Journal Homepage: - www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

ISSN NO. 2320-5407

Article DOI: 10.21474/IJAR01/3486
DOI URL: http://dx.doi.org/10.21474/IJAR01/3486

RESEARCH ARTICLE

DEGRADATION OF TEXTILE INDUSTRY'S EFFLUENT USING INTEGRATED CHEMICAL-BIOLOGICAL PROCESS.

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Manuscript Info

Manuscript History

Received: 06 January 2017
Final Accepted: 04 February 2017
Published: March 2017

Key words:-
textile, effluent, coagulation, flocculation, activated sludge.

Abstract

Interest in ecologically friendly, wet-processing textile techniques has increased in recent years because of increased awareness of environmental issues throughout the world. With more stringent controls and more demand in environmental friendly product expected in the future, it is essential that control measures be implemented to minimize effluent problems. The textile dyeing industry consumes large quantities of water and produces large volumes of wastewater from different steps in the dyeing and finishing processes. Wastewater from printing and dyeing units is often rich in color, containing residues of reactive dyes and chemicals, and requires proper treatment before being released into the environment. The goal of this research was to study the performance of the integrated chemical (coagulation-flocculation)-biological (activated sludge) process and to develop a potential textile industry's wastewater treatment system for reuse. The results show that coagulation-flocculation process (optimum coagulant of 10 mg/l FeSO4) was effective enough in removing color while activated sludge process effective in removing other organic materials contain in the effluent. Integrated chemical-biological process to treat textile effluent was able to remove organic with an efficiency of 71 - 91 %. Re-use of this kind of wastewater than to discharge it after treatment are preferably due to increase in the costs of chemicals, energy and water consumption.

Background:-

The textile and clothing industry in Indonesia played a significant role in the national economy. In 2006, this industry contributes 11.7% to the total national exports, 20.2% of the national trade surplus, and 3.8% to the formation of Gross Domestic Product (GDP). This industry employs about 1.84 million workers and the lives of many Indonesian families are connected with the textile industry (agriculture, trade and services). Until year 2006, the number of Indonesian textile industry reached 2,699 companies, with a total investment of 135.7 trillion rupiah. This number is only slightly increases over the previous year, amounting to 2,656 companies. Textile industry is concentrated in West Java (57%), Central Java (14%), and Jakarta (17%). The rest are scattered in East Java, Bali, Sumatra and Yogyakarta [1]. The textile industry consumes large quantities of water and produces large volumes of

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wastewater from different steps in the dyeing and finishing processes. These problems may occur during the production processes which usually require the input of a wide range of chemicals and dyestuffs, which generally are organic compounds of complex structure. Because all of them are not contained in the final product, they became waste and require proper treatment before being released into the environment. Major pollutants in textile wastewaters are high suspended solids, chemical oxygen demand, heat, color residues of reactive dyes and chemicals, acidity, and other soluble substances [2]. Effective and economic treatment of a diversity of textile effluents containing color has become a problem. No single treatment system is adequate for degrading the various dye structures. Currently, much research has been focused on chemically and physically degrading color dyes in wastewaters. These methods include chemical oxidation, which uses strong oxidizers such as hydrogen peroxide or chlorine dioxide. Chemical oxidation is sometimes coupled with UV light exposure to increase the color removal. Other techniques involve electrochemical or wet oxidation, activated carbon adsorption, reverse osmosis, or coagulation/flocculation. Many of these technologies are cost prohibitive, however, and therefore are not viable options for treating large waste streams [3]. To ensure the safety of effluents, proper technologies need to be used by treatment facilities when degrading fiber-reactive dyes. Many research efforts have focused on various biological, chemical, and physical techniques for treating dye wastes. There is evidence that all three areas have potential for remediating textile industry wastes. However, chemical treatment is often cost and application limited, while physical removal can lead to extra solid wastes and increased overhead. Biological treatment has been effective in reducing textile industry effluents, and when used properly has a lower operating cost than other remediation processes. Combinations of chemical and biological or physical and biological treatment have also proven to be effective. The primary objective of this study was to determine the best way to increase the color-reducing efficiency of the textile industry's effluent and to develop a potential textile industry's wastewater treatment system for reuse.

Materials and Methods:-

Wastewater used in this research was obtained from a synthetic textile dyeing factory located in the Nanjung industrial complex in Bandung, West Java. The characteristics of textile wastewater are showed in **Table 1**. Its average BOD, COD, pH, Ammonia, Oil&Grease and conductivity were 160 mg/l, 314 mg/l, 7.81, 4.46 mg/l, 16 mg/l and 5060 umho/cm, respectively. The combined process for textile wastewater treatment consists of chemical coagulation and flocculation pre-treatment followed by biological activated sludge treatment. Biological treatment was conducted in a 15 l reactor (10 1 working volume) as described in **Figure 1** and 2000 mg/l of mixed liquor suspended solids (MLSS) were inoculated into the reactor. This reactor was equipped with a diffused aeration device at the bottom of the reactor. The wastewater was continuously fed to the reactor using peristaltic pumps with a desired flow rate. Chemical coagulation and flocculation were conducted in batch mode act as pre-treatment before biological treatment step. Jar-test at the laboratory scale was carried out in order to choose the adequate coagulant and the reaction condition (pH, dosage). $Al_2(SO_4)_3$, poly-aluminum chloride (PAC), $FeSO_4$ were tested as chemical coagulant candidates. One normal H_2SO_4, NaOH solution was added to adjust pH of the solution to the desired value. Chemical coagulant was added and mixed for 2 min under rapid mixing condition (200 rpm) and the solution was mixed at slow flocculation (40 rpm) for 15 min after rapid mixing. And then, COD, SS, and pH of supernatant were measured after settling for 30 min. Standard methods [4] were used for the estimation of MLSS, COD, H_2S, Ammonia.

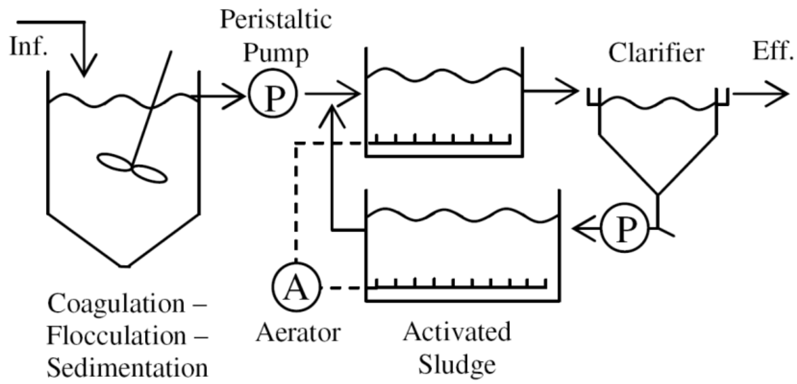


Figure 1 :- Reactor configuration schematic.

Results and Discussion:-

The raw textile wastewater samples were obtained from a large synthetic textile dyeing factory located in the Nanjung industrial complex in Bandung, West Java. The textile products processed in this plant were made primarily of cotton, linen and polyester fibers and small quantity of silk. According to the operational personnel, no less than 10 different kinds of dyes were used in the dyeing and finishing mill during the half-year period of this experimental study. Therefore tracking of the kind of dyes employed every day was virtually impossible because no record was kept at the mill. In general, the wastewaters had a BOD within the range between 125 and 172 mg/l, while COD within the range 281 and 315 mg/l. BOD:COD ratio of these wastewater within the range between 0.4-0.5 are quite biodegradable to biological process.

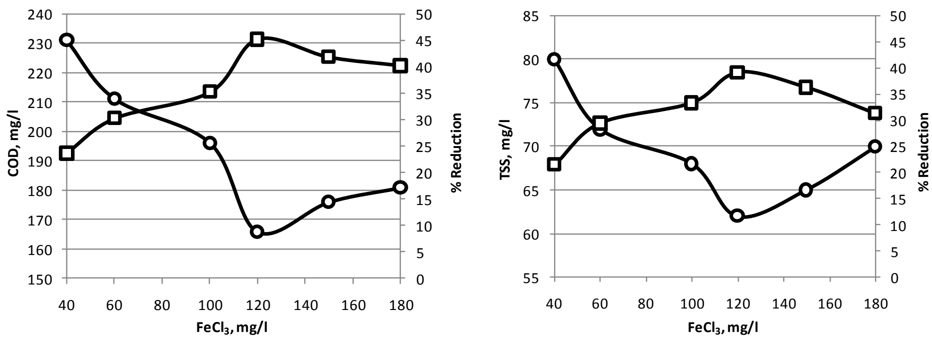
Table 1:- Characteristics of textile wastewater.

Parameters	Unit	Sample 1	Sample 2	Sample 3	Standard*
BOD	mg/l	160	125	172	60
COD	mg/l	314	281.6	315	150
TSS	mg/l	8	102	55	50
Phenol	mg/l	0.16	0.214	n.d	0.5
Cr Total	mg/l	0.008	0.088	n.d	1
Ammonia	mg/l	4.46	11.6	0.99	8
H_2S	mg/l	28	0.325	n.d	0.3
Oil & Grease	mg/l	16	12.4	4	3
Conductivity	us/cm	5060	4280	5300	-
pH	-	7.81	7.38	7.29	6-9

* Governor of West Java Decree No. 6, Year 1999; n.d.: no data

Conclusion:-

Studies on the effects of the optimum coagulant, dosage and pH are conducted in order to investigate the sorption capacity of coagulant in flocculation process. Since the Chemical Oxygen Demand (COD) level in wastewater from textile industry is considered as the most important parameter, so it has been used as the indicator on the sorption capacity of coagulant in these experiments by supporting with other parameter which is turbidity as total suspended solid/TSS. The jar test results showed that among others coagulant, $FeCl_3$ was the best coagulant for reducing organic in wastewater tested (performance data for $Al_2(SO_4)_3$ and PAC not shown in this report). $FeCl_3$ performance were presented in **Figure 2(a)** which showed the effects of coagulant (FeCl3) dosage on COD level and the percentage of COD levels reduction. While **Figure 2(b)** showed the effects of coagulant dosage on turbidity levels and the percentage of turbidity levels reduction. From the jar test experiment, the curves for the both graphs were in the U-shape form for the condition of COD level and turbidity level versus coagulant dosage.



(A) (B)

Figure 2 :- Effect of FeCl3 dosage on (a) COD level (open circle) and the percentage (open square) of COD level reduction, (b) turbidity level as TSS (open circle) and the percentage (open square) of TSS level reduction

In wastewater treatment using metallic coagulants, pH plays a very important role in determining coagulation efficiency. Therefore, experiments were designed to determine the optimum pH for textile wastewater that allowed for maximum COD reduction and de-colorization. The effect of pH on the treatment efficiency was examined using optimum amount of coagulant at various pH conditions (4, 6, 8, 9, 10, 11, and 12). Lime and H_2SO_4 was used to adjust the desire pH. It is well known that pH affects the molecular structure of the dyes, which changes the absorbance of the solution. Optimum pH for COD reduction and de-colorization found within the range between 6 to 9. The optimum conditions for chemical coagulation flocculation process for pretreatment of textile wastewater are as follows: $FeCl_3$ coagulant with 120 mg/l dose with pH value 6-9. Pre-treated textile wastewater (with chemical coagulation process) then use as influent for biological (activated sludge) process for further treatment of wastewater (**Figure 1**). During operation, the DO concentration in the reactor was kept at 3 to 4 mg/l, MLSS was maintain at 2000-3000 mg/l and stable COD reduction were achieved after 2 d. In this case, about 72.9% of COD was removed. Other waste constituents like ammonia were reduced to 84%, phenol was reduced to 92% and oil&grease was reduced to 74% (**Table 2**). In addition, the result of COD removal capability in this study was compared with other similar combined processes for textile wastewater treatment as shown in **Table 3**. Two treatment operations comprised coagulation and activated sludge process, while the other comprised activated sludge followed with coagulation process.

Table 2:- Characteristics of textile wastewater after treatments

Parameters	**Unit**	**Influent**	**Coagulation eff.**	**Activated sludge eff.**	**Removal efficiency**
BOD	mg/l	152.3	70	36	76.3 %
COD	mg/l	303.5	165.9	82	72.9%
TSS	mg/l	55	32	23	58.2%
Phenol	mg/l	0.187	0.157	0.014	92%
Cr Total	mg/l	0.048	0.092	n.d	-
Ammonia	mg/l	5.68	10.2	0.909	84%
H_2S	mg/l	14.16	0.349	n.d	-
Oil & Grease	mg/l	10.8	8.8	2.81	74%
Conductivity	us/cm	4880	4310	n.d	-
pH	-	7.49	7.12	6.8	-

n.d.: no data

Table 3:- Comparison of the COD removal of textile wastewater treatment.

COD value after each individual process, mg/l				
Influent	**Stage I**	**Stage II**	**Total reduction, %**	**Ref.**
900	Chemical coagulation 600	Activated sludge 120	86.6	[5]
870	Activated sludge 272	Chemical coagulation 100	88.5	[6]
	Chemical coagulation	Activated sludge		[7]

694	391	236	65.9	
303	Chemical coagulation 165	Activated sludge 82	72.9	This study

The characteristic of wastewater discharged from textile industrial activities was strictly controlled by government. This was basically due to the wastewater from textile industry was contaminated with a complex set of oxygen demanding materials and poses a great problem to natural environment. As a result, the wastewater from textile industry was treated by using chemical via coagulation and flocculation processes followed with biological activated sludge for further treatment of textile wastewater. The goals of this study are multifold. It aims at enabling the textile industry to treat and reuse the wastewater from its operations using a simple and feasible technology (best available technology). It also aims at preventing the pollution that results from textile industries to the receiving water body and saving significant quantities of water for other domestic uses. In this point of view, the choice of studied technologies was kept to the simplest level to make it easy for the textile industry to accept and implement it.

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