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A Study on the Effect of Textile Effluents and Best Effective Effluent Treatment Plant in Bangladesh Textile Industry

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Abstract

Textile Effluents are unavoidable in most of the Textile Production. Despite having proper treatment of these effluents many people are severely affected by cancer, skin diseases, allergy, and respiratory problems. It also has adverse impact on animal, fish, plant growth and soil chemistry. Present study aimed to find more cost effective and eco safe treatments of textile effluents. In this study we report a comparison and analyze the performance between different ETP methods i.e. Physico- chemical, biological activated sludge method, combined physyco-chemical and biological method according to many testing parameters. We find Biological treatment method as best among them in economic, efficiency and ecologic perspective. Biological effluent treatment plant (ETP) optimizes effluent generation and toxicity of dye house. It needs less chemical cost as well as total running cost. We find that only Biological ETP can satisfy discharging standard as owners are very much interested to run it 24 hours in 365 days for additional economic benefits.

Keywords: Textile Effluents, ETP, Testing parameters, Discharging standard, Economic benefits.

"1. Introduction"

Textile Effluents are the stream of excess chemical liquor extracted from textile industry after using in original operations like pretreatments, dyeing and finishing. The risk factors of textile effluents are primarily associated with the wet processes - scouring, desizing, mercerizing, bleaching, dyeing and finishing that produce large quantities of wastewater. The major chemical pollutants present on textiles are dyes containing carcinogenic amines, toxic heavy metals, pentachlorophenol, chlorine bleaching, halogen carriers, free formaldehyde, biocides, fire retardants, and softeners. Heavy metals used as oxidizing agents, as metal complex dyes, dye stripping agents, fastness improvers, and finishers (water repellents, flame retardants, anti-fungal and odor preventive agents) are not only poisonous to humans but also found toxic to aquatic life (WHO, 2002) and they may result in food contamination (Novick, 1999). Dyeing process usually contributes chromium, lead, zinc and copper to wastewater. Copper is toxic to aquatic plants at concentrations below 1.0 mg/l while concentration nears this level can be toxic to some fish (Sawyer and McCarty, 1978). Studies indicate that effluents have harmful effects on a wide variety of aquatic organisms. Table 1 represents the effluent characteristics from textile industry. Experiment shows that the presence of metals and other dye compounds in textile effluents inhibit microbial activity, damages of organs, disorders in the respiratory tract and lung diseases, dysfunction of the heart and blood producing organs, disorders in the nervous system, skin diseases, and abnormalities in fertility and pregnancy are reported. Contaminated air, soil, and water by effluents from the industries are associated with heavy disease burden (WHO, 2002) and this could be part of the reasons for the current shorter life expectancy in the country, (WHO, 2003) when compared to the developed nations.

Effluent can be treated in a number of different ways depending on the level of treatment required. These levels are known as preliminary, primary, secondary and tertiary (or advanced). The mechanisms for treatment can be divided into three broad categories: physical, chemical and biological, which all include a number of different processes like Physico- chemical, biological activated sludge method, combined physico-chemical and biological method.

Several pollutants in Textile effluent can be removed with the help of an effluent treatment plant (ETP). Effluent from textile dyeing industries must meet the national effluent discharge quality standards set by the Government of Bangladesh, including the "Quality Standards for Classified Industries" (Tables 2 and 3), and may also need to meet additional standards set by international textile buyers. Consequently any ETP must be designed and operated in such a way that it treats the wastewater to these standards. Some others information are needed for planning an ETP. They are volume of the effluent, chemical cost & concentration, any plan to increase production, if any increase to the amount of effluent to be treated, affordability to spend on constructing & running ETP, availability of the land for ETP, ETP expert or designer, best suited plant, capacity in the factory to manage ETP, requirement of hiring and training staff. Present research will help textile industry personnel to select the most suitable, profitable and eco-friendly ETP considering above factors.

Table 1. Effluent characteristics from textile industry

Process	Effluent Composition	Nature of pollution
Sizing	Starch, waxes, Carboxymethyl cellulose (CMC), Polyvinyl alcohol (PVA), wetting agents.	High in BOD, COD
Desizing	Starch, CMC, PVA, fats, waxes, pectin.	High in BOD, COD, SS, dissolved solids (DS)
Bleaching	Sodium hypochlorite, C12, NaOH, H_20_2, acids, Surfactants, $NaSi0_3$, sodium phosphate, short cotton fiber.	High alkalinity, high SS
Mercerizing	Sodium Hydroxide, Cotton wax	High pH, low BOD, high DS
Dyeing	Dyestuffs urea, reducing agents, oxidizing agents, Acetic acid, detergents, wetting agents.	Strongly coloured, high BOD, DS, low SS, heavy Metals,
Printing	Pastes, urea, starches, gums, oils, binders, acids, thickeners, cross-linkers, reducing agents, alkali.	Highly coloured, high BOD, oily appearance, SS slightly alkaline, low BOD

Source: AEPA (Australian Environmental Protection Authority, 1998).

Table 2. National Standards - Waste Discharge Quality Standards for Industrial Units and Projects (quality standard at discharge point)

Parameter	Unit	Inland surface water	Public sewer secondary treatment plant	Irrigated land
Ammoniacal Nitrogen(N molecule)	mg/l	50	75	75
Ammonia(free ammonia)	mg/l	5	5	15
Arsenic	mg/l	.2	.5	.2
$BOD_5$200C	mg/l	50	250	100
Boron(B)	mg/l	2	2	2
Cadmium(Cd)	mg/l	.005	.5	.5
Chloride(Cl^-)	mg/l	600	600	600
Chromium	mg/l	.5	1	1
COD	mg/l	200	400	400
Copper(CU)	mg/l	.5	3	3
Dissolved Oxygen(DO)	mg/l	4.5-8	4.5-8	4.5-8
Electrical Conductivity		1200	1200	1200
Total Dissolved Solids(TDS)	mg/l	2100	2100	2100
Fluoride(F)	mg/l	7	15	10
Sulfide(S)	mg/l	1	2	2
Iron(Fe)	mg/l	2	2	2
Lead(Pb)	mg/l	.1	.1	.1
Manganese(Mn)	mg/l	5	5	5
Mercury(Hg)	mg/l	.001	.001	.001
Nickel(Ni)	mg/l	1	1	1
Nitrate(N molecule)	mg/l	10	undermined	10
Oil and Grease	mg/l	10	20	10
Phenol Compounds(C_2H_5OH)	mg/l	1	5	1
Dissolved Phosphorous(P)	mg/l	8	8	10
Radioactive materials	As determined by Bangladesh Atomic Energy Commission			

P^H	mg/l	6-9	6-9	6-9
Zn	mg/l	5	10	10
Temperature	Centigrade			
Summer	mg/l	40	40	40
Winter	mg/l	45	45	45
Total Suspended Solid(TSS)	mg/l	150	500	100
Cyanide(CN)	mg/l	.1	2	

Table 3. Discharge Quality Standard for Classified Industries - Composite Textile Plant and Large Processing Units (investment over Tk 30,000,000)

Parameter	**Limit (mg/l)**
Total Suspended Solid (TSS)	100
BOD_5 20° C	150*
Oil and Grease	10
Total Dissolved Solid (TDS)	2100
Waste Water Flow	100 l/kg of fabric processing
Ph	6.5-9
Special parameters based on classification of dyes used	
Total Chromium (as Cr molecule)	2
Sulfide (as S molecule)	2
Phenolic compounds as C_6H_5OH	5

* BOD limit of 150 mg/l will be applicable only for physico-chemical processing method.

"2. Methodology"

In this study we have collected information about the harmful effects of textile effluents from several journals, books, publications and investigating from different textile factories and their surrounding inhabitants. In addition, we have also compared and analyzed the performance of various types of effluent treatment plants by collecting information from some textile factory in Bangladesh where ETP is running. Our findings about different types of ETP are presented here which will help us to decide the most suitable type of ETP for Bangladeshi Textile Industry.

"Effluent Treatment Methods"

Table 4. Wastewater Treatment Levels, Mechanism, and Processes

Treatment level	**Description**	**Process**
Preliminary	Removal of large solids such as rags, sticks, grit and grease that may damage equipment or result in operational problems.	Physical
Primary	Removal of floating and settle able materials such as suspended solids or organic matter.	Physical and chemical
Secondary	Removal of biodegradable organic matter and suspended solids	Biological and chemical
Tertiary/advanced	Removal of residual suspended/Dissolved solids	Physical biological and chemical

"Biological Treatment Processes"

The basic units needed for biological treatment are: screening; an equalization unit; a pH control unit; an aeration unit; and a settling unit. A sludge dewatering unit may also be included. Biological treatment plants require the presence of microorganisms that are adapted to degrade the components of the effluent to be treated.

Textile industry waste will not contain suitable microorganisms so these must be added to the ETP when it is set up. Traditionally in Bangladesh cow dung is used as a source of microorganisms. Evidence shows that output quality from biological treatment can satisfy the national standards for most of the required parameters except colour. A properly designed biological ETP can efficiently satisfy BOD, pH, TSS, oil and grease requirements (Metcalf & Eddy, 2003). A sludge recycle line is essential for activated sludge systems but is not needed for fixed film systems. The aeration unit can be either activated sludge or a fixed film reactor.

"Physico-chemical Treatment Plant"

The basic units needed for a stand-alone physico-chemical treatment plant are screening, an equalization unit, a pH control unit, chemical storage tanks, a mixing unit, a flocculation unit, a settling unit and a sludge dewatering unit. With physico-chemical treatments generally used in Bangladesh (coagulation and flocculation) it is possible to remove much, possibly all of the colours depending on the process used. It is however difficult to reduce BOD and COD to the value needed to meet the national effluent discharge standard, and impossible to remove TDS. The removal rate is dependent on the influent wastewater quality. The removal efficiency of this type of treatment has been found to be 50% and 70% for BOD_5 and COD respectively.

"Physico-chemical and Biological Treatment"

In this type of treatment a combination of physical operations, and physico-chemical and biological processes are used. The basic units needed for a physico-chemical and biological treatment plant are screening, an equalization unit, a pH control unit, chemical storage tanks, mixing units, flocculation units, a primary settling unit, an aeration unit, and a secondary settling unit. The physico-chemical unit always comes before the biological unit. A sludge recycle line is essential for activated sludge systems but is not needed for fixed film systems. The aeration unit can be either activated sludge or a fixed film reactor.

"3. Result and Discussion"

"Cost Comparison"

The installation costs of ETPs can vary greatly depending on such factors as the materials used, including the quality and source of the equipment (e.g. pumps and air blowers), and dimensions for construction, the quality and quantity of wastewater to be treated, and the quality of the required output. In addition, the operating costs of ETPs can also vary greatly depending on quality and quantity of inputs such as chemicals, the efficiency and size of motors and therefore the energy required the method of treatment and the efficiency of ETP management.

Biological plant incurs 12 times less chemical cost than other plants. Generally in combined method-1 chemical treatment (coagulation & flocculation) is done before biological treatment. By modifying (first biological then chemical treatment) i.e. in combined method-2 running cost per m^3 is 28% reduced due to less chemical cost, sludge treatment and disposal cost (Courtesy: Interstoff Apparels Ltd).

Table 5. Chemical Consumption of different ETP

Process	Peak flow m^3/hr	Chemicals	Dosing Rate kg/day	Consump-tion kg/ m^3	Price tk/kg	Cost tk/m^3	Total tk/m^3
Physico-chemical	65	Lime	600-650	0.38-0.42	10-12	3.86-5.04	15.5-22.5
		$FeSO_4$	1000-1200	0.64-0.77	14-16	8.97-12.32	
		Polyelectrolyte	8-10	0.005-0.01	260-280	1.33-2.80	
		H_2SO_4	250-300	0.16-0.19	8-12	1.28-2.28	
Biological	60	H_2SO_4 (98%)	150-200	0.10-0.139	8-12	0.83-1.6	1.5-2.0
		Polyelectrolyte	1.5-2	0.001-0.0013	260-300	0.27-0.36	
		Antifoam	0ccasional	-	200-250	-	
		Decolorant	0ccasional	-	95-100	-	
		Nutrient	0ccasional	-	150-300	-	
Combined chemical-biological -1	55	Lime	650-800	0.49-0.61	10-12	4.92-7.32	17-25
		$FeSO_4$	1000-1300	0.75-0.98	14-16	10.6-15.68	
		Polyelectrolyte	2-3	0.0015-0.002	260-280	0.39-0.64	
		HCl	120-150	0.09-0.11	8-12	0.72-1.32	
		Nutrient	0ccasional	-	150-300	-	
Combined chemical-biological -2	75	Lime	600-700	0.33-0.39	10-12	3.33-4.68	12-17
		$FeSO_4$	1050-1200	0.58-0.67	14-16	8.16-10.72	
		Polyelectrolyte	1.5-2	0.0008-0.001	260-280	0.22-0.3	
		HCl	120-150	0.06-0.08	8-12	0.53-0.96	
		Nutrient	0ccasional	-	150-300	-	

Chemical consumption can fluctuate according to effluent composition and concentration.

Table 6. Man Power Cost:

Process	Peak flow m^3/hr	No of labour	Salary/month Tk	Treatment/month m^3	Cost tk/m^3
Physico-chemical	65	9	60000	46800	1.28

Biological	60	6	45000	43200	1.04
Combined-1	55	9	58000	39600	1.46
Combined-2	75	10	80000	54000	1.48

"Performance Analysis"

In Biological method the average BOD removal efficiency gained the highest value (84%) compared to other methods. In combined bio-chemical method the average COD removal efficiency gained the highest value (70.8%), in biological method 59.1%. Among all methods highest average TSS removal efficiency (81.7%) found in biological method. Before treatment TDS level was under discharging standard (2100 mg/l) in ETPs A1, A2, C1, C2, C3. Physico chemical based ETP A3 cannot maintain discharging standard. Except biological method, TDS value increased after treatment in physico-chemical based ETP A2 and combined bio-chemical ETP C3. Biological treatment reduces TDS significantly and satisfy discharging standard.

Table 7. Performance Analysis of Active ETP

Physico-chemical												
			A1			A2			A3			
Facts	Unit	Standard	BT	AT	RE %	BT	AT	RE%	BT	AT	RE%	Avg. RE%
BOD_5	mg/l	50/150	125	65	48	147	69	53.1	115	56	51.3	50.8
COD	mg/l	200	340	135	60.3	290	110	62.1	295	153	48.1	56.8
TSS	mg/l	150	170	62.9	63	276	80	71	210	53.88	74.3	69.5
TDS	mg/l	2100	1956	1795	8.2	1600	1820	-13.8	3045	2245	26.2	6.9
DO	mg/l	4.5-8	0	4.9		0	5.1		0	4.9		
P^H	-	6-9	11.5	8.6		11.2	7.3		10	7.72		
TEMP	ºC	40	37	29		41	30		40	29		
Biological												
			B1			B2			B3			
Facts	Unit	Standard	BT	AT	RE%	BT	AT	RE%	BT	AT	RE%	Avg. RE%
BOD_5	mg/l	50	110	29	73.6	145	19.45	86.6	281	23	91.8	84
COD	mg/l	200	320	128	60	304	102	66.4	356	174	51.1	59.19
TSS	mg/l	150	130	18	86.2	230	54	76.5	204	36	82.4	81.7
TDS	mg/l	2100	4950	2010	59.4	2492	1135	54.5	3200	1580	50.6	54.8
DO	mg/l	4.5-8	0	4.5		0	4.7		0.1	4.6		
P^H	-	6-9	10.5	8.03		9.76	7.69		10.3	8.1		
TEMP	ºC	40	41	35		43	34		50	35		
Combined chemical & biological												
			C1			C2			C3			
Facts	Unit	Standard	BT	AT	RE %	BT	AT	RE %	BT	AT	RE%	Avg. RE%
BOD_5	mg/l	50	110	43	60.9	144	36	75	112	24	78.6	71.5
COD	mg/l	200	284	110	61.3	372	95	74.5	292	68	76.7	70.8
TSS	mg/l	150	75	52	30.7	192	30	84.4	62	34	45.2	53.401
TDS	mg/l	2100	1960	1610	17.9	1880	1600	14.9	840	1050	-25	2.6
DO	mg/l	4.5-8	0	4.4		0	4.4		0	5.9		
P^H	-	6-9	8	7.5		11	6.4		9.2	7.7		
TEMP	ºC	40	35	29		36	27		38	32		

*BT-before treatment value, AT-after treatment value, RE (removal efficiency)={(BT-AT)/BT}*100

Table 8. Sludge Characterization

Parameters	Physico-chemical	Biological	Combined chemical & biological
Sludge quantity	2-5 kg/m^3	300-400 gm/m^3	2-5 kg/m^3
Sludge toxicity	Highly toxic	Non-toxic	Toxic
Sludge disposal problem	Severe	Slight	Medium
Sludge disposal cost	High	Very low	High
Sludge utilization	Brick	Fertilizer,brick	Brick

"4. Conclusion"

There is wide variation between actual efficiency and typical efficiency except Biological method. Considering chemical consumption, Biological treatment plant needs very less amount of money to do treatment of waste water compared to other treatment plants. Biological treatment plant needs low manpower cost that is 1.04 tk/m^3 whereas more cost is essential for other treatment plants. Physico-chemical treatment shows average removal efficiency of BOD, COD, TSS from 51% to 70%, Whereas it is between 60 % to 84% for Biological treatment plant. Besides after doing biological treatment we can get non toxic and less amount of sludge(300-400 gm/m^3) form discharging water, while it is toxic and more amount(2-5 kg/m^3) for other treatments. To run the plant regularly and efficiently and to bring business profit, owners prefer Biological ETP. So by considering the economic, ecologic and functionality perspective Biological ETP perform best than any other Effluent Treatment Plants (ETP).

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