Simple Treatment of Textile Industry Wastewater For Reuse And Recycling

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Abstract

The aim of the present work is at describing a simple physico-chemical treatment for the textile wastewater of a local plant to bring its characteristics to that used within the plant. Lime and polyelectrolyte were employed individually to aid the removal of pollutants. The effectiveness of the treatment was indicated by measuring parameters like biochemical oxygen demand, BOD, turbidity, electrical conductivity, EC, total suspended solids, TSS, total dissolved solid, TDS, for the produced water after filtration through simple sand filter. The treatment was supported by an extensive study of the coagulation/flocculation and filtration processes. Color dyes adsorb efficiently onto the coagulant particles and separates from the original liquor. Pollutants removal efficiency (Turbidity, TSS, TDS, and color), by (87-90%, 81-85%, 30-32% 40-45%) respectively could be obtained by using lime solution of concentration 35-40 mg/L without addition of cationic polyelectrolyte. Increasing lime concentration results in some difficulties like high pH value of water discharged, dewatering problems and sand filter clogging.

Keywords: Recycling; wastewater treatment, Textiles industry

معالجة بسيطة للمياه العادمة من صناعة النسيج بهدف أعادة التدوير والاستخدام

الخلاصة

الغرض من العمل الحالي يتلخص في وصف طريقة معالجة كيميائية – فيزيائية بسيطة للمياه العادمة من صناعة النسيج ماخوذة من مصنع محلي وذلك للوصول بخصائصها الى مايقارب خصائص النوع المستخدم داخل المصنع بهدف اعادة استخدامها في بعض الاغراض. تم استخدام النورة والبولي الكتروليت بشكل منفرد للمساعدة في ازالة الملوثات. تم الاستدلال على كفاءة طريقة المعالجة الحالية من خلال قياسات قيم المؤشرات مثل الحاجة البايوكيميائية للاوكسجين BOD العكورة، التوصيلية الكهربائية EC، المواد الصلبة الكلية العالقة TSS، والمواد الصلبة الذائبة الكليةTDSللماء الناتج من المعالجة بعد الترشيح خلال مرشح رملي بسيط. قمنا بتعزيز المعالجة بدراسة مستفيضة لعمليات التخثير والتكتيل والترشيح. لقد تبين ان الصبغات الملونة تمتز بشكل كفوء على دقائق المادة المخثرة وتنفصل عن المحلول الاصلي. تم التوصل الى كفاءة ازالة للملوثات وكما يأتي : العكورة 78-90% ، 81-85%TSS ، TDS

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30-32% و اللون بنسبة 40-45%. وذلك باستخدام معلق النورة في المـــاء بتركيـــز 35-40 مغم/لتر بدون اضافة البولي الكتروليت. ان اضافة زيادة من النورة تتسبب في بعض الصعوبات مثل زيادة القاعدية للماء الناتج ومشاكل في التنشيف وانسدادات في المرشح الرملي.

Introduction

Direct re-use and recycling require only a minimum of capital outlay and extremely low running cost [1]. The intended water reuse applications dictate the extent of wastewater treatment required. The quality of finished water, and the method of distribution and application, water reuse may involve a completely controlled "pipe-to-pipe" system with an intermittent storage step, or it may include blending with non reclaimed water either directly in an engineered system or indirectly through surface water supplies or groundwater recharge [2].

Textile processing industry is one of the water intensive consumptive industries in almost every stage for processing and requires volumes of water about 100-150 m^3/ton and produces high volumes of effluent wastewater, which is mainly characterized by salts, organic matter and color [3]. The standard methods of treating textile wastewater are biological, chemical or physical process. These methods can be used to remove color in the wastewater with varying effectiveness depending on the types of colors and their concentration. Physical-chemical methods are always used for color removal, and other organic and inorganic impurities. Some of the methods are relatively expensive especially those including advanced filtration like ultrafiltration, UF, nanofiltration, NF and reverse osmosis, RO. These filters are sensitive for impurities and colors which cause damage [4].

Sand filters are widely used in the treatment as they are characterized by simple technology for design and production, low cost and easy maintenance than advanced filters. The coagulation/ flocculation process is an important part of surface water and wastewater treatment. It has a direct impact on the reliability of plant operations and final water quality together with cost control [5].

The aim of the present work is at finding the most effective coagulant and its most advantageous dose, besides determining the best dose of the coagulant aid (cationic polyelectrolyte), to get best results, the coagulation, flocculation periods must be satisfied, and the other operation conditions (speed of mixing, for both coagulation and flocculation processes).

Experimental

Apparatus

The jar test experiments were carried out a Floc Tester CHC supplied from Hoelze and Chelus com. KG (W. Germany) to study the coagulation and flocculation. The pH measurements were performed on a pH 211supplied from HANNA with accuracy of ±0.1%. The instrument was also employed for measuring temperature and electrical conductivity. Turbidity of water samples was tested using Hach A 2001–Lab Turbidity meter) which is characterized by accuracy of ± 0.5% T. The HI 83000 Multi-parameter (Bench photometers) was used for color measurements over a range of 0.0 to 500 Pt/Co with accuracy of ± 0.5%. in accordance with APHA [6]. Total Dissolved Solids (TDS)and electrical conductivity (EC) measurements were taken with model 214 EC HANA , accuracy ± 0.4% according to (APHA,

A series of sieves were used in the sieving analysis of media of sand filter that is (sand and gravel) materials in order to prepare sand with the proper effective size (Es) and uniformity coefficient (UC) for filtration purposes. The shaker was a AS 200-digit manufactured by Retsch Electric Co.

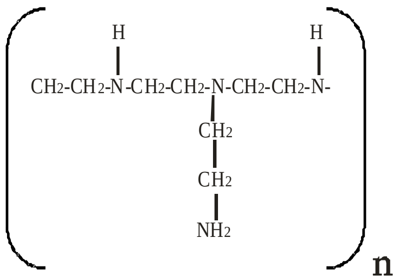
Sand Filter:

A 1000 cm^3 graduated cylinder filled for a height of 12 cm of sand and 4 cm of gravel was used to filter the treated water next to the coagulation process.

Standard tests were employed for the evaluation of Chemical oxygen demand (COD) and Total Suspended Solids (TSS).

Chemicals and Coagulants

The coagulants and chemicals used to enhance the pollutants removal efficiency, included lime, CaO 90%, Ferric chloride, $FeCl_3$, and cationic polyelectrolyte (CPE), (Mangafloc LT 225) (polyalkyenimine) multipurpose polymer with a molecular range (10000-500000) as shown below.



Stock suspension of 1% of lime in water was prepared by homogenizing 10 gm of CaO with water at 80˚C, to make 1000 ml with tap water. Similarly a 1% $FeCl_3$ solution was prepared. The polyelectrolyte solution was prepared by dissolving 1.0 gm of the polymer in 10 ml of ethyl alcohol to be completed to one liter with tap water. Thus, 1 ml of these solutions when added to 1 L of water sample will be equivalent to 1 mg/L of the coagulant. The shelf life of the coagulant solutions is given in Table 1.

The color dyes used to prepare the synthetic wastewater are acid-blue and acid-red blended with basic-blue. They are used for textile colorizations.

Determination of the best doses:

The standard jar test was employed to determine the best dose of coagulant and polyelectrolyte with the 6-place stirrer in six (1000 ml) beakers by following this procedure:

1. One liter of wastewater was placed in each of the six beakers.
2. Appropriate quantity of coagulant (10-60 mL of the stock coagulant solution) was added.
3. The speed of the stirring paddles was adjusted initially at 100 rpm then to 120 rpm.
4. The coagulation period was chosen in accordance with the wastewater type, G factor and coagulant dose. The period is about (1 – 3) min after the addition of the coagulant, then speed was reduced to 30 – 80 rpm for 15–30 min depending on the flocculation time provided in the treatment plant.
5. Time required from the coagulant addition until the first appearance of visible, discrete floc particles in each beaker was recorded.
6. After a suitable period for flocculation the agitation step should be stopped and the treated water was left for 10-30 min for settling. The time needed for the settling of the majority of the flocs formed is recorded.
7. An aliquot of 100 mL of the supernatant liquid was decanted and kept for analysis.

Velocity Gradient Determination

The coagulation, flocculation velocity gradient experiments were conducted by a jar test, using various doses of coagulant agent and coagulant aid inside a 1000 ml graduated cylinder and mixed at various speeds (80 – 130 rpm) using a G value of 130-280 sec^{-1} for the coagulation and 20-50 rpm using a G value of 22 -33 sec^{-1} for the flocculation process, accuracy ± 1.2**%** in accordance with the Phipps and Bird jar test WHO.

The choice of the best coagulation /flocculation periods depends upon optimum removal of turbidity and suspended solids. Table 2 shows the operating conditions for the bench scale (jar test)

Two types of wastewater were used in this investigation: synthetic wastewater prepared to meet the original textile wastewater with various color dye concentrations and real textile wastewater ready to discharge, from Al-Kadhimiya Textile State Co. for, Table 3 shows the main characteristics of this type of wastewater

Results And Discussion

Coagulant Agent Selection

Fig. 1 and Fig. 2 show a comparison of the effect of $FeCl_3$, CaO and cationic polyelectrolyte (CPE) on the removal efficiency of turbidity of wastewater (initial turbidity 41 NTU) in different doses. Ferric chloride, however, was the least effective additive of the group. Comparatively, the (CPE) gave better efficiency of turbidity removal than ferric chloride and close to that of lime which was the most effective coagulant giving turbidity removal increased up to 70% at the 25 mg/l dose of lime and more than 75% for TSS removal efficiency at the same dose. As a result, ferric chloride was omitted from the comparison studies. The following sections will deal with the action of lime and CPE and their combination.

Effective Dose of Lime:

Starting with textile effluents of various turbidities, experiments were carried out to apply various lime doses and follow the product water quality parameters like (Turbidity, TSS, Color COD and pH). The results are shown in Fig 3 and 4. It appears that lime doses of 35 – 40 mg/L gave maximum turbidity removal efficiency and TSS reduction for all wastewater samples. Wastewaters of low turbidity undergo higher reduction efficiency. Many authors reported similar results for coagulant dose effect, with different operating conditions [7, 8].

The alkaline nature of lime affects the pH value of the treated wastewater and pH range (7-12) could be attained by using lime dose of 10 –50 mg/L. The high pH values of treated wastewater are not acceptable to achieve high quality of product water, since high pH values reduce the floc particles growth and formation. At high pH, the Zeta potential will be highly affected and the colloids of the solution are very stable [9]. Thus lime dosage in the range of 25-35 mg/ L was adopted throughout this study. Such a result enhances the economic side of the study by using lower lime quantities for treatment as well as limiting any additive materials. Table 4 shows the pH behavior changes with lime dosage.

During the study on the effect of lime dose on the color removal it can be seen from Table 5 that a significant color reduction could be achieved at lime dosage ranging from 30 – 40mg/L. Further increase in lime dose causes a poor result in color removal which is in agreement with some results published [5, 10]. The organic nature of color dyes and their high solubility in water lead to high level of COD. Therefore, any reduction in this parameter will be important. The use of lime as a coagulant is helpful to increase COD reduction to a level 58 t0 60 mg/L of wastewater with initial COD 114 mg/L, as can be seen in Fig. 5.

Effective Dose of The Cationic Polyelectrolyte .

Table 6 shows the effect of CPE as a coagulant on color removal efficiency. It is clear that doses in the range of 1-1.25 mg/l have significant effect on the removal of color. At higher CPE doses, the removal performance drops, due to the ability of the CPE to fold back itself at this point [5, 11]. Similarly, the turbidity removal is enhanced with increasing dose of CPE up till a range of 1-1.25 mg/L (Fig. 6). Further increase in CPE dose tends to reduce the turbidity removal. However, the use of cationic polyelectrolyte alone is not favorable because of the weak structure of the flocs formed and the rapid clogging of the sand filter surface, in addition to the cost of the material [12]. For the TSS removal, Fig. 7 shows that 1.25 mg/l stands as the acceptable CPE dose which is in agreement with published cases [13, 14].

Starting with wastewater with initial COD value of 114 mg/l, the test results shown in the Fig . 8 indicated that the significant effect of CPE on the COD removal. Maximum removal efficiency could be obtained in the range of 1-1.25 mg/l. [11] obtained similar results.

Conclusions

1. Pollutants removal efficiency (Turbidity, TSS, TDS, and color), by (87-90%, 81-85%, 30-32% 40-45%) respectively could be obtained by using lime solution of concentration 35-40 mg/L without addition of cationic polyelectrolyte. Increasing lime concentration results in some difficulties like high pH value of water discharged, dewatering problems and sand filter clogging.

The use of cationic polyelectrolyte alone at concentrations of 1.25-1.5 mg/l. causes low pollutants removal efficiencies, and causes rapid clogging for sand filter due to its physical nature. Further, CPE is not effective at high levels of turbidity and TSS, besides it cost much money.

References

[1]Metcalf and Eddy inc. Georg, T., Franklin L. Burton; and Stensel D., "Wastewater Engineering Treatment and Reuse" 4th Ed, Mc Graw- Hill, New York, 2003.

[2]Barens, D., Bliss P.J. and Gould B.W. (1984) "Water and Wastewater Engineering System" Pitman Publishing Limited London, WC2E 9AN.

[3]Orhan D., Babuna F.G. and kabdasli I., J. water Sci. and Tech." 43 (11) (2001) 223-231.

[4]Chen X., Shen Z, Zhu X. and Fan Y. (2004)" Advanced Treatment of Textile Wastewater for Reuse Using Electrochemical Oxidation and Membrane Filtration", 2004.

[5]Rahbar, M.S., Alipour, E. and Sedighi, R.E., Int. J. Environ. Sci Tech., 3(2006) 79-88.

[6]APHA, "Standard Methods of Water and Wastewater Examination" 18th Ed. American Public Health Association. Washington, D.C. (1985).

[7]Conley W.R. and Evers R.H. (1968) "Coagulation Control", J. AWWA. 60 (12) 167-178.

[8]Niam M.F., Othman F., and Fauzia Z., The Malaysian J. Analytical Sci., 11 (2007) 198-205.

[9]Ademoroti C.M.A., J. Water Sci. and Tech. 14(1980)51-57.

[10]Al- Desgs,Y., Khraishen M. A. M. and Ahmed, M. N. , (2000)" Effect of Carbon Surface Chemistry on the Removal of Reactive Dyes from Textile Effluent"J.Water Research 34 (3) pp: 927-935.

[11] Pia A.B., J.A. Mendoza J.A, Alcover L.R. and Iborr A., Desalination 157 (2003) 81-86.

[12]O'Melia, C.R., and Werrner Stumm, J.AWWA 68(1978) 514-537

[13]Theodore, S.T., and Pirazari, M., J. AWWA, 78 (1986) 57-56.

[14]Leu, R. and Ghosh, M.M., J. AWWA, 80 (1988) 159-167.

TABLE (1) CHARACTERISTICS OF COAGULANT SOLUTIONS

Chemical	Conc. of stock sol:	Life	1.0 ml equivalent to
CaO	1%	1 month	10 mg/ l
Polyelectrolyte	0.01%	1 week	1.0 mg/ l
$FeCl_3$	1 %	2 weeks	10 mg/l

TABLE (2) TYPICAL CONDITIONS OF COAGULATION AND FLOCCULATION PROCESSES

Type of sample	Lime dose mg/L	CPE dose mg/L	Coagulation step		Flocculation		Settling time (min)
			Speed rpm	Detention Time (min)	Speed rpm	Detention time (min)	
Synthetic wastewater	35	0	130-140	2-3	40-45	40	25
	25	1	120-130	2-3	30-35	30	15
Real discharge wastewater	30	0	130-140	2-3	30-40	35	20
	20	1	110-120	2-3	30-35	25	15

TABLE (3) MAIN CHARACTERISTICS OF FEED WATER AND EFFLUENT OF SOME IRAQI TEXTILE FACTORIES.

Pollutants	AL-Kadhimia Factory, WW	AL-Hilla Factory, WW	Environmental limits for industrial wastewater*	Feed water (Iraqi standard)
	value	value		
'urbidity,NTU	26-30	8-12	-----	1-4
TDS mg/l	600-700	1340 - 1350	< 600	700-800
TSS mg/l	200-300	312 - 400	< 60	60-70
pH	7-9	7.9 - 8.5	< 8.5	6.5-8.5
Chloride mg/l	120-140	542 - 550	< 600	003-400 as chlorine
SO_4 mg/l	140-200	410 - 580	< 400	200-250
COD mg/l	120-140	80 - 90	< 100	------
BOD_5 mg/l	15-20	50 - 60	< 40	-------

*Reference 6.

Table(4) Effect of Lime doses on pH values of the wastewater samples with various turbidities (initial turbidity ranging from 6.5-7.5)

Lime dose mg/ l	Turbidity of wastewater			
	Turbidity. 41 NTU	Turbidity 88 NTU	Turbidity 129 NTU	Turbidity 213 NTU
	pH values of treated water			
	pH	pH	pH	pH
10	8.2	8.7	8.5	8.7
20	8.7	9.5	8.9	9.4
30	9.2	10.3	8.6	11.4
40	9.5	10.3	10.7	12.2
50	11.6	10.4	11.5	12.3

Table (5) Effect of lime dose on color removal efficiency of wastewater with various turbidity levels

Lime dose mg/ l	Turbidity of wastewater			
	Turbidity. 41 NTU	Turbidity 88 NTU	Turbidity 129 NTU	Turbidity 213 NTU
	Color removal efficiency			
	Color removal%	Color removal%	Color removal%	Color removal%
10	33.5	30.5	26.8	23.5
20	47.2	43.1	35.5	30.8
30	56.2	54.6	43.3	31.5
40	65.5	63.4	42.5	42.7
50	54.5	43.7	34.2	33.8

TABLE (6) EFFECT OF CATIONIC POLYELECTROLYTE (CPE) DOSE ON COLOR REMOVAL EFFICIENCY WITH VARIOUS TURBIDITY LEVELS

CPE dose mg/ l	Turbidity of wastewater			
	Turbidity. 41 NTU	Turbidity 88 NTU	Turbidity 129 NTU	Turbidity 213 NTU
	Color removal efficiency			
	Color removal%	Color removal%	Color removal%	Color removal%
0.5	**15.5**	**16.7**	**21.2**	**12.5**
0.75	**19.5**	**22.2**	**25.0**	**25.5**
1.0	**30.8**	**35.5**	**38.2**	**37.2**
1.25	**33.6**	**37.8**	**37.4**	**34.6**
1.5	**20.2**	**34.5**	**31.2**	**32.6**

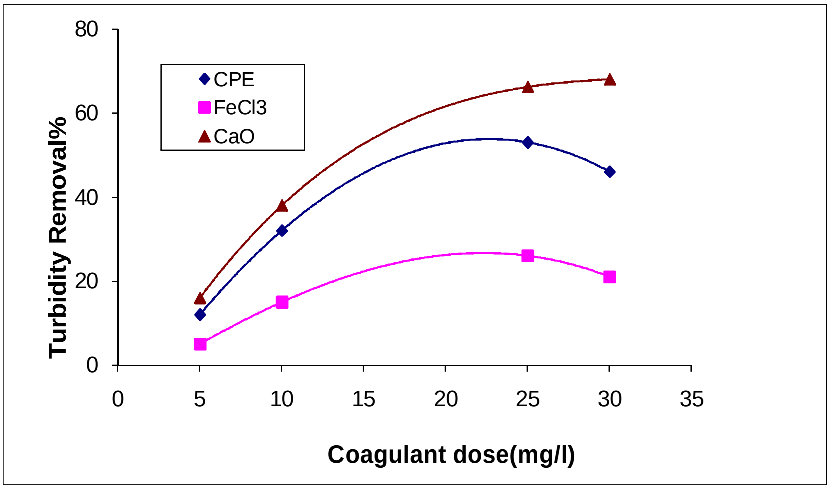


Figure (1) Effect of coagulant type on turbidity removal efficiency of wastewater (initial turbidity 41 NTU)

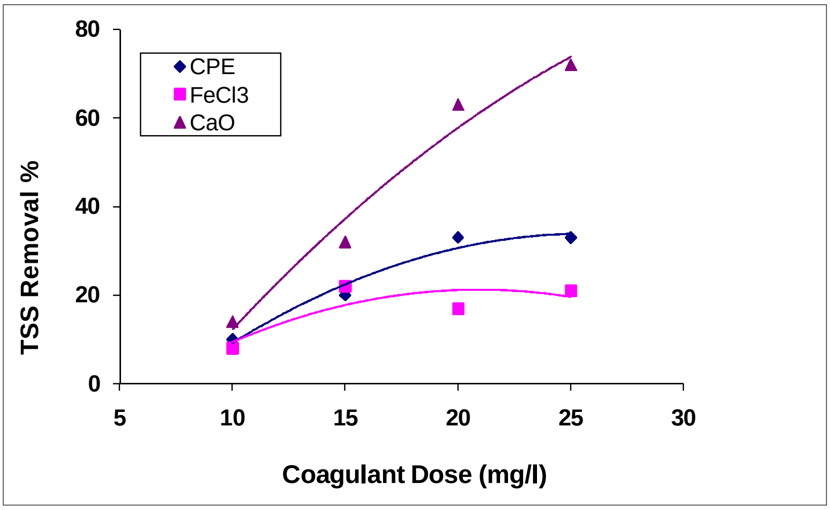


Figure (2) Effect of coagulant type on total suspended solids removal efficiency with different dosages (initial TSS 266 mg/L)

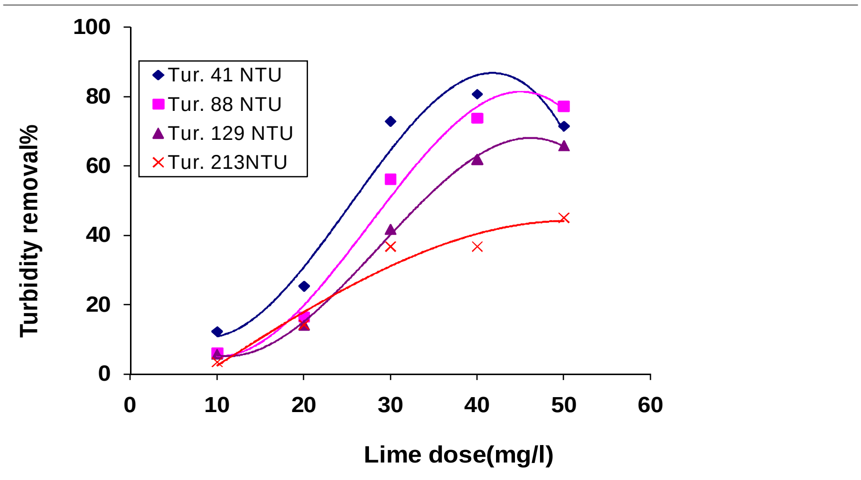


Figure (3) Effect of lime dose on turbidity removal efficiency of several wastewater turbidity level.

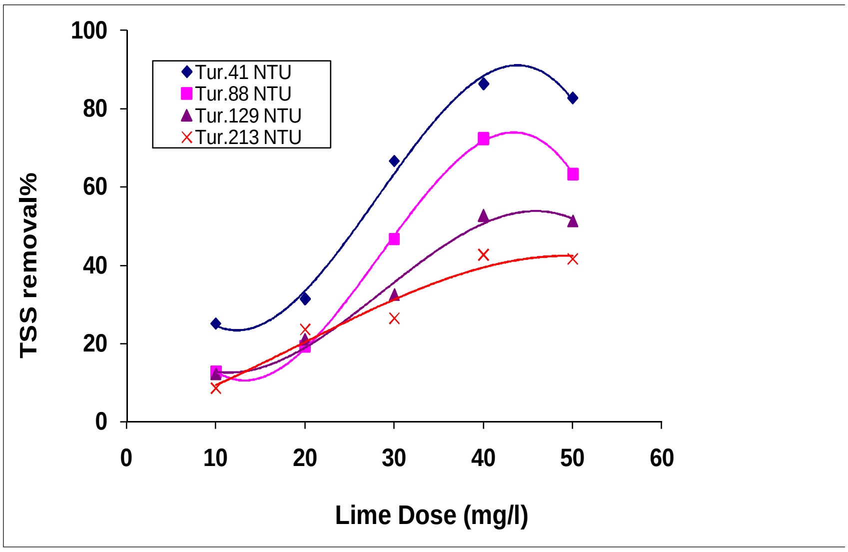


Figure (4) Effect of lime dose on TSS removal Efficiency of several wastewater turbidities

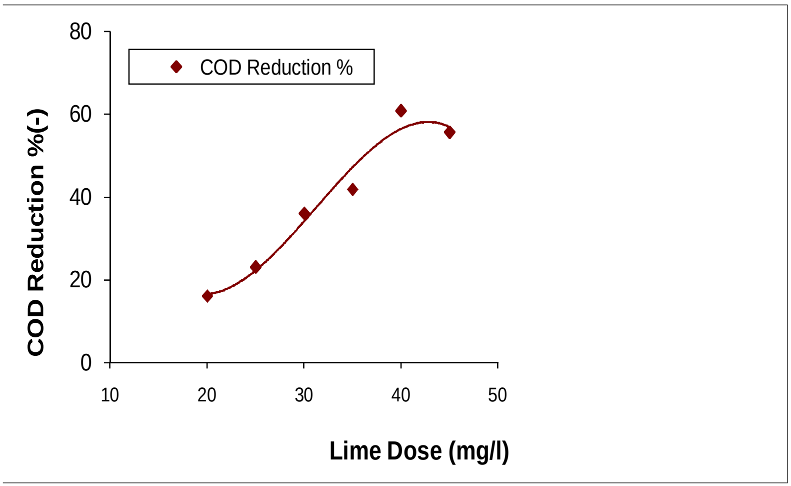


Figure (5) Effect of Lime Dose on COD Reduction Efficiency of Wastewater (initial COD 114 mg/L)

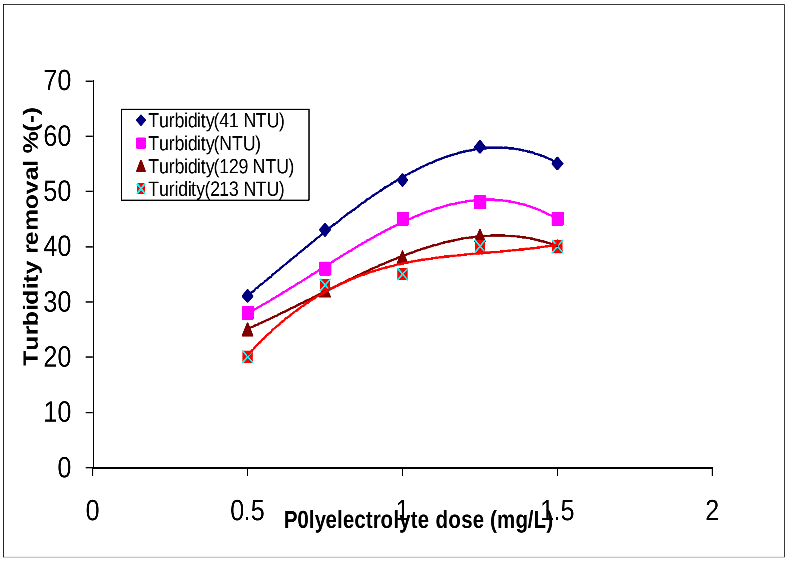


Figure (6) Effect of polyelectrolyte dose on turbidity removal efficiency

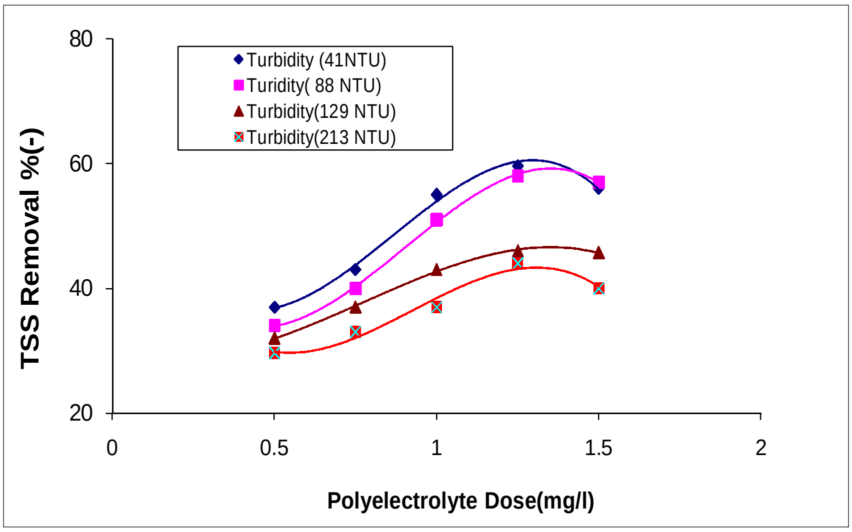


Figure (7) Effect of polyelectrolyte dose on TSS efficiency removal 0f wastewater with different properties

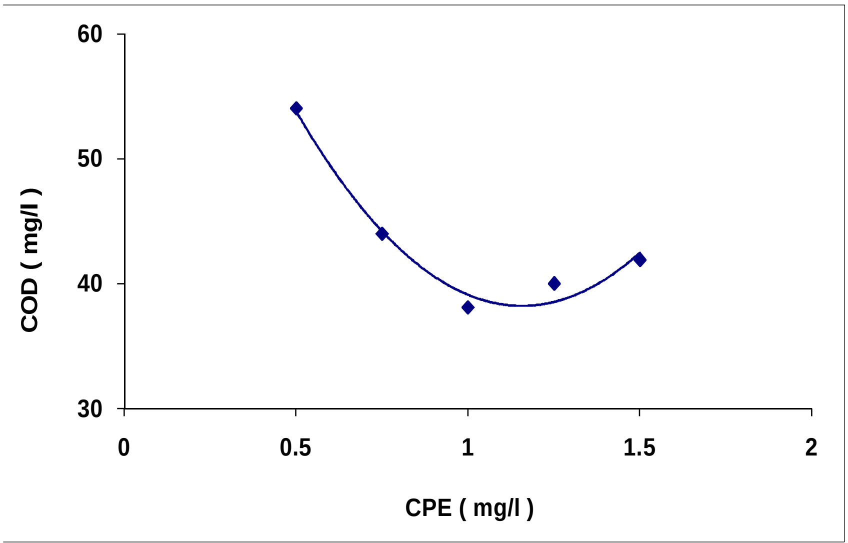


Figure (8) Effect of cationic polyelectrolyte addition on the Residual COD of wastewater with initial COD (114 mg/l)