

Textile Dyeing Industries in Bangladesh for Sustainable Development

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Abstract—The textile dyeing and washing industry plays an important role in the economical growth as well as the environmental sectors of Bangladesh. The textile dyeing industries has been condemned as being one of the world's most offenders in terms of pollution. There are many dyeing industries in Bangladesh which are mainly located at Gazipur and Narayanganj industrial area. This study was aimed at the dyeing industries to assess the present situation of environmental impacts arising from the activities of dyeing industries in Bangladesh. This was done by analyzing numerous data obtained from different laboratory test concerning a range of water quality parameters of Bangladesh. Important water quality parameters like pH, turbidity, TSS, BOD, COD and presence of metals were measured by testing samples. The samples were collected from effluent water of a renowned and international buyer recognized industry named UNIQUE Washing and Dyeing industry Limited in Gazipur. The results show that all the water quality parameters are within the permissible limits. Though the water test report shows no vulnerable change in water quality for this particular industry, but the overall EIA report shows the highest negative impact on physico-ecological environment. The human interest related factors make the total EIV positive.

Index Terms—EIA, environmental impact, mitigation measures, pollution, textile dyeing industry.

I. INTRODUCTION

Bangladesh has emerged, in just under decade, as the twelfth largest garment-manufacturing nation in the world, thanks largely to the Multi-Fiber Agreement (MFA), and the Generalized System of Preferences (GSP) of the European Union, that conferred significant quota benefits to the country. The garment sector now accounts for about 77% of the country's foreign exchange earnings, and 50% of its industrial work force [1]. Textile is the most important sector of Bangladesh's economy. Textile industry uses large quantity of water in its production processes and highly polluted and toxic waste waters are discharged into sewers and drains without any kind of treatment. The textile dyeing industries of Gazipur and Narayanganj generate large amount of effluents, sewage sludge and solid waste materials everyday which are being directly discharged into the

surrounding channel, agricultural fields, irrigation channels, surface water and these finally enter in to Turag and Shitalakkhya River. Textile and dyeing industrial effluents may cause alteration of the physical, chemical, and biological properties of aquatic environment by continuous change in temperature, odor, noise, turbidity etc that is harmful to public health, livestock, wildlife, fish, and other biodiversity. The presence of dyes in surface and subsurface water is making them not only aesthetically objectionable but also causes many water borne diseases, viz. mucous membrane, dermatitis, perforation of nasal septum and severe irritation of respiratory tract. Contamination to this aquatic system brings serious threat to the overall epidemic and socio-economic pattern inside. Industrial effluents impart a minor fraction of chemical load to the environment; its integrity renders the environmental quality fairly deplorable. For this, nearly 30 numbers of villages at Gazipur and a large number of people living near the D.N.D Embankment area are now being threatened due to the environmental degradation. People who live in these areas are utilizing surface water for their house hold washing, bathing, irrigation, fish culture and other necessary works. Furthermore no systemic data had been obtained on water quality of these areas. So, proper analysis is needed to assess the pollution level also for the protection of environment and natural resources. Such information is important for the authorities to take proper action in preventing pollution of the area for the good health of the population. Therefore in the present study we tried to determine the extent of pollution level of various physicochemical parameters and heavy metals in order to characterize the effluents of the textile dyeing industries [2]. Besides we also did the environmental impact assessment in the surroundings of Gazipur area on the basis of relevant environmental parameters and made an EIA report based on it.

II. CHEMICAL COMPONENTS USED IN DYEING INDUSTRIES

A dye can generally be described as a colored substance that has an affinity to the substrate to which it is being applied. The dye is usually used as an aqueous solution and may require a mordant to improve the fastness of the dye on the fiber. The dyes were obtained from animal, vegetable or mineral origin with no or very little processing. So dyes are mainly organic and inorganic chemical substances. And if these substances spread out in the environment, they may cause huge adverse impact on the environment [3]. Fig. 1 shows different types of dye used in unique washing and dyeing industry Ltd. in Bangladesh.

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Fig.1. Different type of dyes used in Unique washing and dyeing industries

III. HEALTH AND ENVIRONMENTAL HAZARDS

The first step in prevention of poisoning in the dye industry includes well ventilated, properly equipped buildings. Selection of workmen is important and the use of the best methods in manufacturing. The hazards of the dye industry are those connected with any industry plus the poisonous chemicals necessarily handled in the production of dye stuffs. The first hazard we meet in the dye industry is from strong acids, such as nitric and sulphuric or a mixture of these two known as mixed acid. These are used to nitrate the benzene, toluene etc. Their destructiveness to the human tissues is well known and every precaution is taken to prevent these acids from getting on the skin of the workmen. When acid does get on the workman, he quickly knows it by the pain it causes, and he immediately drowns it with water and seeks a soothing dressing for his burn. Nitrous fumes may also be considered under this hazard and are the reddish brown fumes, nitric peroxide, together with some finely atomized acid. Exposure to these fumes must be considered in the nature of an accident and occurs as the result of a nitrator fire or a large spill. Their effects are those of an irritant to the mucous membrane of the respiratory tract and they may cause anything from slight bronchial irritation to a fatal pulmonary edema [4]. The textiles sector contains many hazards and risks to workers, ranging from exposure to noise and dangerous substances, to manual handling and working with dangerous machinery. Each processing stage from the production of materials to the manufacturing, finishing, coloring and packaging poses risks for workers, and some of these are particularly dangerous for women's health. Many different groups of chemical substances are used in the textiles sector, including dyes, solvents, optical brighteners, crease-resistance agents, flame retardants, heavy metals, pesticides, and antimicrobial agents. They are used in dyeing, printing, finishing, bleaching, washing, dry cleaning, weaving slashing/sizing, and spinning. Respiratory and skin sensitizers can be found in the textiles industry, for example textiles fibres, reactive dyes, synthetic fibres, and formaldehyde. The exposure of workers to dusts from material such as silk, cotton, wool, flax, hemp, sisal, and jute can occur during weaving, spinning, cutting, ginning, and packaging. Exposure to loud noise can result in permanent hearing damage such as noise-induced hearing loss and tinnitus. Exposure to vibration, particularly together with risk factors for MSDs, can lead to long-term harm. Electromagnetic fields may also be found in some

workplaces in the textiles sector [5]. Over a long period of time, exposure to noise has been known to cause damage to the ear drums as well as hearing loss. Noise has also been known to cause fatigue, anxiety and a lack of productivity [6].

IV. EFFLUENT TREATMENT TECHNOLOGIES FOR TEXTILE DYEING INDUSTRIES

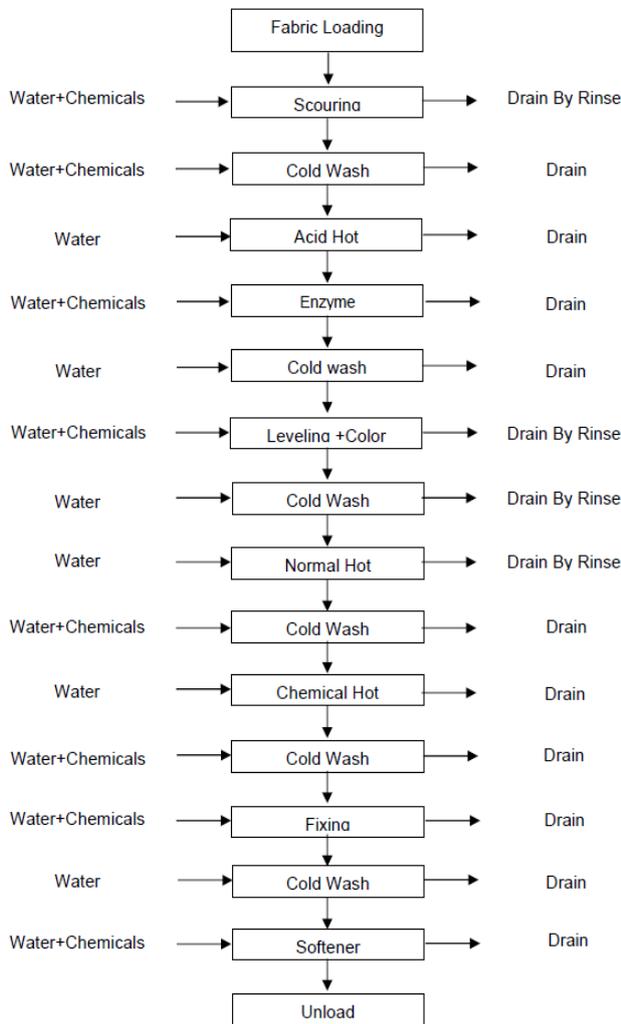
Trade effluent is any effluent (liquid waste) that is discharged from any premises where a trade or industry is carried out. A dye contaminated effluent, then, is one which contains residual dye, here a dye is defined as a soluble substance suitable for staining or colouring, which has an affinity to the substrate that it is being applied to. The treatment of textile effluents is of interest due to their toxic and esthetical impacts on receiving waters. While much research has been performed to develop effective treatment technologies for wastewaters containing azo dyes and other toxic materials no single solution has been satisfactory for remediating the broad diversity of textile wastes [7]. The most common and so far effective solution is to use effluent treatment plant to treat the waste water of dyeing industries. But due to their high operational and maintenance cost, the concept of CETP (common effluent treatment plant) can be introduced which is discussed later broadly in this section. Moreover some other technologies like effective process for handling effluent water, designing of zero discharge system and applying of semiconductor photocatalysis system are also discussed here.

A. Effluent Treatment Plant for Textile Dyeing Industries

All the dyeing industries should have the authentic waste water treatment plant but unfortunately there are many dyeing industries in Bangladesh which are running without any ETP. Only a few of them have ETP like Unique dyeing industry. A major environmental hazard present in textile industries is the discharge of untreated effluent to the environment, causing pollution of nearby soil and water. To mitigate the risks from the discharge of untreated water, an effluent treatment plant is required. Effluent must meet the national effluent discharge quality standards. As water passes through the ETP, pollutants are removed and the quality of the water is improved, allowing for final discharge to the environment without significant risk. The EMP should contain the Process Flow Diagram, Layout Plan including the location for the Effluent Disposal System, and the plan and design of the Effluent Treatment Plant with full information about its effectiveness. The EMP should also include a post-project monitoring program.

Textiles are dyed using reactive, dispersed, indanthrene or other kinds of dyes. These dyes use various types of chemicals. The concentrations of chemical substances in the effluent from this process always vary because of compound chemical reactions taking place and the effluent is colored. In the printing process high color impurities are generated. This is the last step of wet processing. The inducted coloring process uses various dyes depending on the buyer's wishes, including:

- For cotton: Reactive dye, direct dye, vat dye (Maximum efficiency 55%-65%);
- Basic dye, Acid dye;
- Sulphur dye (more useful for black shed), azoic dye, pigments; and
- For polyester: Dispersed dye (Efficiency 95%).



• Fig. 2 Process flow diagram of textile dyeing industry (color)

The process flow diagram for garment dyeing (color) is shown in Fig. 2 [8]. Unique has authentic waste water treatment plant which is designed by Techno economic service (from India). Their waste water from dyeing and washing section is refined to dispose in Turag River. The sludge produced from ETP is disposed in city corporation waste disposal center. Moreover the lime, alum from sludge is used as chemical fertilizer in local farm. The effluent flow chart layout collected from Unique is given in the Fig. 3.

B. Applying the Idea of Common Effluent Treatment Plant to Minimize the Cost Effect

Common Effluent Treatment Plant is the concept of treating effluents by means of a collective effort mainly for a cluster of small scale industrial units. This concept is similar to the concept of Municipal Corporation treating sewage of all the individual houses. The main objective of CETP is to reduce the treatment cost for individual units while protecting the environment. The criteria for consideration for financial assistance are as follows:

- CETPs should be in industrial estates or in a cluster of Small Scale Industrial units.
- Central Assistance will be available only for clusters of SSIs.
- Projects for assistance will be prioritized on the basis of toxicity of pollutants.
- The CETPs are to be set up and managed by the State Industrial Infrastructure Corporation (by whatever name known) or through an appropriate institution including a
- Cooperative body of the concerned units as may be decided by the State Governments/SPCBs concerned.
- The project should be self-supporting for repayment of the loan and meeting operation and maintenance costs.
- The scheme must have the technical recommendation of the State Pollution Control Boards.
- The CETP project should have the conveyance system from the individual units to the CETP.

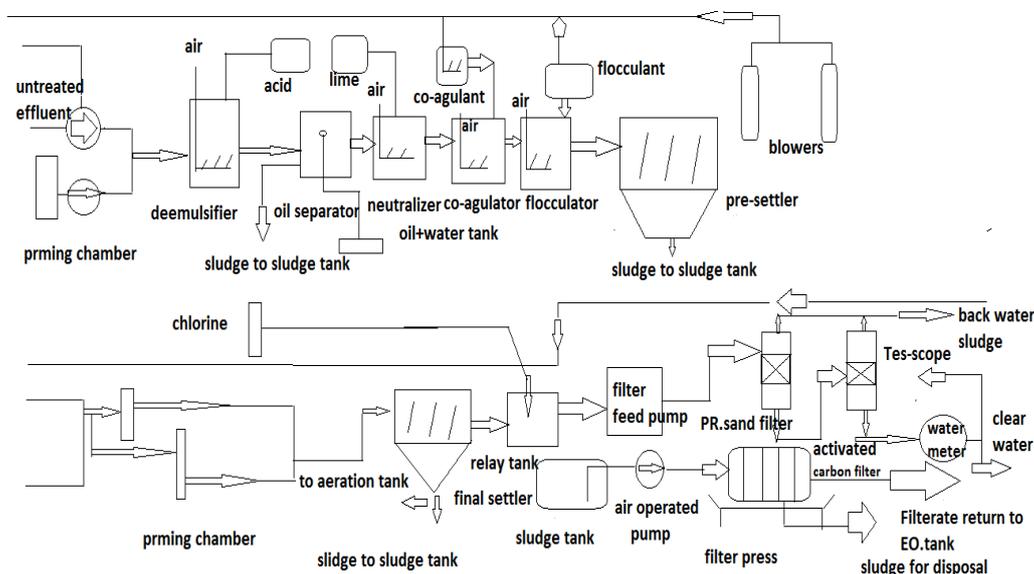


Fig. 3 Effluent flow chart layout of Unique washing and dyeing industry Ltd.

Wastewater treatment at CETP can be divided into four major categories or steps-

1) *Preliminary treatment*: It involves a number of unit processes to eliminate undesirable characteristics of wastewater. Processes include use of screen sand grates for removal of large particles, comminutors for grinding of coarse solids, pre-aeration for odour control and some removal of grease.

2) *Primary treatment*: It involves removal of readily settleable solids prior to biological treatment. Sedimentation chambers are the main units involved but various auxiliary processes such as floatation, flocculation and fine screening may also be used.

3) *Secondary treatment*: It involves purification of waste water primarily by decomposition of suspended and dissolved organic matter by microbial action. A number of processes are available but mainly used are land treatment, activated sludge process or the biological filtration methods.

4) *Auxiliary treatment*: This mainly includes large number of physical and chemical treatment processes that can be used before or after the biological treatment to meet the treatment objectives.

Design of the actual treatment system for a CETP involves selection of alternative processes based on the ability of individual treatment processes to remove specific waste constituents [9]. The treated waste water should be reused or recycled if it has the proper holding capacity. Depending on the sewer standard which is given in Table I for the outlet of CETP, treated water can be either used for irrigation or disposed off in municipal sewers or in inland water- courses.

TABLE I. OUTLET CETP (SEWER STANDARDS) [9]

PH	BOD	TSS	COD	Oil & grease
6.5 to 8.5	less than 350mg/l	200 mg/l	700-1200 mg/l	less than 20 mg/l

C. Effective Process for Handling Effluent Water of Textile Dyeing Industries

Textile waste water can be handled by using evaporation and solid separation process. The technology is based on basic principle of reduction of quantity by concentrating the effluent and subsequently separation of salt and water.

1) The evaporation system:

Textile Effluent is fed to the vacuum evaporator to concentrate up to 40% solids concentration. The total process is under vacuum and the vapors generated in the system are re-used to economize steam consumption in multiple effect evaporation system with thermal vapour recompression system. The thermal vapour recompression system use Vapours generated in the evaporator and compress it by steam and the compressed vapours are used as heating medium in the evaporator, in this way steam consumption is reduced. Water recovered from the evaporator has low COD/BOD value and can be recycled in the plant.

2) The separation process (Zero Liquid Discharge Section):

The resultant slurry (concentrate) is fed to the thickener and centrifuging section for converting the liquid concentrate to solid waste. The mother liquor from thickener and centrifuge is recycled back to evaporator. The water separated out from evaporator is good enough in quality to recycle in the plant for Dyeing. The machinery used in separation process is shown in Fig. 4 [10].



Fig. 4. Machinery used in separation process

D. Designing of Zero Discharge System

The designing of zero discharge system can also be helpful for textile effluent water. The zero discharge system can be implied to dyeing and bleaching operation. In this method the waste water is recovered from dyeing and bleaching operation and it is reused again in these two operations. So the environment has zero liquid discharge. The solid waste generated from this process should be stored in a secured landfill. It can minimize the effect of waste water on the environment as far as possible. Any zero discharge treatment system design should consider the following facts/requirements:

1. Quantity of the effluent to be treated.
2. Variability in time of the quantity as well as quality of the effluent.
3. Unit processes suitable for achieving desired purposes [such as removal of total suspended solids (TSS), reduction in biological oxygen demand (BOD), etc.] for the given nature of the effluent.
4. The upper and lower limits of performance of each unit process.
5. The durability of the system to be adopted.
6. The feasibility of establishing suitable collection and conveyance system in the case of a common treatment facility [11].

E. Treatment of Textile Dyeing Waste Water by Using Semiconductor Photocatalysis

Dyes are extensively used in the textile industry. The colour which dyes impart to water bodies is very undesirable to the water user for aesthetic reasons. Due to high concentration of organics in the effluents and higher stability of modern synthetic dyes, their discharges into rivers are harmful to aquatic life. To minimize the harmful effects of the waste water a comparatively new method can be used like semiconductor photocatalysis. Semiconductor photocatalysis is an attractive treatment for industrial wastewater. Semiconductor photocatalysis can be defined as the reaction in which the decomposition of organic substances in an aqueous solution by means of semiconductor likes TiO_2 or ZnO in presence of light. Semiconductor photocatalysis is an aqueous process where the water is integral part of the reaction residence time may vary from 100 to 150 minute, and the Chemical Oxygen Demand (COD) removal may

typically about 50-60 % insoluble organic matter is converted to soluble organic compound which are turn in oxidizing and eventually converted to CO₂ and water, without emission of NO₂, SO₂, HCl, furans, fly ash etc.

Semiconductors are used to degrade the organic pollutant in water to less harmful materials. The removal of colour from wastewater is often more important than the removal of other organic colourless chemicals. Decolourization of effluent from textile dyeing and printing industry was regarded important, because of aesthetic and environmental concerns. The TiO₂ and ZnO have photocatalytic properties to be promising substrate for photodegradation of water pollution and show appropriate activity in the range of solar radiation. The overall benefits of the decolourization of textile industrial wastewater may include very interesting subject saving huge amount of water because textile dyeing industries are regarded as chemical intensive and water intensive. This type of industry has more pollutants and consumes a huge amount of water [12].

V. ENVIRONMENTAL SUSTAINABILITY OF TEXTILE DYEING INDUSTRIES

The textile industry is considered as the most ecologically harmful industry in the world. The eco-problems in textile industry occur during some production processes and are carried forward right to the finished product. In the production process like bleaching and then dyeing, the subsequent fabric makes a toxin that swells into our ecosystem. During the production process controlling pollution is as vital as making a product free from the toxic effect. Taking incremental steps in supply chain processes to make it happen that is need to believe in environmental sustainability; and need to be aware about the social, economical and ecological benefits of environmentally sustainable products and development processes. So the care for the Environment must influence the supply chain to use Sustainable Processes, run business operations in an environmentally friendly way, work to conserve energy and reduce waste. Exploring and implementing sustainable textile materials and products through sustainable design approach.

A. Eco Friendly Textile Fibres

There are some Eco friendly Textile Fibres called green fibres which are described below:

1) *Organic Cotton*: Cotton is one of agriculture's most water-intensive and pest sensitive crops; it is estimated to consume 11% of the world's pesticides. A sustainable alternative is Organic cotton having social and environmental benefits includes:

- Organic cotton cultivation helps in decreasing pollution.
- Organic cotton cultivation helps in improving soil fertile. Organic cotton farming helps in preventing water, soil and air contamination.
- Equivalent/ better fiber properties help in diversified products development- suitable for all products.

2) *Recycled Cotton*: Recycled Cotton is also an ecofriendly choice in cotton clothing since recycled cotton is cotton fabric which is made from recovered cotton that would otherwise be cast off during the spinning, weaving or cutting process. The discarded cotton waste is collected, shredded

into small fibers and processed again into yarns and fabrics. Truly ecofriendly – because of waste recycling process, no chemicals used during processing, it helps in generating employment and good for the environment.

3) *Recycled Polyester*: Polyester fibre is one of the most non-biodegradable polymer which create environmental problems. The legislation opens the door towards working over recycling of PET. The Wellman Inc is the world's largest Polyester recycler. A new generation of fiber that is most suitable for diversified products range such as backpacks and blankets, T-shirts, sportswear, soft luggage and socks. Whereas the certification obtained in licensed or patented yarns (eco spun) along with eco certification from Oeko-tex and SGS or any other environmental testing agency.

4) *Sustainable Processing of Textiles*: There is need for ecofriendly wet processing that is sustainable and beneficial methods. Number of sustainable practices has been implemented by various textile processing industries such as Eco friendly bleaching; Peroxide bleaching; Eco friendly dyeing and Printing; Low impact dyes; Natural dyes; Azo Free dyes; Phthalates Free Printing.

B. The Impact of Green Chemistry in Coloration

1) *Dye Chemistry*: If we look into the Dye chemistry, the appreciable work has been seen by alternative synthesis, sustainable source and natural platform chemicals. Dyes in effluent on other hand, is reduced due to efficiencies of dye sorption and cleaner treatment technologies.

2) *Auxiliary Chemicals*: Auxiliaries chemicals are those which are used other than colorants (dyes and pigments). Most of the harmful chemicals have been replaced with the sustainable ones or have less effect on the effluent load and even reduction in use and emission of harmful auxiliaries (e.g. salt, reducing agents and carriers)

Reduction in energy, water usage, time in the processes have also been in practice, some of the example such as use of automation in the form of controlled temperature and time of dyeing E-Control Dyeing and use of ultrasonic waves in dyeing that will gain commercially importance in near future [13].

VI. RESEARCH PROCEDURE

The research procedure was conducted by a series of following tasks:

1. Visiting a renowned and international buyer (puma, GAP, Levi's) recognized dyeing industry.
2. Understanding the operational activities of a dyeing industry and its compliance with the environment along with the process flow diagram of the ETP used there.
3. Collecting the samples from both effluent and underground water and analyzing the laboratory experimental data.
4. Preparation of EIA report from the interviews of relevant workers and local people.

A. Study Area

Our study was conducted at Unique washing and dyeing industry Ltd. which is Located in Kalemesh, K.B. Bazar, Gazipur, Bangladesh. The reasons for selecting this industry for our study are:

- Centrally located,
- Personal industrial building,

- In-house laboratory for all types of fabric testing,
- Fully equipped separate chemical mixing room,
- Authentic waste water treatment plant,
- Established in 1999 & fulfilled every condition of DOE.

B. Operational Activities of Unique Washing and Dyeing Industry Limited

The chemicals used in dyeing of Unique washing and dyeing industry Ltd. have certificates from OCTEX to ensure that the compositions of chemical substances are satisfactory. They believe in excellence in providing quality wash, timely shipments and affordable prices to their customers with preserving the surrounding environment. They are fully compliant with local laws as they follow ECA 1995 properly. The waste water produced from dyeing activities is discharged through well drainage system in natural canal and Turag River after treatment in ETP (effluent treatment plant). Due to their environmental precautions they have a good relationship with buyers.

C. Evaluation of Impacts on Physico-Chemical Environment

Digital pH meter was used for the determination of pH of the samples. Two buffer solutions containing pH 4.0 and 7.0 were used to calibrate the digital pH meter. The most accurate way to determine water's turbidity is with an electronic turbidimeter. The turbidimeter has a light source and a photoelectric cell that accurately measures the light scattered by suspended particles in a water sample. The concentrations of dissolved species were determined by DR-4000 spectrophotometer. DO was measured by Winklers method and BOD₅ was measured by incubation in the dark at 20°C for 5 days. Total dissolved solid was dried to a constant weight at 105°C. In summary, testing for dissolved solid involves weighing a clean beaker to the nearest mg. Fill the beaker with test water and evaporate off the water. Weigh the beaker again with the resulting residue. Then subtract the two results to determine the amount of milligrams of residue per liter of water.

Highly colored liquid effluents with pungent odor were observed in the effluents of the studied industrial area of D.N.D Embankment, Narayanganj. The average temperature of the effluent was found about 50°C which is slightly higher than DOE standard. The pH of the effluents was varied from 7.59 to 11.91. The pH variation is primarily caused by different kinds of dye stuff used in the dyeing process in different industries. The average pH value was found 9.88 which is higher than the DOE standard. In textile dyeing industries H₂O₂ and NaOH are used as bleaching and kier agents. Higher pH approaches in effluents owing to the wastes composition of textile mills such as: NaOCl, NaOH, Na₂SiO₃, surfactants, sodium phosphate. Water pH influences the other properties of water body, activity of organisms, and potency of toxic substances present in the aquatic environment. Excessive pH is harmful to aquatic life like fish and microorganism etc. The electric conductivity (EC) is usually used for indicating the total concentration of the ionized constituents of water. The average values of electrical conductivity of the effluent is 14,109.56 µs/cm which indicates that a large amount of ionic substances is released from textile industries like sodium, chloride etc. in

the area. The average concentration of EC was found around 12 times higher than the DOE standard. Such a high value of EC is not suitable for aquatic life and irrigation purposes. The EC is an indirect measure of the ions or the charge carrying species in the effluents under the measurement conditions. Total suspended solids (TSS) denote the suspended impurities present in the water. Measurement of suspended particulate matter is important as they are responsible for pollutant transport in the aquatic environment.

D. Environmental Impact Assessment (EIA)

The United Nations environment programme defined EIA as a method "To identify, predict and to describe in appropriate terms the pros and cons of a proposed development. To be useful, the assessment needs to be communicated in terms understandable by the community and decision makers and the pros and cons should be identified on the basis of criteria relevant to the countries affected. There are two main objectives of EIA:

- Have two major themes in common that EIA is a planning tool and is concerned with identifying, predicting and assessing.
- Safeguard the environment and for that matter the major aim of EIA is to improve decisions on development by increasing the quality and scope of information on likely impacts presented to the decision makers and the public.

Considering the situation prevailing in the country, a simple methodology was taken for Environmental Impact Assessment of textile dyeing. The methodology used for EIA due to 'Textile dyeing industries' is Environmental evaluation system (EES). Relative importance of the parameters is selected based on 'LGED guideline, 1992'. The environmental parameters are grouped into 4 categories which are: Physical resources, Ecological resources, Human use values and Quality of life values. The environmental impact was assessed by Environmental Impact Values (EIVs) which may be defined mathematically as equation (1):

$$EIV = \sum_{i=1}^n V_i W_i \quad (1)$$

where V_i is the relative change in the value of environmental quality of parameter i with respect to existing situation. W_i is the relative importance or weight of parameter i , and n is the total number of environmental parameter related to the project. The computation of Environmental Impact Value (EIV) of textile dyeing needs determination of V_i , the value representing the magnitude of alteration of the environmental parameters, and W_i , the value representing relative weight or importance of the respective parameters.

The beneficial and adverse changes in environmental parameters resulting from textile dyeing, usually expressed in qualitative terms are plotted in a scale to quantify the environmental alterations in Table IV. Since the changes of environmental parameters are measured with respect to background conditions, no change has 0 values. The adverse changes have been given values -1, -2, -3, -4 and -5 to represent very low, low, moderate, high and severe negative impacts respectively. Similarly +1, +2, +3, +4 and +5 represent very low, low, moderate, high and very high

positive impacts respectively. A value from the scale representing effect of the project on each parameter was taken to compute the EIV of the textile dyeing industry.

VII. RESULTS AND DISCUSSION

A. Laboratory Experimental Data of Physico-Chemical Properties of Effluent

The major problem associated with the dyeing industries is the disposal of liquid waste. To obtain laboratory data, effluent water sample was collected by use of a water can from the outlet drain of Unique washing and dyeing industry Ltd. All possible efforts were made to minimize the time lag between collection and analysis so that no significant change may occur in the quality of the samples. The concentrations of various physicochemical properties of effluent of the study area were determined through extensive laboratory analysis and are shown in Table II.

TABLE II. PHYSICO-CHEMICAL PROPERTIES OF UNIQUE WASHING AND DYEING INDUSTRY EFFLUENT

Water Quality	Unit	Concentration	DOE Standards (for Inland Surface Water) [14]
pH	-	7.35	6-9
Turbidity	NTU	0.23	-
Color	Pt-CO	11	-
TSS	Mg/l	11	150
BOD ₅	Mg/l	1.2	50
COD	Mg/l	4	200
Copper	Mg/l	0.041	-
Cadmium	Mg/l	<MDL ^a	0.5
Cyanid	Mg/l	0.008	0.1
Mercury	Mg/l	0.002	0.01
Nickle	Mg/l	<MDL	1
Zinc	Mg/l	0.037	5
Lead	Mg/l	<MDL	0.1
Arsenic	Mg/l	<MDL	0.2

a. MDL – Minimum Detection Limit

The levels of pollution of the effluents were determined by comparing the observed values of the various parameters with the inland surface water standard value recommended by DOE. Our sample source was the treated effluent water and the test results were found within the standard limits of DOE. Though the water test report shows no vulnerable impacts of water quality for Unique washing and dyeing industry Ltd. because of using their ETP properly, but the overall descriptive statistics of the physicochemical parameters like temperature, pH, EC of the effluent samples collected from D.N.D Embankment, Narayanganj shows deviation from DOE standard because most of the dyeing industries in Narayanganj do not have ETP and they are not willing to use ETP because of higher cost. The concentration ranges of the physicochemical properties of the effluents of the study area are shown in Table III [2].

TABLE III. PHYSICO-CHEMICAL PARAMETERS OF THE EFFLUENT SAMPLES IN D.N.D EMBANKMENT, NARAYANGANJ

Parameter	Concentration	DOE Standards (for Inland Surface Water)
Temperature (°C)	50.22	40
TSS (mg/L)	1123.11	150
TDS (mg/L)	9123.78	2,100
Turbidity (FTU)	130.37	10
DO (mg/L)	2.36	4.5 – 8
pH	9.88	6 – 9
EC (µs/cm)	14109.56	1200
BOD (mg/L)	573.89	50
COD (mg/L)	1223.33	200

The average value of TSS of the effluent was found 1,123 mg/L which indicates that the effluent sample contains TSS concentration of about 7 times higher than DOE standard. TDS in water mainly consist of ammonia, nitrite, nitrate, phosphate, alkalis, some acids, sulphates, metallic ions etc. The average value of TDS of the effluent was found 9,123 mg/L. It is found that the effluent sample contains TDS concentration 4 times higher than DOE standard. The turbidity of the effluent was found 130 FTU which is caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, and plankton and other microscopic organisms. The DO of the effluent with value 2.36 mg/L indicates 2 times lower DO than DOE standard. Textile industries releases a lot of biochemical oxygen demanding wastes. The BOD value of the effluent was found 573.89 mg/L which exhibited 16 times higher BOD value than the standard. Chemical oxygen demand (COD) is defined as the amount of a specified oxidant that reacts with the sample under controlled conditions which is one of the most important parameter for assessing the quantity of chemically oxidizing matter in water. Textile industries release a lot of chemical oxygen demanding wastes. The average value of COD was found 815 mg/L, which is around 7 times higher than the DOE standard.

B. Environmental Impact Assessment:

All environmental parameters influenced by the textile dyeing are not of equal importance or weight. The importance of a parameter varies from country to country depending on the environmental concerns of the country. In Bangladesh, surface and ground water quality, aquatic biology, socio-economic condition, agriculture, fisheries, etc. carry more importance than many others. The parameters related to Textile dyeing industries were given different values based on prevailing environmental concerns in Bangladesh and are presented in Table IV. The values are representing importance or weight of the parameters. They are used to compute the relative impacts of the parameters which are then summed up to obtain the total EIV of Unique washing and dyeing industry Limited.

At first the values indicating magnitude of environmental changes influenced by the textile dyeing were placed in the appropriate columns in Table IV and then multiplied them to obtain positive and negative impact of the parameters. Finally all these impacts were summed up to obtain the total EIV of +26.81 for Unique washing and dyeing industry Limited. Though the water test report shows the water quality parameters are within standard limits for this particular industry, but the overall EIA report shows the highest negative impact on physico-ecological environment. But the human interest related factors made the total EIV positive.

VIII. MITIGATION MEASURES DUE TO ENVIRONMENTAL IMPACTS

Textile dyeing industry is playing an important role in the national economy of our country. It upgrades the lifestyle of lower class people of our country. It minimizes the problem of unemployment to a great extent. So, despite of having some adverse impact of textile dyeing industry it cannot be stopped. Rather we should find some mitigation measures to

minimize the adverse impact and increase the beneficial impact. To do so the following steps should be taken:

1. The most adverse effect of textile dyeing is the decrease of surface water quality. All types of effluent should be treated before discharging as well as ETP should be installed and used by every dyeing industry.
2. To save the aquatic biology the project should be designed to protect existing fisheries and increased flood plain.
3. Due to high positive impact on socio-economic value, it brings happiness in life of workers, remove poverty and fulfill basic needs which are prime cause of unconsciousness of environmental degradation due to textile dyeing.

TABLE IV. ENVIRONMENTAL IMPACT ASSESSMENT (EIA) OF UNIQUE WASHING AND DYEING INDUSTRY LTD.

Parameter	Relative Importance Value	Degree of Impact	Relative Impact		EIV
			Positive	Negative	
1. Physical Resources					-98.97
Surface water quality	10	-2.2		-22	
Ground water quality	10	-2.2		-22	
Hydrology	10	-1.533		-15.33	
Sound pollution	6	-1.67		-10.02	
Air meteorology	5	-0.93		-4.65	
Air quality	5	-0.93		-4.65	
Soil erosion	5	-1.733		-8.665	
Fertility	5	-2.33		-11.65	
2. Ecological Resources					-27.65
Fisheries	3	-2		-6	
Aquatic biology	5	-1.33		-6.65	
Nuisance plant	5	-1.267		-6.335	
Terrestrial flora and fauna	5	-1.733		-8.665	
3. Human Use Values					+72.21
Water supply	6	+1.733	+10.4		
Drainage	5	+1.867	+9.335		
Sewerage and waste disposal	5	+2	+10		
Sanitation	5	+3.67	+18.35		
Drinking water quality	8	+3.267	+26.14		
Agricultural development	3	-0.67		-2.01	
Aquaculture	3	-0.8		-2.4	
Irrigation	2	-0.4		-0.8	
Reforestation	3	+0.267	+0.801		
4. Quality of Life Values					+81.22
Socio economy	10	+4.933	+49.33		
Resettlement	3	+0.933	+2.799		
Public safety	6	+2.67	+16.02		
Public health	6	+2.467	+14.80		
Agricultural land loss	5	-1.467		-7.335	
Nutrition	6	+0.6	+3.6		
Disposal of garbage	5	+0.4	+2		
Total EIV					+26.81

4. Better construction and maintenance is needed for sewerage and waste disposal.

5. Air quality index should be mandatory for every industry like Unique is applied for air emission protection.
6. Every Textile dyeing industry should apply for air emission test to predict climate change.
7. To ensure the public safety the regular checkup of the laborers should be done. Moreover safety precautions like helmet, eye protective glass, hand gloves, ear plug, and air mask should be taken by laborers to avoid any incident.
8. Skin test, blood test should be done for the workers on regular basis.
9. Emergency Evacuation due to fire is very important for dyeing industries as there are many chemicals which may be flammable and explosive used in dying process.
10. For the welfare of all workers training should be given in the correct use of fire extinguishers and fire hoses. These should be easily available throughout the factory and regularly checked by a qualified assessor.
11. To avoid any severe accident there should always be at least one member of staff on each shift that is trained in "First Aid" and who is made responsible for all first aid requirements during their shift. At least one first aid box should be made available in an area that is accessible to all the workers.
12. There are various chemicals present in concentrated doses in a textile dyeing laboratory and precaution has to be taken to minimize the risks of exposure and accidents. All chemicals, dyes and other auxiliaries that enter the laboratory should be logged on arrival, clearly labeled as to what they are and given expiry dates.
13. The working environment needs to be kept as dry as possible to prevent accidents. Hazardous waste must be disposed of properly in accordance with manufacturers' guidelines and national policies.
14. BOD and COD test should be done for effluent as well as for drinking water.
15. DOE should monitor at least 6 months after in every year to check the condition of ETP, effluent samples report and the certificate of chemical composition issued by third party to ensure that, they are using within permissible limits.
16. Every textile industry should be buyers environmental friendly certified, so that they can carry their business with good reputation in abroad and earn more foreign exchange for our country.
17. Any textile dyeing cannot be established without proper ETP system and all license certificates by fulfilling every condition of DOE to ensure the environmental preservation of surroundings. The relevant authority from ministry of govt. should be strict in providing license and honest officers should be appointed for monitoring the textile dyeing industries.
18. Surface water pollution is a major issue due to effluent discharge in textile dyeing industry. To try and control the pollution problem, industries along with the government can set up a common effluent treatment plant at a much larger scale. These can be expected to help a large number of industries treat their wastewater in a cost-effective way.

After taking all environmental precautions, following ECA, using ETP there is black water in nearby canal of UNIQUE washing & dyeing industry Ltd. The authority

claimed that, the water discharged from other industries flowed through this canal and as they don't have any ETP, so the untreated waste water of these industries mixed with their treated effluent and finally discharged in Turag river similar to Shitalakkhya river in Narayanganj. So they claimed that they are not responsible for this kind of pollution. Due to their business policy they are not going to encourage other industries to use ETP. But we recommend them to encourage other industries to follow ECA and use appropriate ETP without thinking about their own benefits for the better preservation of environment to build a green world.

IX. CONCLUSION

In Bangladesh due to textile dyeing industries, the main negative impact afflicting the local environment severely is the hazards caused by dye effluents, which contain both chemical and organic pollutants. These can be highly toxic. This Research has found that the volume of such effluents often exceeds acceptable standards. Though the volume of effluents from individual small-scale dyers might be small, the concentration of pollutants is generally high. The impact is significant where several producers are located at one place and discharge effluents into the same body of water. Large-scale dyers on the other hand generate greater volumes of effluent but show lower pollutant content per cubic meter of water. The results of the study reveal that, the textile dyeing industries in Gazipur and Narayanganj area discharge large quantities of effluent composed of various physicochemical pollutants at significant higher level than standard value of DOE except some industries which have authentic waste water treatment plant. From the above findings it can be easily said that, the water of Turag and Shitalakkhya River is getting highly polluted by the effluent discharged by the dyeing industries of the study area. The concentration of these pollutants is increasing in an alarming rate with the increasing number of textile dyeing industries. So the above mitigation measures can be effective to minimize the pollution to a significant extent. Last of all, for the greater benefits of our country, all people involved in textile dyeing should be environmentally conscious to preserve our environment as well as to carry the reputation of our readymade garments in developed countries.

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