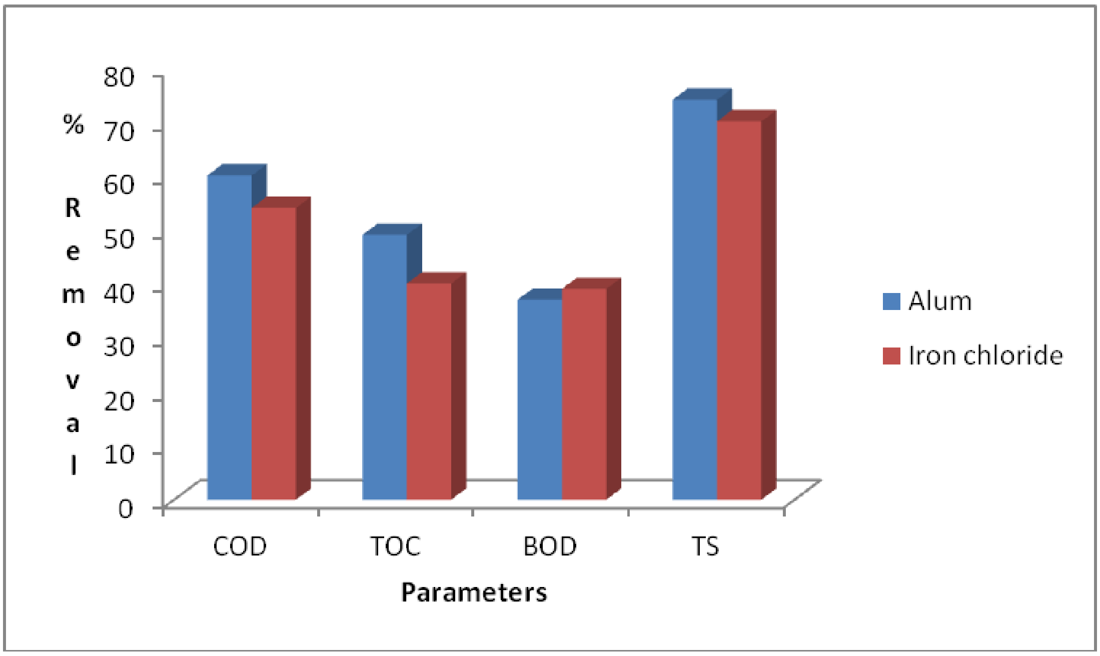
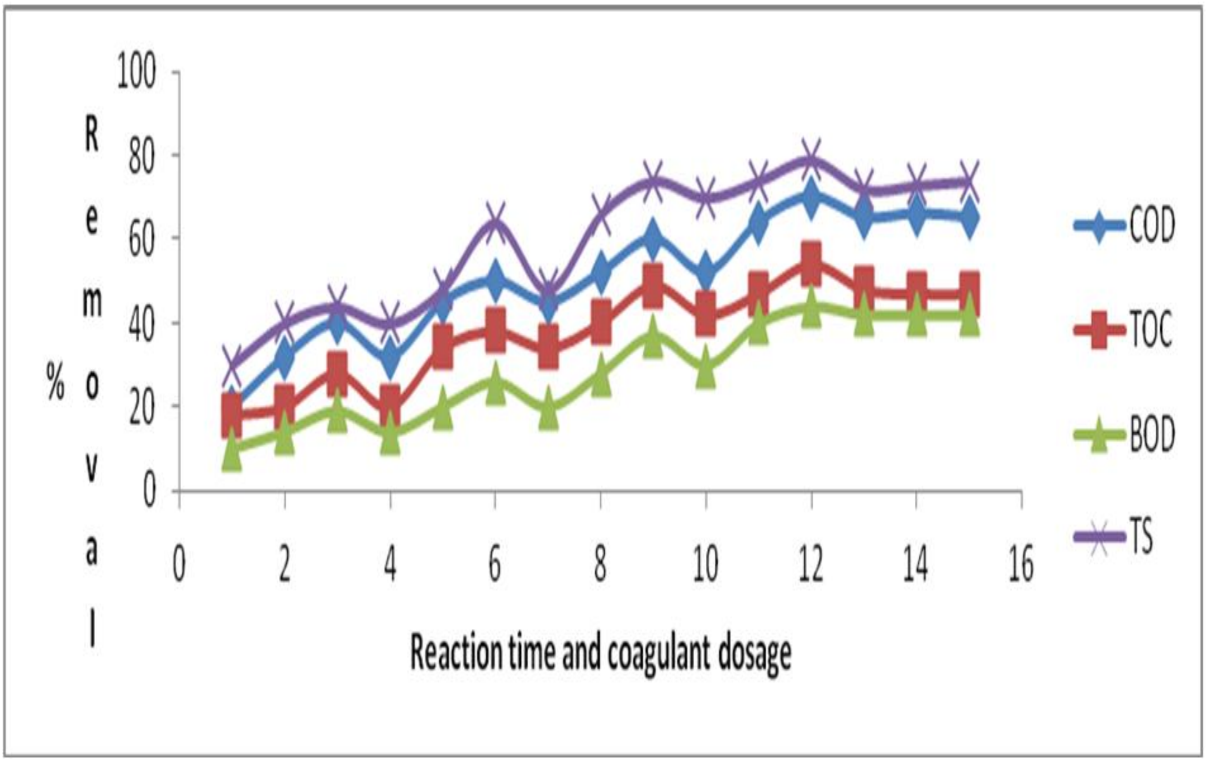
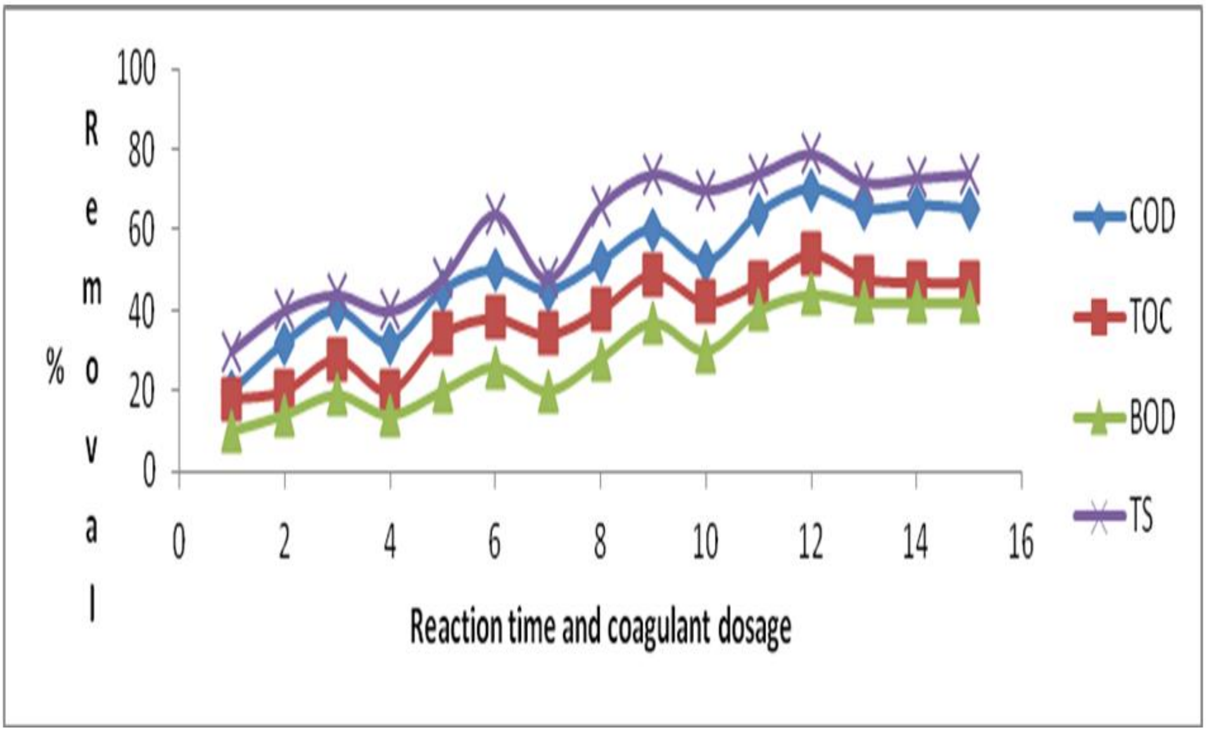


Fig.3: Effect of coagulants on % removal

III.B. EFFECT OF DOSAGE AND TIME:

The alum dosage and reaction time variation on % removal was shown in table. It was observed that with increase in the amount of industrial grade alum the % removal also increased with time. The loading capacity (i.e., the amount of adsorbate adsorbed per gram of alum) increased with time and concentration and then attained a constant value after 40minutes. The time to reach equilibrium conditions appears to be independent of initial fluoride concentrations [12]. Increase in the dosage from 100mg/l to 800mg/l the percentage removal in the solution gradually decreases with respective time (Fig. 4). The optimum time and alum dosage observed to be 40min and 800mg/l respectively.





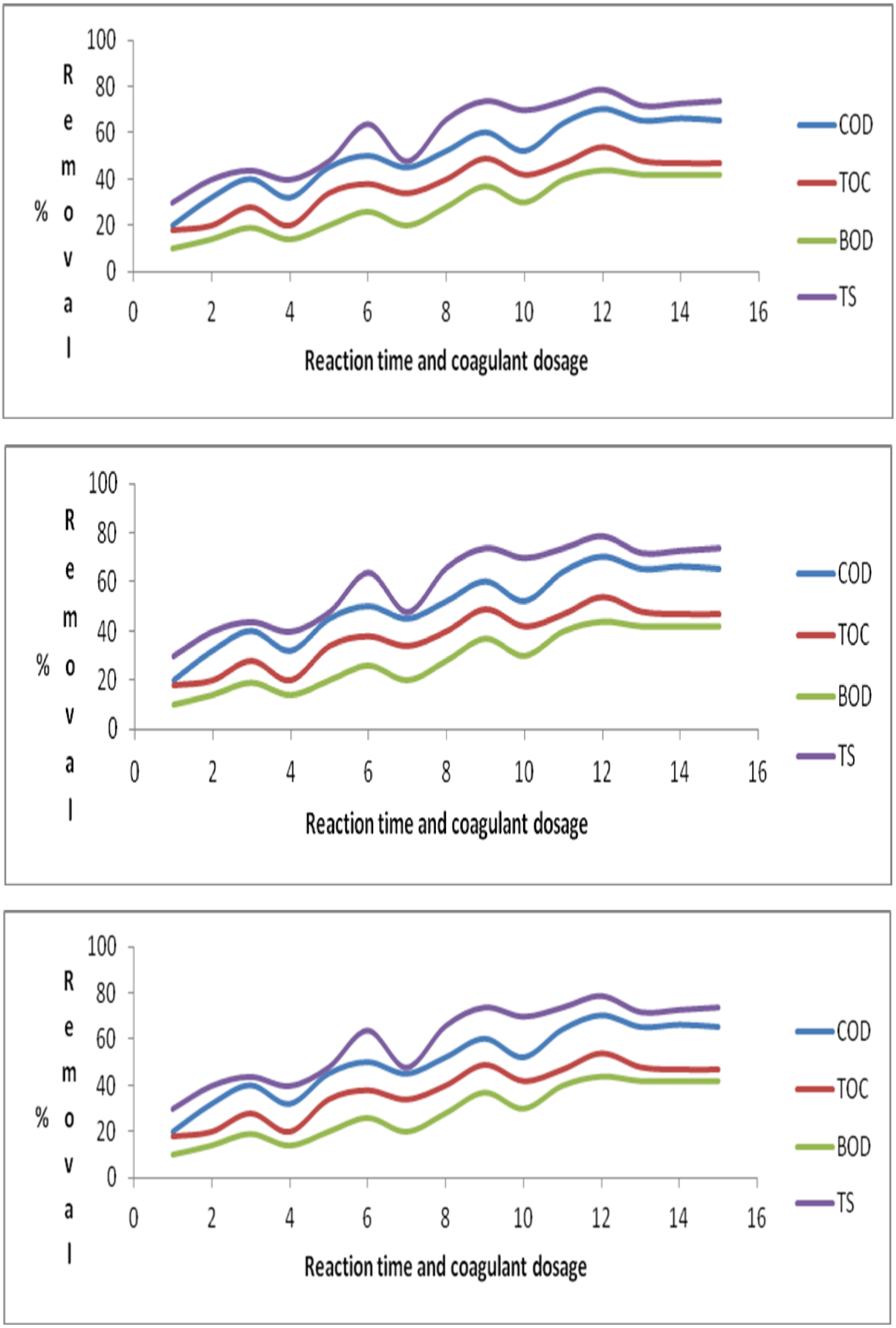


Fig.4: Effect of coagulant dosage and time on % removal

III.C. Effect of pH:

The pH was a key parameter in the coagulation process. The optimum value of pH depends on the properties of the water treated, type of the coagulant used and its concentration. To measure the effect of initial pH , the pH of each of sample was adjusted at different value using 1 N of sulphuric acid or sodium hydroxide solutions. The experiments at initial pH values of 6, 7 and 8 were performed. The results presented in table show at pH 7 maximum % removal of COD, TOC, BOD, TS was observed to be 70, 54, 44, 79 % respectively (Fig. 5). Thus pH 7 was selected for further tests, because it was the initial pH of the raw wastewater [15, 16]. So, no need for adding chemicals to adjust the pH.

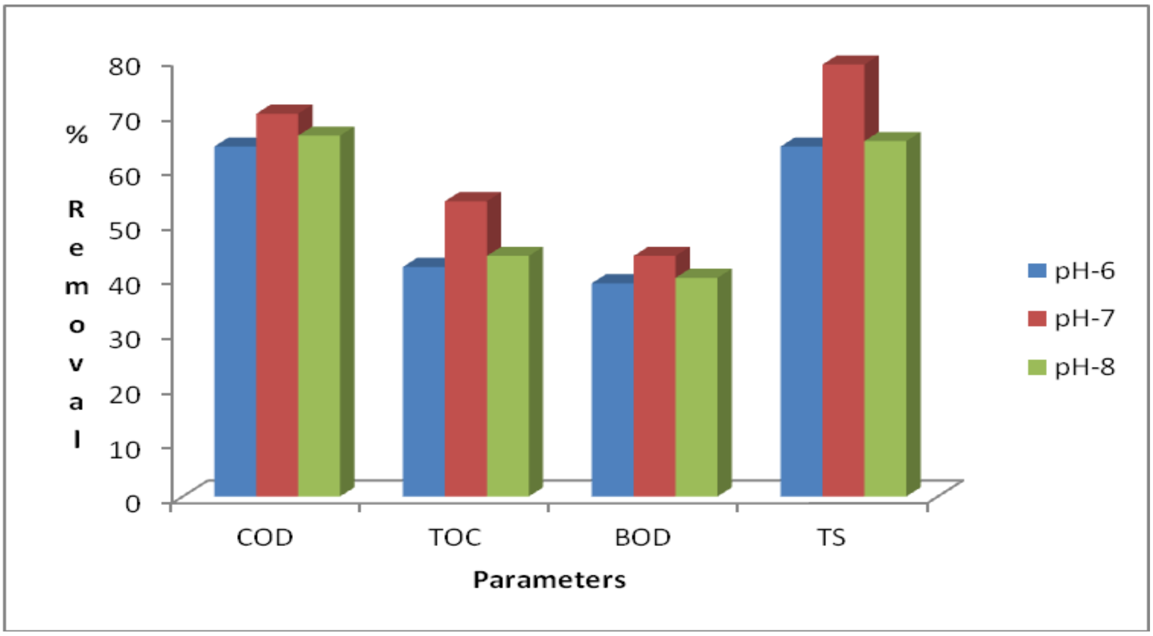


Fig. 5: Effect of Initial pH on % removal

III.D. Effect of mixing:

The effect of agitation rate on the % removal efficiency was illustrated in table. The highest % removal was achieved at 200 rpm of rapid mixing. However, the other rates produced comparable results. The lowest removal efficiency was obtained at a stirring rate of 300 rpm. At 200rpm the maximum removal of COD, TOC, BOD, TS observed to be 79, 60, 49, 80 % respectively (Fig. 6). The use of the lowest velocity for agitation will save the energy [17].

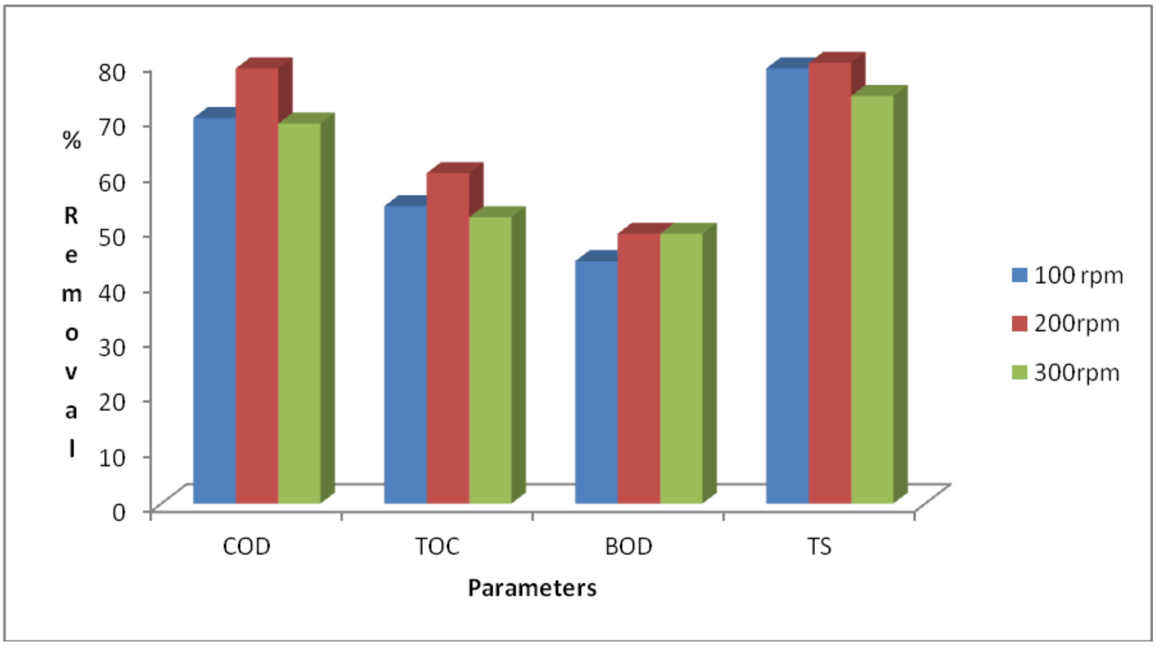


Fig. 6: Effect of mixing speed on % removal

IV. CONCLUSIONS

1. Alum was found to be better for pharmaceutical wastewater treatment.
2. The optimum time and alum dosage observed to be 40min and 800mg/l.
3. The optimum pH observed was at 7 and removal rate of COD, TOC, BOD, TS observed to be 70, 54, 44, 79 % respectively.
4. The maximum removal of pollutants observed at 200rpm and 79, 60, 49, 80 % for COD, TOC, BOD, TS respectively.

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