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Treatment of Paper Industry Wastewater Through Direct Deposition or Triggers Deposition

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Abstract: Industrial wastewater is one of the most important sources of water pollution. This study represents the need to reduce this problem by using different processes, which depends mainly on the use of aluminum sulfate (alum). This study has been at the lab. The bench scale tests were carried out on plain and chemical precipitation on wastewater effluent from Middle East Paper Company (SIMO). The treatment efficiency determined according to BOD, COD and TSS removal. Different doses of alum were examined during this study. The optimum alum dose was 30 ppm. Alum can achieve higher removal efficiency than ferric chloride for the same dosage. Using anionic polymer increases the removal efficiency of BOD, COD and TSS which consequently decrease the optimum alum dose. Other coagulant as ferric chloride was not preferable for wastewater treatment and recycling due to brownish color of the produced water.

Key words: Paper industry · Wastewater · Jar test · TSS · BOD · COD

INTRODUCTION

There are many sources of environmental pollution; one of them is the discharge of the industrial wastewater directly into the water bodies. These effluents cause severe environmental problems when drained in water sources or when drained in public sewer because of its contents of organic and inorganic materials. Pulp and paper industry is one of the major water-intensive chemical process industries. They are significant contributors of pollutant to the environment in the form of black liquor. The effluent from pulp and paper industry contains high organic matter, suspended solids, strong color, biological oxygen demand (BOD) and chemical oxygen demand (COD). The strong blackish color is mainly attributed to the complex compounds derived from polymerization between lignin-degraded products and tannin during various pulping/bleaching operations. Conventionally, the pulp and paper effluent is treated by physical adsorption, chemical oxidation and biochemical methods [1-3]. The raw materials used for the production of paper are, soft woods, hard woods and straws. Among the constituents of wood, in addition to cellulose fibers, there are other natural substances such as tannins, resins and lignins; the latter act as adhesive substances for cellulose fibers in the wood [1]. The goal of pulping is to separate the fibers from the material. The remaining components (hemicellulose and lignin) must be treated and constitute the major potential sources of pollution in chemical pulping. Pulping can be carried out through various processes, which use mechanical, chemical or both mechanical and chemical ways to transform raw material into fibers.

Pulp for packaging material can generally be used without bleaching. For other purposes, it has to be bleached. Additionally, other pollutants are created during the stages of pulping, bleaching and paper production. As an example, the cellulose paste presents an intense brown color caused by the lignin presence, color that has to be removed. In this pulp bleaching process, chlorine was widely used in the paste [1], however the elementary chlorine reaction with lignin and other organic substances generates toxic chlorinated products. In order to minimize the generation of pollutants, other bleaching processes have been developed; processes using chlorine dioxide, oxygen, ozone and hydrogen peroxide are used nowadays [4]. The major part of the residues resulted from the bleaching process (around 90%) is used as energy source because such residues are constituted by rich organic materials – known as black liquor; however the other 10% of residues remain in the water as severe pollutants. The pulp and paper industry is a water-intensive industry and consumes over 60 m^3 of freshwater per ton of paper

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produced [1].About 64% of the total wastewater of the Egyptian Pulp and Paper industry is produced from three mills, e.g.:

- Rakta in Alexandria
- National paper company (NAPA) in Alexandria
- SIMO in Cairo

These mills are public sector companies and they belong to the public so-called "Holding Company for Chemical Industries". There also about small 15 production units for board, tissue, wrapping and packing paper exist in the private sector. The main treatment processes used for pulp and paper mill plants are primary clarification (sedimentation or flotation), secondary treatment (activated sludge process or anaerobic digestion) and/or tertiary processes (membrane processes as ultra filtration) [1].

Physical and chemical processes are quite expensive and remove high molecular weight chlorinated lignins, color, toxicants, suspended solids and chemical oxygen demand. But BOD and low molecular weight compounds are not removed efficiently because an important fraction of the biodegradable organic matter is present as dissolved components [5]. Examples of the methods which are used for wastewater treatment from pulp and paper mills are adsorption [6], wet oxidation [7], ozone treatment [8], chromophores removal via hydrogenation–biological batch reactors [9], color, TOC (total organic carbon) and AOX (adsorbable organic halogens) removals by advanced oxidation processes [10]. In general, several methods have been attempted for removal of color from the pulp and paper mill effluents. Lignin is difficult to degrade biologicallt. Therefore, the effluent from the wastewater treatment system, which is a biological process, still contains a high content of color, lignin and COD [11].Chemical coagulation, using alum, ferric chloride, ferric sulphate and lime have been studied [12, 13].

The biological processes also include different aerobic and anaerobic methods, such as aerated lagoons, the conventional anaerobic completely mixed tank, the anaerobic contact process and the anaerobic ponds. In these processes, their combinations are required in case of discharge of the effluent to the water streams, since generally no single process will provide sufficient effluent treatment. These treatment methods are low rate treatment systems and consequently, the area of land required is large. Investment and operating costs are high and odor nuisance problems are unavoidable particularly with the anaerobic ponds [14, 15].

The main objective of this study is to develop the Middle East Paper (SIMO) Company to be complied with environmental regulations with fiber recovery and water recycling. Therefore, the research in this work will investigate the following:

- Studying the characteristics of effluent wastewater streams resulting from different production processes to determine the maximum influent load to the end of pipe.
- The optimum dosage of mineral salts in chemical precipitation stage which lead to optimum BOD, TSS, COD removal ratios.
- The optimum dosage of mineral salts when plain and chemical precipitations are combined.

MATERIALS AND METHODS

Location and Layout: The Middle East Paper Company (SIMO) is located at Mostorod, Shoubra El Kheima district, about 12 kilometres northeast of Cairo City. Shoubra El Kheima is a major industrial district in Qaloubiya Governorate.

Process Description: The mill has two factories, the Duplex, Heavy gray board factory and the Egg tray factory. The production is about 67 tons/day of different grades of paper and board. The principal fed stock for all products is low grade mixed waste paper and a small amount of virgin fiber.

Plan of Work

Scope: This research presents specification and requirements of the relevant environmental laws applicable to the Middle East Paper Company and to investigate the method of treatment and Recycling the wastewater and fiber recovery.

Samples Collection Points: The influent as well as the effluent sample was composite samples, which were collected during 24 hours of the day. The influent samples were taken 6 times every day.

Sampling and Analytical Methods: Composite samples of raw wastewater and effluents of the different units were collected and analyzed for pH, COD, BOD and TSS. Analyses were carried out according to procedures described by Standard Methods (American Public Health Association APHA) [16].

RESULTS AND DISCUSSION

The research investigates the effect of using different coagulant at different dosage and there effects on the wastewater treatment. The treatment efficiency was evaluated by determining the concentration of biochemical oxygen demand (BOD), the chemical oxygen demand (COD) and the total suspended solids (TSS) in the wastewater and the treated effluents.

The Variation in Ph Values in Different Line: Fig. 1 represents the variation in pH values according to time intervals. This diagram shows the variation in pH values if the operation of the production line one or more. By increasing the pH of duplex stream, gets the same results in presence of egg tray. Also, increasing in pH values recommended in presence of the above line with heavy gray board but this value less than which obtained in each line individual due to the acidity behaviors of the wastewater with using heavy gray board. The later results recommend in this diagram, which represented the variation in pH in heavy gray board stream only or with egg tray.

The Variation in Tss Values in Different Line: Fig. 2 represents the variation in TSS values according to time intervals under the above condition. This relation represent slightly change in TSS values with time which

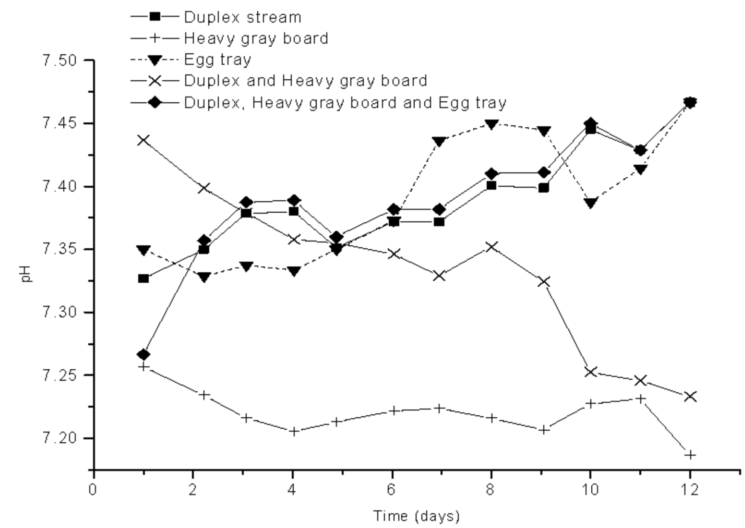

Fig. 1: The relation between pH and interval times in presence of production line one or more

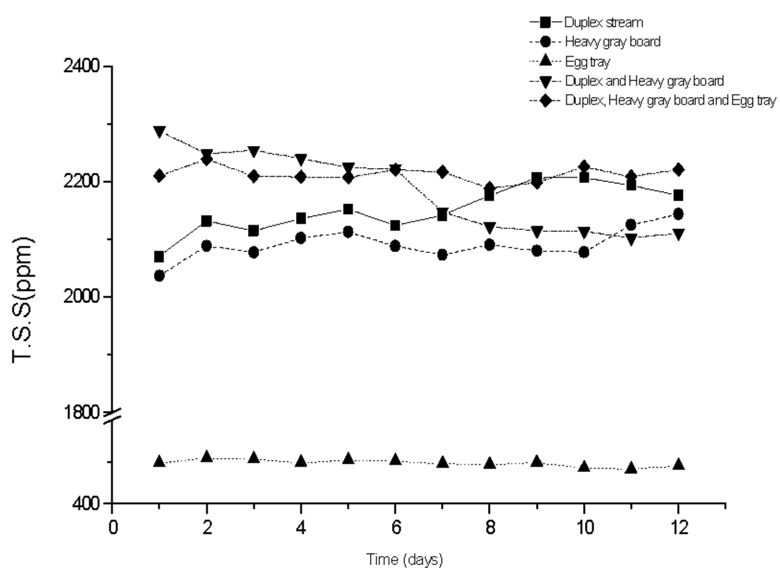

Fig. 2: The relation between TSS and interval times in presence of production line one or more

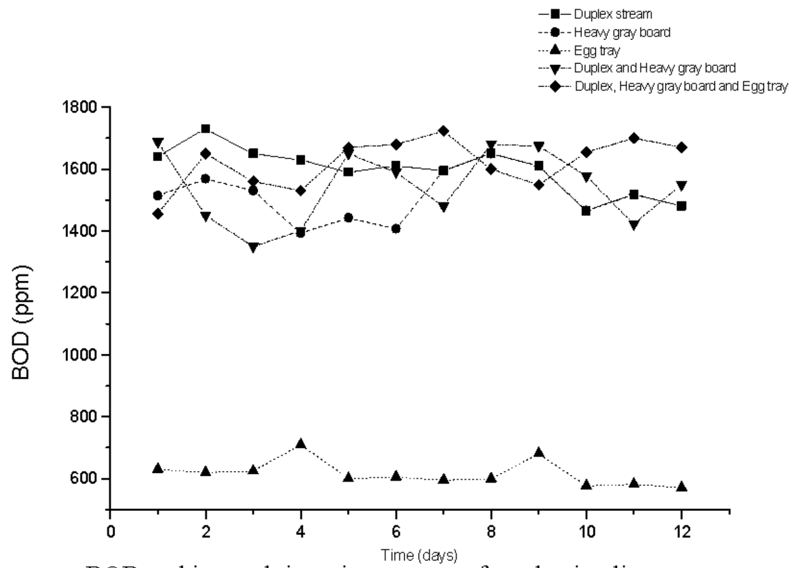

Fig. 3: The relation between BOD and interval times in presence of production line one or more

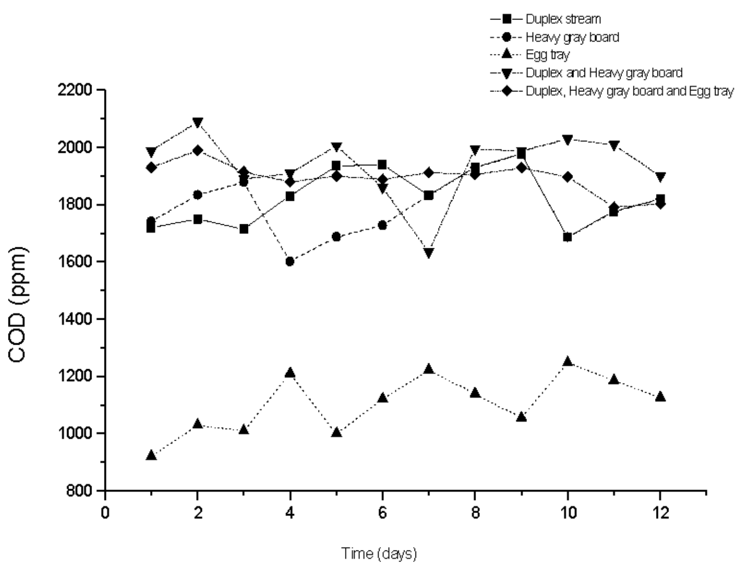

Fig. 4: The relation between COD and interval times in presence of production line one or more

pointing to the stability of residual particles at different time. This behavior noted in all line but TSS record large different in presence of egg tray. This result obtained due to reduce in suspended particles which produce during the production. Also, the result show reducing in TSS values in presence of individual production line which increases due to the cooperation between each line. The above comment represents the compilation properties of TSS in this case. Findings suggest the need for a treatment of industrial wastewater.

The Variation in BOD, COD Values in Different Line: Fig. 3 represents the variation in BOD values according to time intervals under the above condition. Generally, the results of BOD were found to be in a good correlation with TSS trend. This behavior noted in all line but BOD record large different in presence of egg tray. This result obtained from the oxygen consumption due only to reduction in carbonaceous oxidation in suspended particles that produced during the production. Also, the results show that reducing in rate of oxygen in the presence of individual production line which increases due to the cooperation between each line. This result stresses the above result in TSS.

Fig. 4 represents the variation in COD values according to time intervals. All results get the same

Table 1: The variation in TSS, BOD and COD at 30 minutes lasted about 3 days.

	TSS			BOD			COD		
	mg / L		%	mg / L		%	mg / L		%
Jar No.	Inf.	Eff.	η	Inf.	Eff.	η	Inf.	Eff.	η
1	2120	430	80	1688	590	65	1988	990	50
2	2165	450	79	1579	620	61	1992	1010	49
3	2200	478	78	1650	623	62	1845	1050	43
Aver.	2162	453	79	1639	611	63	1942	1017	48

behavior in both BOD and TSS. This result represented the amount of organic compound in water. And this result strongly recommended the highly degree of pollution in wastewater which produce during this process industrial.

Treatment of Wastewater According to Plain Sedimentation: Table 1 carried out in one run for plain sedimentation at 30 minutes lasted about 3 days. The result shows the TSS, BOD and COD. The run had minimum and maximum values of TSS were 430 mg/L and 478 mg/L with an average 453 mg/L The removal efficiency of TSS ranged between 77% and 80% with average value 79% for the last 3 days. BOD were 590 mg/L, 623 mg/L with an average 611 mg/L, the removal efficiency of BOD ranged between 60% and 63% with average value 63% for the last 3 days. COD were 990 mg/L and 1050 mg/L with an average 1017 mg/L, the removal efficiency of COD ranged between 39% and 49% with average value 48% for the last 3 days and pH were 7.1, 7.2 with an average of 7.17. From the previous results we can deduce that the result of plain sedimentation compliance with discharge regulation into the sewage network.

Treatment of Wastewater According to Alum Dosage: Figs. 5-7 represent the removal efficiency of TSS, BOD and COD by using alum at different dosage rates. Generally the removal efficiency increased by increasing the alum dosage getting the maximum values at 30 ppm. But the efficiency was decreased at higher doses of alum. AT 30 ppm, the removal efficiency of TSS was found to by high and the values recorded between (98% to 99%). The above values repeated in determination of the removal efficiency of BOD and COD. In fact, the variation in pH are noted and the values get the above results obtained at pH=7.13.

Treatment of Wastewater According to Alum Dosage in Presence of Polymer: These runs determined at the same condition in determination of alum dosage but that occur in presence of polymer. Figs. 8-10 represent the removal efficiency of TSS, BOD and COD by using alum and polymer. Firstly, the results show the same pattern without polymer. While the efficiency for removing BOD and COD decreases in presence polymer. This behavior very interesting due to the inhibition effect of polymer especially in presence of organic pollution. Also, the efficiency increases with increasing the polymer dosage.

Treatment of Wastewater According to Ferric Chloride: Figs.11-13 represents the removal efficiency of TSS, BOD and COD by using ferric chloride at different doses. Generally, the removal efficiency increases with increasing the ferric chloride concentration reaching maximum value at 45 ppm. The efficiency of ferric chloride for removing TSS reaches 96%. On the other hand, the BOD removal efficiency was about 88%. The effect of ferric chloride increases in presence of organic compound which react directly and the product rapidly precipitate. This reaction increases the efficiency of ferric chloride. So that COD recorded removal percent reach to 94%. The variations in pH were noted and the values get the above results at pH=7.1. But the quality of the effluent was not good and cannot be used for recycling because it makes a color with water.

Effect of Plain Sedimentation with Alum Treatment: The treatment occurs using plain sedimentation then combination between 10 ppm alum lasted about 3 days. Table 2 shows the efficiency of both plain sedimentation and alum treatment. The results show increases in the efficiency for removing TSS with increasing of alum dosage. This behavior repeated in COD and BOD but with different ratio. In fact, this result gets very important note which pointing to the slightly effect of plain sedimentation in the removal efficiency of each factor. So that, this method must be considered according to the cost of sedimentation.

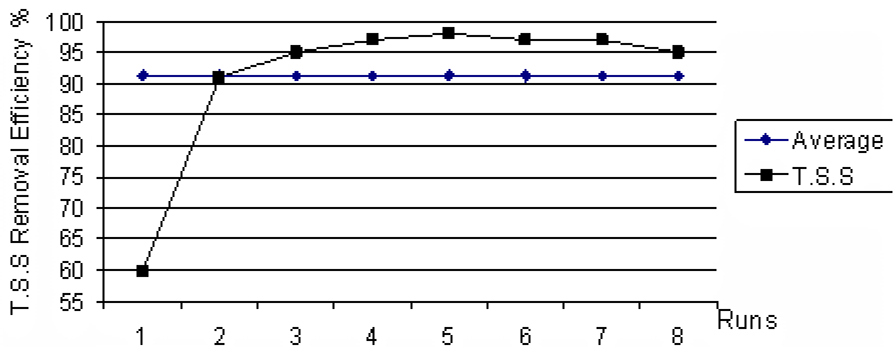

Fig. 5: Removal efficiency of alum at different dosage according to T.S.S

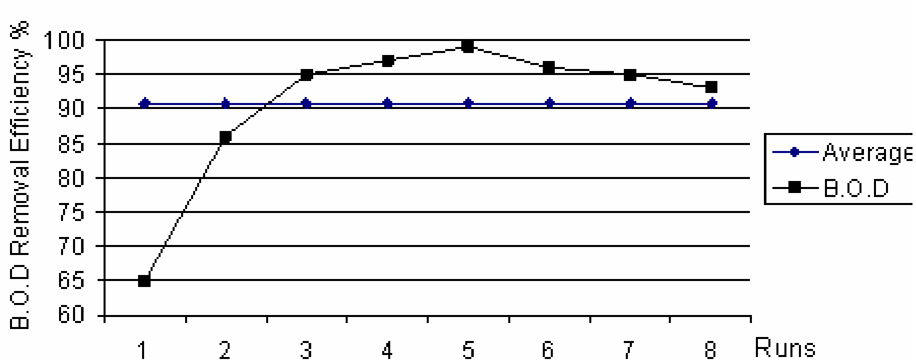

Fig. 6: Removal efficiency of alum at different dosage according to B.O.D

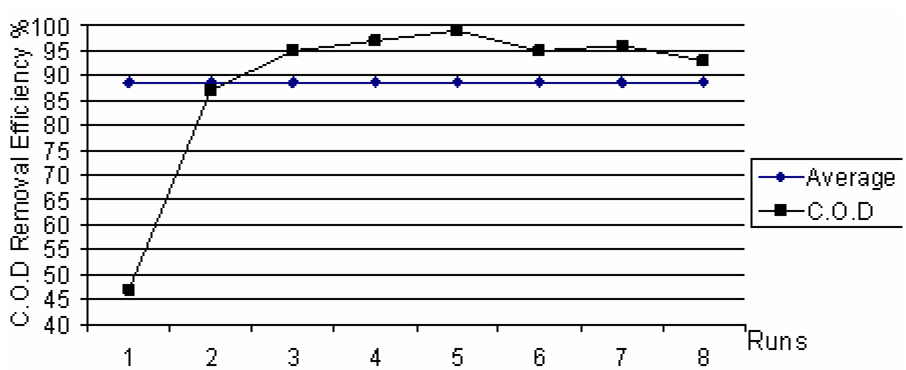

Fig. 7: Removal efficiency of alum at different dosage according to C.O.D

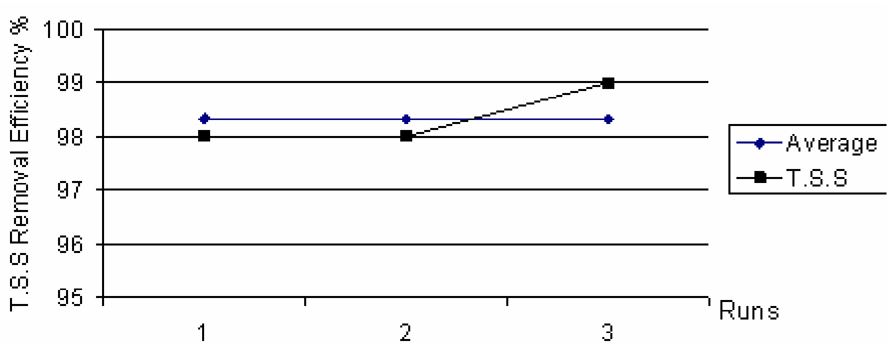

Fig. 8: Removal efficiency of alum and polymer at different dosage according to T.S.S

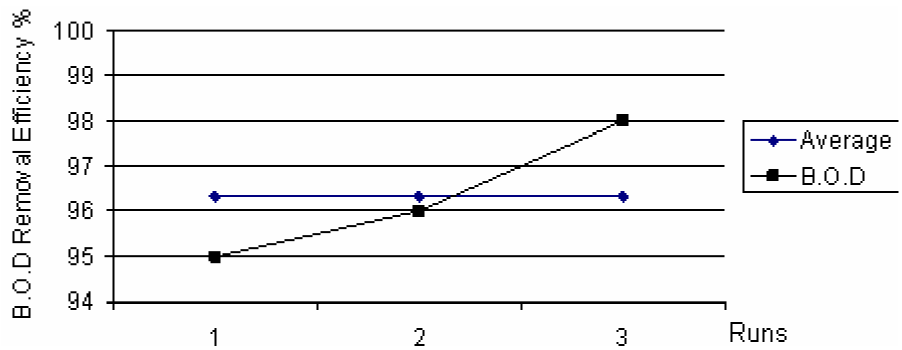

Fig. 9: Removal efficiency of alum and polymer at different dosage according to B.O.D

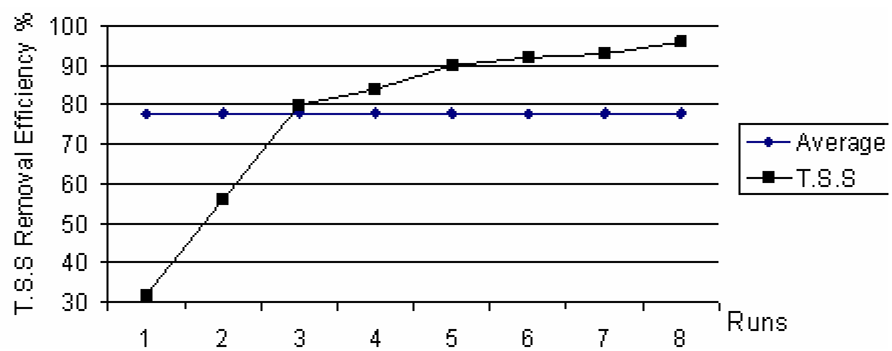

Fig. 10: Removal efficiency of alum and polymer at different dosage according to C.O.D

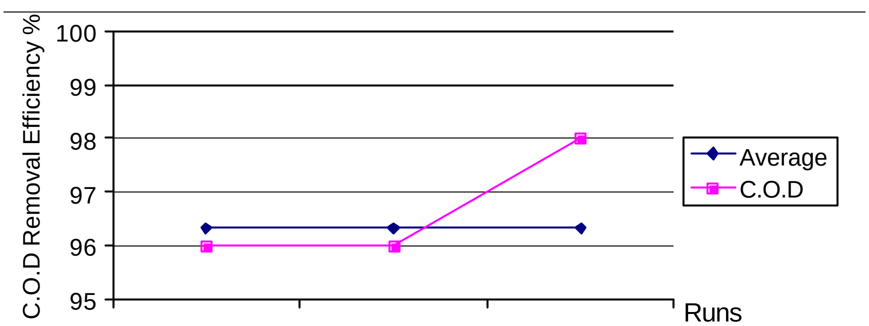

Fig. 11: Removal efficiency of ferric chloride at different dosage according to T.S.S

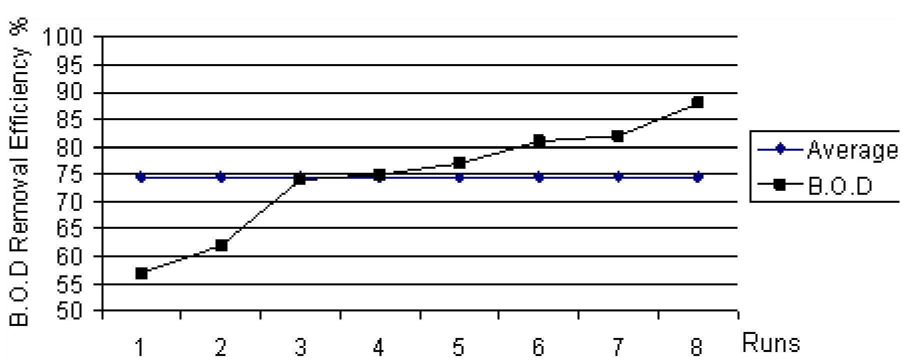

Fig. 12: Removal efficiency of ferric chloride at different dosage according to B.O.D

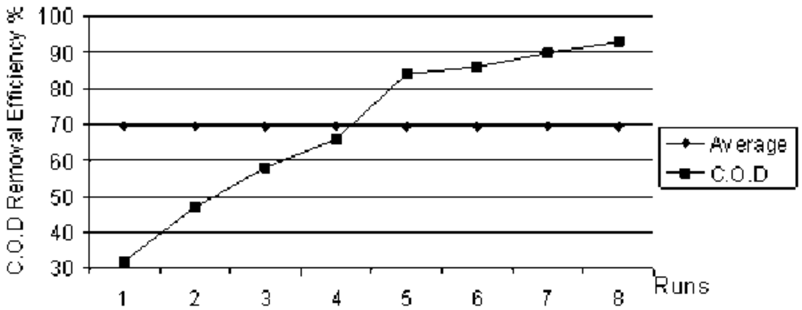

Fig. 13: Removal efficiency of ferric chloride at different dosage according to C.O.D

Table 2: the variation in TSS, BOD and COD at 30 minutes lasted about 3 days in presence of plain sedimentation and different alum dose.

		TSS			BOD			COD		
		mg / L		%	mg / L		%	mg / L		%
Alum dose	Jar No.	Inf.	Eff.	η	Inf.	Eff.	η	Inf.	Eff.	η
Alum dose 10ppm	1	2120	45	98	1688	49	97	1988	85	96
	2	2165	50	98	1579	45	97	1992	80	96
	3	2200	48	98	1650	48	97	1845	88	95
	Aver.	2162	48	98	1639	47	97	1942	84	96
Alum dose 15ppm.	1	2120	25	99	1688	32	98	1988	52	97
	2	2165	23	99	1579	30	98	1992	49	98
	3	2200	27	99	1650	33	98	1845	50	97
	Aver.	2162	25	99	1639	32	98	1942	50	97
Alum dose 20ppm.	1	2120	12	99	1688	21	99	1988	30	98
	2	2165	15	99	1579	20	99	1992	33	98
	3	2200	20	99	1650	25	98	1845	27	99
	Aver.	2162	16	99	1639	22	99	1942	30	98

Table 3: the variation in TSS, BOD and COD at 30 minutes lasted about 3 days in presence of plain sedimentation and different alum dose and polymer.

		TSS			BOD			COD		
		mg / L		%	mg / L		%	mg / L		%
Items	Jar No.	Inf	Eff.	η	Inf.	Eff	η	Inf	Eff.	η
10 mg/L alum and 0.1mg/L polymer	1	2120	41	98	1688	49	97	1988	83	96
	2	2165	45	98	1579	45	97	1992	81	96
	3	2200	48	98	1650	48	97	1845	85	95
	Aver.	2162	45	98	1639	47	97	1942	83	96
15 mg/L alum and 0.2mg/L polymer	1	2120	28	99	1688	31	98	1988	66	97
	2	2165	25	99	1579	30	98	1992	70	96
	3	2200	27	99	1650	34	98	1845	64	97
	Aver.	2162	27	99	1639	32	98	1942	67	97
20 mg/L alum and 0.3mg/L polymer	1	2120	23	99	1688	29	98	1988	35	98
	2	2165	25	99	1579	24	98	1992	31	98
	3	2200	22	99	1650	27	98	1845	28	98
	Aver.	2162	23	99	1639	27	98	1942	31	98

Effect of Plain Sedimentation with Alum and Polymer Treatment: This treatment occurs in presence of plain sedimentation then combination between 10 ppm alum lasted about 3 days. Table 3 shows the efficiency of both plain sedimentation and alum and polymer treatment. The results must be compared with above table which presents the negative effect of polymer especially in COD; this variation may be related to the degradation of polymer which increases the amount of COD this result pointing to the harmful effect of polymer with the plain sedimentation. Generally, increase in the efficiency to remove TSS with increasing of alum dosage is noted. This behavior repeated in COD and BOD but with different ratio.

CONCLUSIONS

In conclusion the most important finding in this study can be summarized as follows:

- The effluent of Duplex, heavy gray and egg tray were not in compliance with discharge regulation into the sewage network, also the analysis of duplex and heavy gray together. The egg tray was compliance with discharge regulation into the sewage network and not effect in additional with duplex and heavy gray to decrease the removal of TSS, BOD and COD and also increase the discharge without any effect. For this reason we take the influent of duplex and heavy gray in this research.
- From jar test we choose the optimum dosage of chemicals and the best. Using plain sedimentation then used chemical alum and polymer with different dose more effective than using chemicals only.

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