Department of Environment

Performance Evaluation of Zero Liquid Discharge-Effluent Treatment Plants (ZLD-ETPS) In Textile Industries of Bangladesh

FINAL REPORT

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Executive Summary

BACKGROUND

In an effort to reduce the use of natural resources, to ensure sustainable wastes management and to improve the carbon footprint of the production processes, the Department of Environment (DoE), Bangladesh is imposing an obligatory clause for developing a 3R strategy / Zero Discharge (ZD) plan for different industries from early 2014. The 3R concept is related to the conservation of resources and incorporates sustainable technologies in different industrial processes. The 3R strategy incorporates aspects of reduce, reuse and recycle in different phases of production through optimization and modification of existing processes and adoption of more green and environmental friendly technologies.

Textile industry is one of the most significant industries in Bangladesh whose contribution in national economy is enormous. Along with its contribution in national economy, its contribution in polluting the environment is also enormous. The industry uses considerable resources (energy, water and chemical) in its processes (washing, dyeing, printing and finishing) and discharges huge volume of wastewater into land or surface water and thus impacting on environment, local communities and ecosystem.

After the directives of DoE of introducing zero discharge policy, different textile industries have submitted their respective 3R plan to Department of Environment (DoE) since 2014. A major focus of these submitted 3R plans involves achieving a zero liquid discharge (ZLD) as well as Environmental Management System (EMS) in the respective industries over a time period of 3 to 5 years for environmental protection. A number of industries have already adopted ZD approach at their facility and is supposed to achieve a significant portion of the treated water from its ETP for recycling. To achieve ZD, the main challenge for a industry is how to treat the wastewater in such a way so that there will be no discharge of liquid waste in the environment, i.e. almost 100% recycling/reusing of treated water (ZLD) should be accomplished. Implementing only ETP will be not enough to achieve this Zero Liquid Discharge (ZLD); some advanced technologies (ZLD system) should be introduced with conventional ETP to achieve this level of treatment. Moreover, most of the industries may have adopted various treatment schemes to achieve ZLD, which vary from one industry to the other depending on budget, location, and types of industries. There is a need to determine the efficiency of different proposed ZLD systems adopted in different textile industries. Also, it is essential to assess the progress of different textile industries in terms of achievement of ZLD system with respect to their 3R plan. Such action research work would enable regulatory authorities like DoE to understand maximum level of ZLD achievable for a particular textile industry and also provide an idea on the time required to achieve the target.

OBJECTIVES OF THE RESEARCH

The main objective of the present action research is to assess the status of textile industries in Bangladesh regarding their performance in wastewater treatment and their progress in achieving zero discharge under 3R plan and also to develop an idea on the technological achievability of ZLD systems both in terms of required time frame of installation and amount/percentage of recycled wastewater.

The specific objectives of the present research are to:

- Analyze 3R plans of different types of textile industries (e.g., dyeing plant, washing plant, composite plan etc.) to assess technological schemes to achieve ZLD
- Evaluate the consistencies of present ZLD-ETP status with the proposed 3R plan (both in terms of design layout and time frame of installation) and monitor the performance of the ZLD-ETP system.
- Assess the baseline condition of industry's treated effluent quality and water use and reuse scenario.
- Evaluate performance of different ZLD technologies in terms of cost and level of treatment achieved
- Identify the handling and disposal system of sludge, specially the reject/concentrate from ZLD units in different industries
- Develop a database for different ZLD technologies for easier understanding of performance and suitability of technologies for different types of textile industries
- Evaluate the overall drop of groundwater extraction (qualitatively, if not possible quantitatively) in respective industries due to implementation of 3R plan and evaluate how implementation of the ZLD system is contributing to the reduction of groundwater extraction.

RESEARCH METHODOLOGY

The present action-research required support from DoE for carrying out initial document (3R plans) review and then water sampling collection from ZLD-ETPs in different industries. Firstly, DoE approved 3R plans of different industries (about 25) have been collected from different zonal offices of DoE to review the zero discharge/3R plans, timeline of implementation of proposed 3R plan and water reuse scenario in the industry. This review work has helped the study team in identifying the industry type, ZLD technologies proposed, timeline of implementation, and enhancement of water reuse due to implementation of 3R plan.

After this initial review, 20 industries have been selected considering industry types, ZLD technologies and time frames, for field visit. Among the 20 industries, 10 industries represent those industries that have submitted their plan for zero discharge and approved by DoE and specified as ZLD-ETP industries in the present report. The other selected 10 industries are those who do not have approved 3R plan and are running with only conventional ETP and is specified as ETP industries in the present research. It is mentioned here that for the sake of the industries, the name and address of the industries are not mentioned in this report; the industries are designated by numbers. The industries with approved zero discharge plans are represented by Z-1 to Z-10 and industries without zero discharge plans but only ETPs are represented by E-1 to E-10. The field visit has been planned to evaluate the progress of work in the industries regarding its wastewater treatment and to find out the consistencies with the 3R plan (both in terms of design layout and time frame of installation). The field visit was conducted between 06/05/2017 and 17/06/2017. During the visit, wastewater samples were collected from different locations of the ZLD-ETP, as shown in Figure E.1, to assess the treatment efficiency of the combined primary and secondary (conventional ETP treatment units) and tertiary treatment units (proposed ZLD units). Here, the influent raw wastewater quality and treated effluent quality from ZLD units were used to assess the overall treatment efficiency of the ZLD-ETP system. On the other hand, water characteristics from secondary treatment units and treated effluent from ZLD unit was used to determine the treatment efficiency of the ZLD technology.

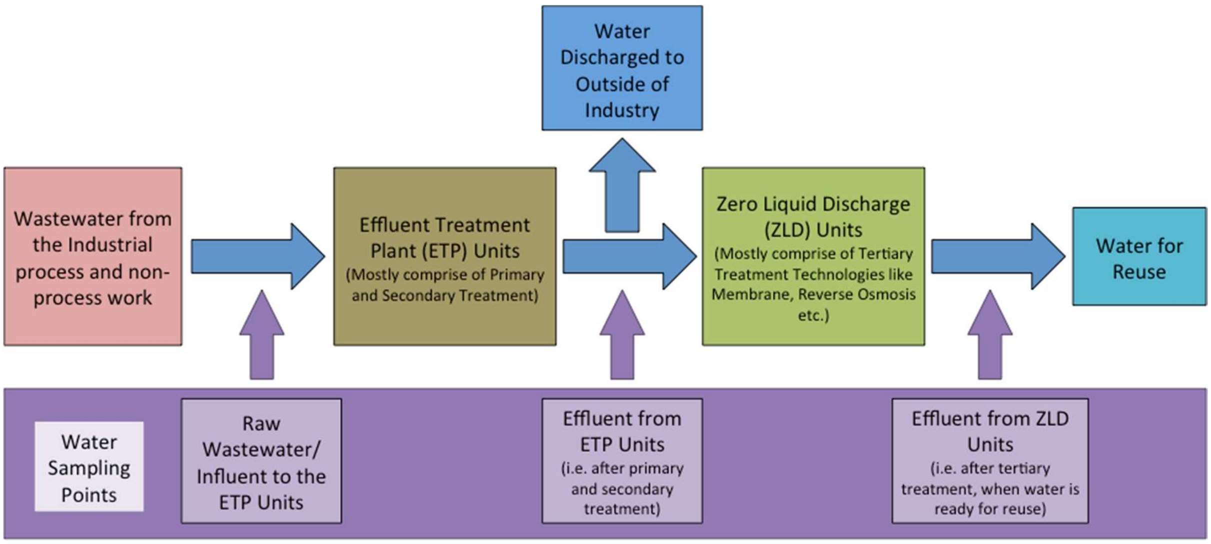

Figure E.1: Simplified layout of a Zero Liquid Discharge Effluent Treatment Plant (ZLD-ETP) showing locations of water sampling in the present action research

A questionnaire survey has also been conducted while visiting the industry. The survey included the collection of information on overall water reuse practices and the cost (capital and operational) of ETP. Moreover, the total percentage of flow from the ETP reused/recycled in the process and non-process purposes has also been assessed from the field data. Disposal of sludge and handling mechanism of reject/concentrate wastewater from ZLD units in different industries has been noted and relevant cost association was recorded during the field visit.

These data would have enabled development of a database for different ZLD treatment technologies in terms of treatment efficiencies, cost, and suitability for a particular type of industry in future.

ANALYSIS AND DISCUSSION

The present action research has been undertaken with an objective to investigate the status of textile industries in Bangladesh regarding their performance in effluent treatment and their progress in achieving zero discharge under 3R plan. Keeping this objective in view, a detail analysis has been carried out using the collected data, information and laboratory test results in order to get a clear understanding of the existing status of ZLD-ETP systems of textile industries. The discussion is focused in the light of the objectives and outcomes of this research.

General Information of Studied Industries

The industries selected in the present research vary in size (area), investment cost, production capacity, type and also the wastewater treatment technology. Table E.1 shows the information collected on individual industry.

Table E.1: General Information of Selected Industries

Industry ID	Production Capacity	Industry Type	Water Consumption	ETP capacity	ETP Investment cost (BDT)	Treatment Technology
Z-1	20 ton/day	Composite (Knitting, Dyeing, finishing, Yarn dyeing, Zipper Dyeing and RMG)	3000 m^3/day	2400 m^3/day	10 Crs	Physico-Chemical followed by biological
Z-2	6 ton/day	Composite (Dyeing and RMG)	800 m^3/day	640 m^3/day	90 Lacks	Physico-Chemical followed by biological
Z-3	8-9 ton/day	Dyeing	600 m^3/day	800 m^3/day	2 Crs	Physico-Chemical followed by biological
Z-4	40 ton/day	Composite (Knitting, Dyeing and Finishing)	6044 m^3/day	4800 m^3/day	4 Crs	Physico-Chemical followed by biological
Z-5	120000 Yards/day	Dyeing& Finishing	300 m^3/day	240 m^3/day	70-80 Lacks	Physico-Chemical

Industry ID	Production Capacity	Industry Type	Water Consumption	ETP capacity	ETP Investment cost (BDT)	Treatment Technology
						followed by biological
Z-6	22 ton/day	Composite (Dyeing, Finishing and RMG)	3000 m^3/day	3300 m^3/day	6 Crs	SBR+Physico -Chemical
Z-7	6, 00,000 meter/day	Dyeing and Printing	Data Not Found	7500 m^3/day	170 Crs	Biological
Z-8	100000 Metric ton/day	Composite (Knitting, Dyeing, Washing, Finishing)	4870 m^3/day	4080 m^3/day	6 Crs	Biological Process
Z-9	12 ton/day	Composite (Knitting, Dyeing and RMG)	2900 m^3/day	1440 m^3/day	3 Crs	Physico-chemical followed by Biological
Z-10	20.000 pieces /day	Washing and RMG	370 m^3/day	280 m^3/day	Data Not Found	Physico-Chemical
E-1	1,40,000 Yards/day	Dyeing, Washing & Finishing	4800 m^3/day	4800 m^3/day	10 Crs	Physico-chemical followed by biological
E-2	20,000 pieces/day	RMG Washing	1890 m3/day	1440 m^3/day	2 Crs	Physico-Chemical
E-3	8 ton/day	Composite (Knitting, Dyeing, Washing, Finishing)	768 m^3/day	960 m^3/day	3 Crs	Physico-chemical followed by Biological
E-4	10-11 ton/day	Dyeing, Washing	1200 m^3/day	1200 m^3/day	2.5 Crs	Physico-Chemical
E-5	4.5 ton/day	Dyeing	450-500 m^3/day	840 m^3/day	1.2 Crs	Physico-Chemical
E-6	8 ton/day	Knitting, Dyeing, Finishing	806 m^3/day	720 m^3/day	Data Not Found	Physico-Chemical
E-7	1 ton/day	Dyeing	5 m^3/day	15 m^3/day	40 Lacks	Physico-Chemical

Industry ID	Production Capacity	Industry Type	Water Consumption	ETP capacity	ETP Investment cost (BDT)	Treatment Technology
E-8	0.1- 0.2 ton /month	Washing	4-5 m^3/day	5 m^3/day	25-30 Lacks	Electro-Chemical
E-9	10 ton/day	Knitting, Dyeing, Finishing	960 m^3/day	1200 m^3/day	2.5 Crs	Physico-chemical followed by biological
E-10	1,50,000 Yards /day	Dyeing	2500 m^3/day	2400 m^3/day	34 Crs	Anaerobic Biological (UASB)

Table E.1 shows that the studied industries vary widely in production capacities, ETP capacities and investment costs for the ETPs. It is worth mentioning that area allocated for ETP also varies greatly from industry to industry. Some industries use huge area for ETP units, especially for biological (ASP) treatment process. The industries which are located within BSCIC area generally have space constraint. It is difficult to accommodate biological treatment units in the available space and are fully dependent on chemical process, which increases the treated effluent TDS as well as volume of sludge.

Baseline Status of Textile Industries' Effluent Treatment

Of the twenty industries selected for this study nineteen industries are running with ETP only and one industry has ETP with ZLD (in the form of RO system). Therefore, comparison of performance between these two unequal groups would be improper. Moreover, the industry with RO system has only the Washing Plant whereas others are of various types. Therefore, it would be appropriate to consider all the industries as one group while evaluating their performance in treating the industrial effluent.

The baseline scenario of the influent to the ETP and treated effluent of the ETP of the studied industries (20) are presented in Table E.2 and Table E.3.

From Table E.2, it is evident that the wastewater of textile industries is heavily polluted with high organic loading, less dissolved oxygen, and high dissolved solids which should not be discharged directly into the environment without treatment. The data shown in Table E.3 indicates that the concentrations of the parameters of most of the industries' treated effluent are within the allowable limit set by ECR, 97, except for DO and TDS. Therefore, the treatment of textile industry effluent scenario is not so dismal.

Table E.2: Influent Wastewater Characteristics of Textile Industries

Industries	Wastewater Quality Parameters										
	pH	Color (Pt-Co)	Turbidity (NTU)	DO (mg/L)	BOD_5 (mg/L)	COD (mg/L)	EC (µs/cm)	Cl^- (mg/L)	NH_3-N (mg/L)	PO_4^{3-} (mg/L)	TDS (mg/L)	TSS (mg/L)
Z1	7.51	256	55.3	0.31	240	541	1772	180	0.942	1.38	1410	65
Z2	7.4	186	94.7	0.16	116	228	1240	390	1	0.325	669	94
Z3	9.83	1150	27.1	0.09	104	328	4520	150	2.21	0.95	3402	93
Z4	8.98	4000	49.7	2.73	160	816	13700	7400	5.94	0.147	10710	128
Z5	10.07	2340	361	0.19	720	3600	1264	135	5.32	0.298	1021	402
Z6	10.54	484	66.6	5.14	187.5	505	2660	205	1.19	0.299	1848	53
Z7	11.56	4500	249	0.81	700	1232	4410	380	11.63	4.74	3756	428
Z8	10.09	2650	746	1.0	140	561	2140	290	5.24	1.5	1418	128
Z9	9.74	3780	59.9	0.08	840	1728	7870	150	7.63	4.82	6226	350
Z10	7.88	78	85.1	5.59	100	320	540	165	2.26	0.058	341	129
E1	11.51	800	303	0.31	920	1856	3760	340	0.468	0.91	2736	242
E2	7.03	36600	371	5.64	240	687	755	240	1.46	0.16	678	586
E3	9.5	1700	88.2	0.11	112	372	3700	230	1.99	1.09	2804	240
E4	9.15	1420	219	0.1	256	704	4320	540	2.09	0.275	3302	226
E5	7.77	202	74.3	0	220	443	2710	140	0.54	1.04	2000	72
E6	7.72	1396	101	0.05	300	794	7120	350	2.03	0.392	5550	231
E7	7.68	1070	98.6	0.08	80	660	755	165	2.77	0.02	634	36
E8	5.63	53	51	4.25	28	137	863	125	1.23	0.038	601	93
E9	6.85	5500	56	5.21	128	698	6320	110	11.5	0.37	708	124
E10	11.52	8500	744	0.05	1160	2078	7370	520	14.46	2.35	1078	396
Range (min. – max.)	5.63 - 11.56	53 - 8500	27.1 - 746	0 - 5.64	28-1160	137-3600	540-13700	110-7400	0.468-14.46	0.02-4.82	341-10710	36-586
ECR, 1997 (Discharge into surface water)	6.0-9.0	-	-	4.5-8.0	≤ 50 at 20^0C	≤ 200	≤ 1200	≤ 600	≤ 5	-	≤ 2100	≤ 150

Table E.3: Characteristics of Treated Effluent of Textile Industries

Industries	Treated Effluent Parameters											
	pH	Color (Pt-Co)	Turbidity (NTU)	DO (mg/L)	BOD_5 (mg/L)	COD (mg/L)	EC (µs/cm)	Cl^- (mg/L)	NH_3-N (mg/L)	PO_4^{3-} (mg/L)	TDS (mg/L)	TSS (mg/L)
Z1	8.13	125	14.9	1.87	10	70	2280	180	0.338	0.08	1542	8.13
Z2	8.09	87	9.04	4.08	9.6	42	2460	510	1.69	0.492	1610	8.09
Z3	8.24	55	11.2	5.08	8	67	1841	455	0.55	0.105	1184	8.24
Z4	7.71	920	8.23	3.79	24	283	3590	405	1.05	2.435	2622	7.71
Z5	7.81	400	60.2	0.26	140	553	1148	365	1.5	0.095	840	7.81
Z6	7.6	284	11	0.15	26	80	4550	295	3.06	0.81	3173	7.6
Z7	7.32	1020	4.36	0.32	18	122	4360	90	1.712	3.2	3364	7.32
Z8	7.49	1150	5.58	4.23	5	57	3330	325	1.295	2.5	2289	7.49
Z9	6.9	310	25.5	5.39	32.5	95	5650	395	0.483	13.21	4137	6.9
Z10	6.52	10	0.72	3.67	0.4	5	367	200	0.465	0.055	187	6.52
E1	7.32	32	8.62	5.25	12.8	68	2160	680	0.469	0.505	1354	43
E2	6.99	110	14.3	0.25	56	159	1235	540	1.103	0.073	858	28
E3	7.72	148	8.62	5.39	8	44	1560	300	1.17	0.132	1107	35
E4	7.12	335	57.4	0.06	192	359	4090	470	0.457	0.082	3051	60
E5	7.4	113	33.2	0.05	40	119	2660	135	0.652	0.242	1790	45
E6	7.43	231	25.2	0.05	220	389	7000	600	2.9	0.256	5224	28
E7	7.3	85	4.07	0.38	10	67	1020	275	1.275	0.05	775	42
E8	7.64	13	1.29	6.07	1.2	7	1533	265	0.567	0.2	989	15
E9	7.47	820	23.9	5.24	7	53	3280	260	1.825	2.32	2298	27
E10	7.48	10	1.2	5.39	0.4	5	264	80	0.224	0.445	173	11
Range (min. – max.)	6.52-8.24	10-1150	0.72-60.2	0.05-6.07	0.4-220	5-553	264-7000	80-680	0.224-3.06	0.05-13.21	173-5224	7-72
ECR, 1997 (Discharge into surface water)	6.0-9.0	-	-	4.5-8.0	≤ 50 at 20^0C	≤ 200	≤ 1200	≤ 600	≤ 5	-	≤ 2100	≤ 150

The concentration of DO, BOD_5, COD and TDS of ten ZLD-ETP industries are presented in Figures E.2 to E.5.

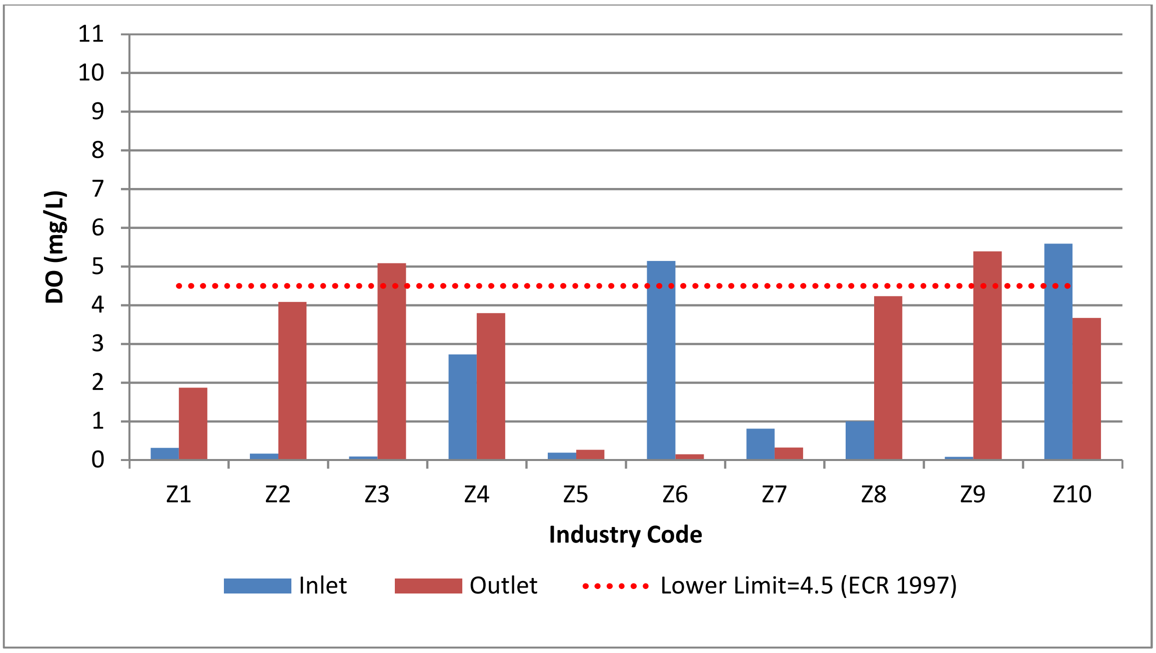

Figure E.2: Variation of DO Content of Selected ZLD-ETP Industries

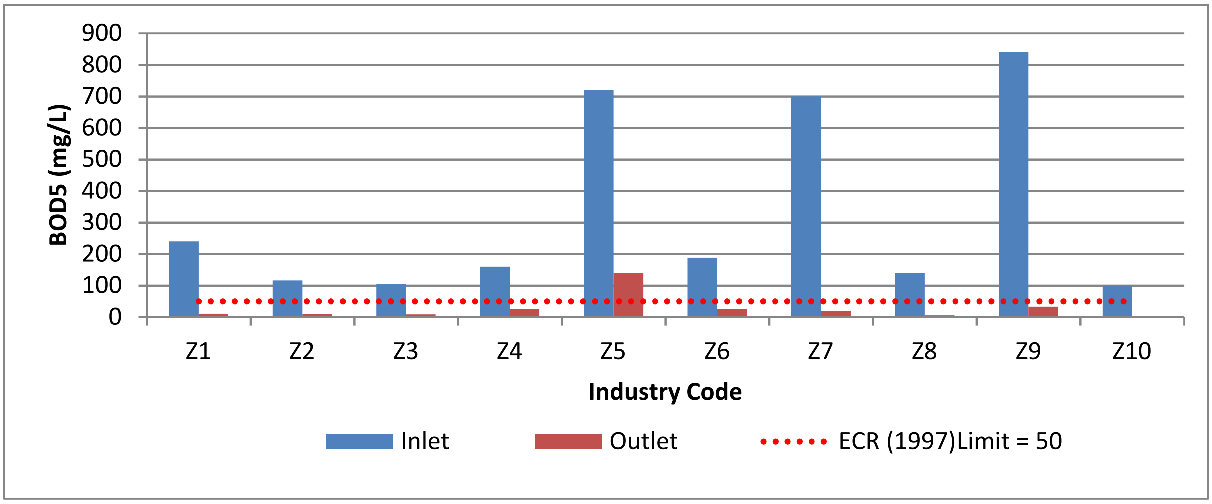

Figure E.3: Variation of BOD_5 Concentration of Selected ZLD-ETP Industries

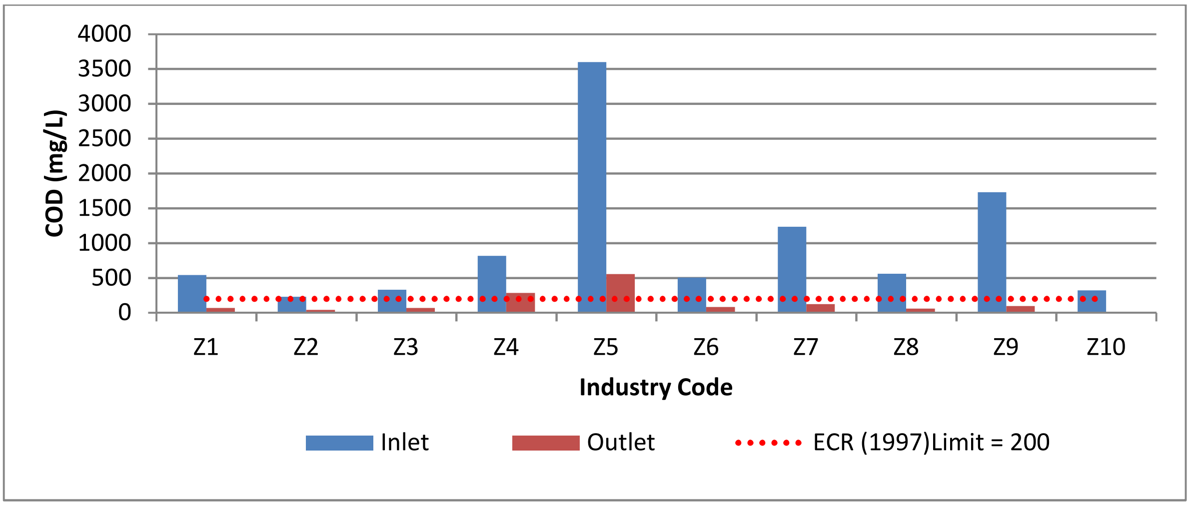

Figure E.4: Variation of COD Concentration of ZLD-ETP Industries

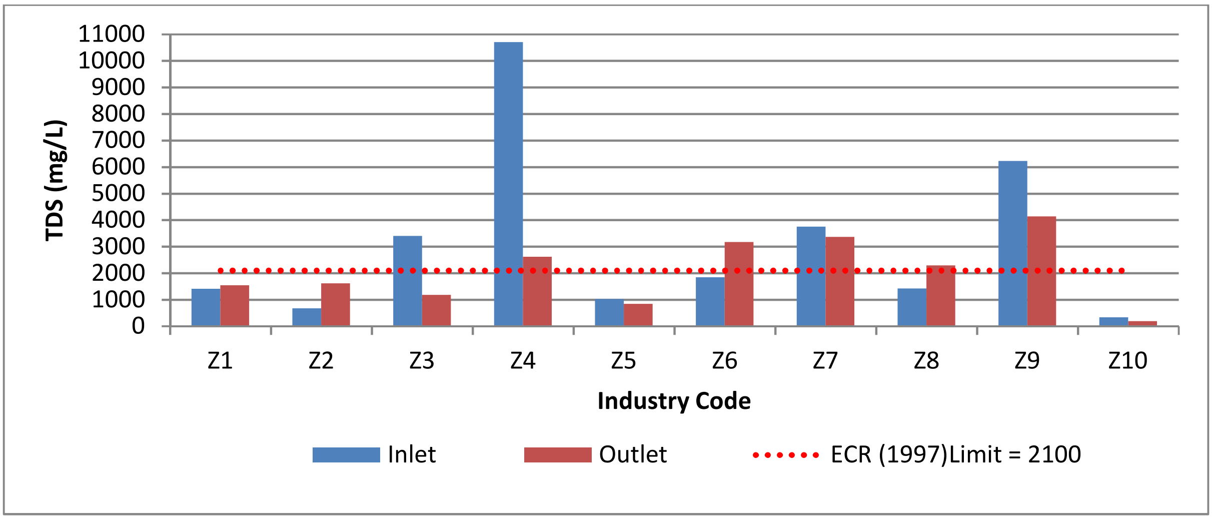

Figure E.5: TDS Variation among the ZLD-ETP Industries

The concentration of DO, BOD, COD and TDS of ten ETP industries are presented in Figures E.6 to E.9.

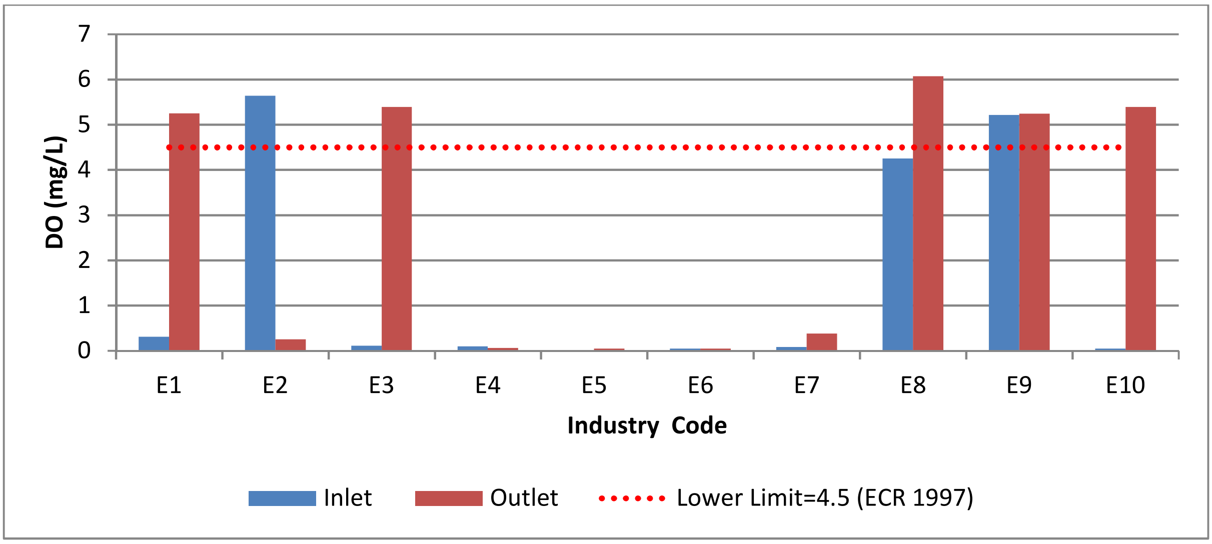

Figure E.6: Variation of DO Concentration of Selected ETP Industries

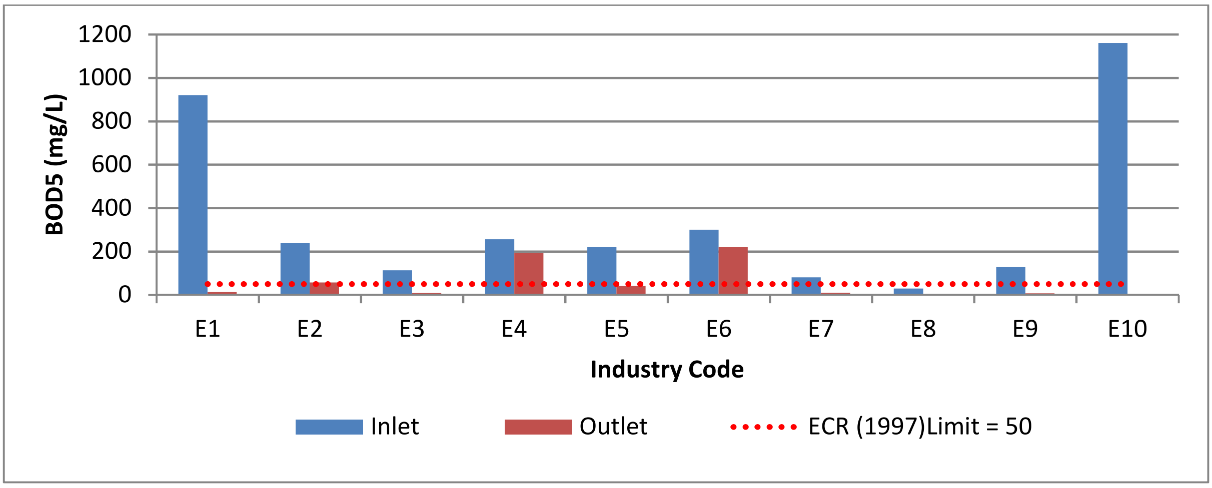

Figure E.7: Variation of BOD_5 Concentration of Selected ETP Industries

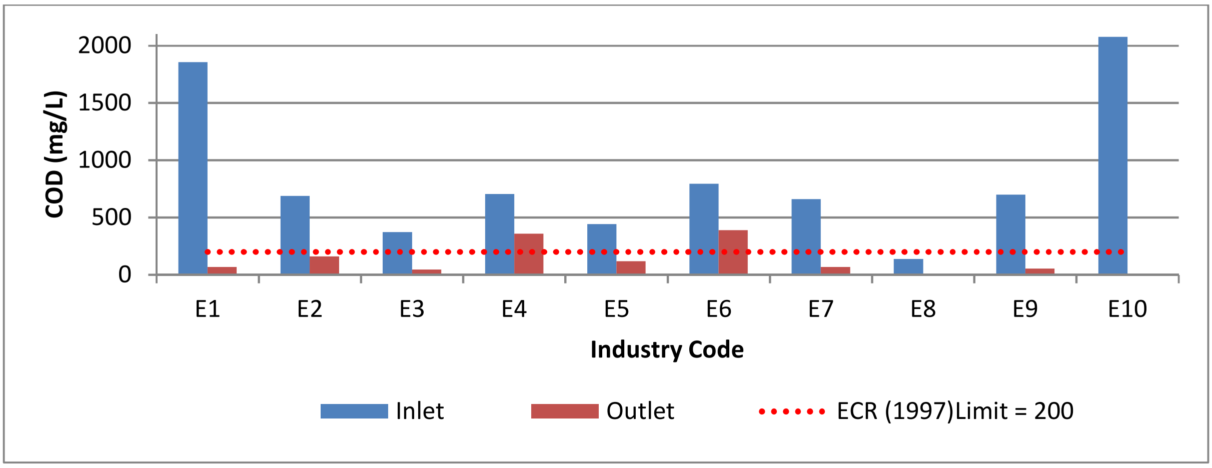

Figure E.8: Variation of COD Concentration of Selected ETP Industries

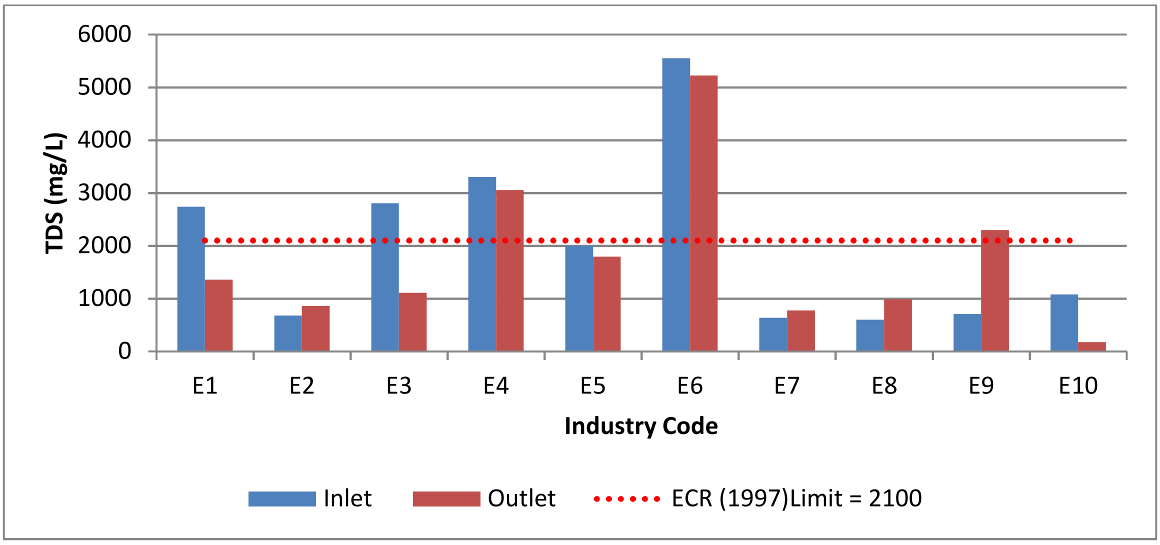

Figure E.9: TDS Concentration Variation of Selected ETP Industries

Considering individual industries compliance status, it has been found (Table E.3 and Figures E.2, E.3 E.4, E.5, E.6, E.7, E.8 and E.9) that 8 industries fail to comply with TDS, 13 industries fail to comply with DO, 3 industries fail to comply with BOD_5 and 4 industries fail to comply with COD Standard (ECR, 97). Therefore, it can be said that ETP of the studied industries is effective in reducing BOD_5 and COD but not so effective in reducing TDS and complying DO content. The color removal efficiency of ETP is also not noticeable, although there is no standard for Color. Of all the industries studied, the color removal of industry E-10 is very good (100%), which have Upflow Anaerobic Sludge Blanket (UASB) technology to treat its wastewater.

Assessment of Pollution Load

Performance of an ETP depends not only on the physico-chemical and biological processes but also largely on the pollutant loadings it has to endure. Usually, an ETP is designed for a specific average and a peak flow and/or loading. Unfortunately, sustained high loading endured by an ETP reduces its performance significantly. The loading rates of different pollutants at ETPs of the ZLD-ETP and ETP (Only) industries are given in Tables E.4 and E.5 respectively.

Information collected from the ZLD-ETP industries show that Z-7 industry receives about 0.92 tons of pollutants exerting COD per day. Although it treats 90% of this load, it discharges almost 2 tons of COD to the receiving environment every day. This factory discharges about 13 tons of NH_3-N, 25 tons of TDS, 0.25 tons of TSS, and 0.68 of chloride in the receiving environment per day. In general, this industry fails to perform adequately to achieve the objectives, but it performs very well in removing organic loading in the form of BOD_5, where it receives 5.25 tons and discharges only 0.13 tons in the receiving environment every day.

Table E.4: Influent and Effluent Loadings on Ten ZLD-ETP industries

Industry Code		Pollution Loading (kg/day)					
		NH_3-N	TDS	TSS	BOD_5	COD	Cl^-
Z-1	Inlet	2.261	3384	156	576	1298	432
	Outlet	0.811	3701	122	24	168	432
Z-2	Inlet	0.64	428	60	74	146	250
	Outlet	1.082	1030	33	6	27	326
Z-3	Inlet	1.768	2722	74	83	262	120
	Outlet	0.44	947	14	6	54	364
Z-4	Inlet	28.512	51408	614	768	3917	35520
	Outlet	5.04	12586	96	115	1358	1944
Z-5	Inlet	1.276	245	96	173	864	32
	Outlet	0.36	202	17	34	133	88
Z-6	Inlet	3.95	6098	175	619	1667	677
	Outlet	10.098	10471	102	86	264	974
Z-7	Inlet	87.225	28170	3210	5250	9240	2850
	Outlet	12.84	25230	255	135	915	675
Z-8	Inlet	21.359	5785	522	571	2289	1183
	Outlet	5.284	9339	184	20	233	1326
Z-9	Inlet	10.98	8965	504	1210	2488	216
	Outlet	0.696	5957	88	47	137	569
Z-10	Inlet	0.361	55	21	16	51	26
	Outlet	0.074	30	1	0.1	1	32
Minimum	Inlet	0.36	55	21	16	51	26
	Outlet	0.07	30	1	0.1	1	2
Maximum	Inlet	87.23	51408	3210	5250	9240	35520
	Outlet	12.84	25230	255	135	1358	1944
Average	Inlet	15.83	10726	543	934	2222	4131
	Outlet	3.67	6949	91	47.3	329	673

Information collected from the ETP industries show that E-1 industry receives the highest amount of pollutants exerting COD per day (about 8.9 tons/day). However, it removes 96% of COD load and discharges about 4% to the receiving environment every day. Performance of E-1 industry in treating BOD_5 loadings is significant removing 98.5% of received load. On the other hand, E-10 industry receiving about 5 tons of pollutants exerting COD per day removes

99.75% of the same. This factory also receives significantly high NH_3-N loading (34 kg/day), successfully removing 98% of the same.

Table E.5: Influent and Effluent Loadings on Ten ETP industries

Industry Code		Pollution Loading (kg/day)					
		NH_3-N	TDS	TSS	BOD_5	COD	Cl^-
E-1	Inlet	2.246	13133	1162	4416	8909	1632
	Outlet	2.251	6499	206	61	326	3264
E-2	Inlet	2.105	976	844	346	989	346
	Outlet	1.588	1236	40	81	229	778
E-3	Inlet	1.914	2692	230	108	357	221
	Outlet	1.123	1063	34	8	42	288
E-4	Inlet	2.508	3962	271	307	845	648
	Outlet	0.548	3661	72	230	431	564
E-5	Inlet	0.453	1680	60	185	372	118
	Outlet	0.548	1504	38	34	100	113
E-6	Inlet	1.458	3996	166	216	572	252
	Outlet	2.088	3761	20	158	280	432
E-7	Inlet	0.042	10	1	1.2	10	2
	Outlet	0.019	12	1	0.2	1	4
E-8	Inlet	0.006	3	0	0.1	1	1
	Outlet	0.003	5	0	0	0	1
E-9	Inlet	13.8	850	149	154	838	132
	Outlet	2.19	2758	32	8	64	312
E-10	Inlet	34.704	2587	950	2784	4987	1248
	Outlet	0.538	415	26	1	12	192
Minimum	Inlet	0.01	3	0.47	0.14	0.69	0.63
	Outlet	0.00	5	0.08	0.01	0.04	1.33
Maximum	Inlet	34.70	13133	1162	4416	8909	1632
	Outlet	2.25	6499	206	230	431	3264
Average	Inlet	5.92	2989	383	852	1788	460
	Outlet	1.09	2091	47	58	149	595

Evaluation of Zero Discharge Progress

The DoE approved ZD plans under 3R policy were collected from DoE zonal offices. Ten industries were selected for the study after comprehensive review of basic data. (During the field visit of those industries, an attempt was made to observe the 3R measures adopted/ implemented in the respective industry to achieve zero discharge. A comparison was made between the proposed ZD measures and progress/achievement of the ZD plans till June, 2017. Table E.6 shows a summary of this comparison.

Table E.6: Field Observation of Progress/Achievement of ZD/3R plan and the Proposed Measures

Industry Code	ZD/3R plan Approval Date	Proposed ZD/3R units	Implementation till 2017
Z1	Aug-14	1st year: primary treatment unit for 36% reuse (Scouring, bleaching, washing) 2nd year: extra clarifier, sand filter, and AC filter for 25% reuse (Gardening, washroom, fire fighting) 3rd year: sand filter, AC filter for medium and fine filtration for 30% reuse (washing unit & household purpose) 4th year: RO unit for 8% reuse (main dyeing process & final washing) 5th year: Evaporation unit in RO system & 1% water is evaporated in air (salt recovery)	☑ Primary treatment unit ☒ Extra clarifier ☒ Sand filter ☒ Activated carbon filter ☒ RO unit ☒ Evaporation unit Provision of 180.5 m^3 storage tank of ETP treated recycle water for fire fighting
Z2	Oct-14	1st Phase- 20% (1st year) : 176 m^3/day water reuse in Toilet flashing, chemical dosing tank, car & floor washing, fire fighting, road washing and others Treated water (reservoir cum sedimentation tank)→ MGF→ ACF →Reuse 2st Phase- 80% (3st year) : 704 m^3/day water reuse in Dyeing unit and bathrooms. Sedimentation tank→ Flocculation→ Lamella clarifier→ MGF → ACF→ Micron filter →Softener → RO unit →Reuse	☑ Multi-grade filter ☒ Activated carbon filter ☒ Reservoir cum sedimentation ☑ Flocculation tank ☒ Lamella clarifier ☒ Softener ☒ Micro filter ☒ Ro unit 10-15 % water reuse in gardening & car wash
Z3	Jan-16	1st and 2nd year (1st stage): reuse of effluent treated water 3rd year (2nd stage): RO unit & incinerator plant	☒ RO unit ☒ Incinerator unit No reuse
Z4	Jan-16	1st year: primary treatment unit for 36% reuse (Scouring, bleaching, washing) 2nd year: extra clarifier, sand filter, and AC filter for 25% reuse (Gardening, washroom, fire fighting)	☑ Primary treatment unit ☑ Extra clarifier ☒ Sand filter ☒ Activated carbon filter

Industry Code	ZD/3R plan Approval Date	Proposed ZD/3R units	Implementation till 2017
		3rd year: sand filter, AC filter for medium and fine filtration for 30% reuse (washing unit & household purpose) 4th year: RO unit for 8% reuse (main dyeing process & final washing) 5th year: Evaporation unit in RO system & 1% water is evaporated in air (salt recovery)	☒ RO unit ☒ Evaporation unit 5 m^3 reuse for gardening
Z5	Jan 15	1st year: primary treatment unit installation for 36% reuse (Scouring, bleaching, washing) Sedimentation tank→ MG filter→ AC filter→ Softener → Micron filter→ Reuse 2nd year: Extra clarifier , Sand filter, Carbon filter for 55% water reuse in Reuse in Dyeing & washing unit and gardening, washroom, fire fighting Sedimentation tank→ Flocculation→ Lamella clarifier→ MGF → ACF→ Micron filter →Reuse 3rd year: medium and fine filtration in outlet and RO unit for 8% water reuse in dyeing unit and rest 1% water in Evaporation unit to blow in air.	☑ Primary treatment unit ☑ Sedimentation tank ☒ Multi-grade filter ☒ Activated carbon filter ☒ Softener ☒ Micron filter ☒ Extra clarifier ☒ Sand filter ☑ Flocculation tank ☒ Lamella clarifier ☒ Evaporation unit No reuse
Z6	April-14 03/04/2014	1st Phase- 20% (1st year) : 360 m^3/day water reuse in Toilet flashing, chemical dosing tank, car & floor washing, fire fighting, road washing and others Treated water (reservoir cum sedimentation tank)→ MGF→ ACF →Reuse 2st Phase- 80% (3st year) : 1440 m^3/day water reuse in Dyeing unit and bathrooms. Sedimentation tank→ Flocculation→ Lamella clarifier→ MGF → ACF→ Micron filter →Softener → RO unit →Reuse	☑ Primary treatment unit ☑ Sedimentation tank ☑ Multi-grade filter ☑ AC filter ☑ Flocculation tank ☒ Lamella clarifier ☒ Micron filter ☒ Softener ☒ RO unit Exhaust Gas Boiler (EGB), Boiler with default Economizer, Rain water harvesting, Heat recovery in finishing, Hot water Chiller, Servo motor M/C in sewing machine, Heat Trap in

Industry Code	ZD/3R plan Approval Date	Proposed ZD/3R units	Implementation till 2017
			Ironing machine, LED light, Soft start-up washing m/c
Z7	Apr-15	1st year: Hot Water Recovery, Automation System, Energy & Gas Savings, Wastewater Line Segregation and installation of Plumbing system, Dyeing cooling water recycle, Wastewater Recycle First Phase, Caustic Recovery Plant, Magneto Hydro Dynamics Installation, Water Flow meter Installation 2nd year: Rain Water Harvesting, WTP new reserve tank for blackwash water storage, Bio Gas Plant, Sludge Disposal & Management 3rd year: Salt recovery Plant, Wastewater Recycle Second Phase, Sewage Treatment Plant	☑ Automation System ☑ Water Flow meter Installation ☑ Energy saving ☑ Plumbing system ☒ Waste water recycle 1st phase ☒ Caustic recovery ☒ Magneto Hydro Dynamics ☒ Rain water harvesting ☒ New reserve tank for backwash ☒ Biogas plant ☒ Salt recovery plant ☒ STP ☒ Waste water recovery 2nd phase No reuse
Z8	Jan 17	1st year: Water consumption reduction (60 gallon/kg), Minimization of water loss, Recycling of dyeing water 2nd year: Rain water harvesting, Salt recovery 3rd year: ETP expansion, Flow segregation, Ultra-filtration	☑ Low Liquor ratio machine for water consumption reduction ☑ Minimization of water loss ☒ Recycling of dyeing water ☒ Rain water harvesting ☒ Salt recovery ☒ ETP extension ☒ Flow segregation ☒ Ultra-filtration No reuse
Z9	May-14	1st year: Hot Water Recovery 2nd year: Rain water harvesting	☑ Hot water recovery from boiler ☑ Condense recovery ☑ Cooling water reuse

Industry Code	ZD/3R plan Approval Date	Proposed ZD/3R units	Implementation till 2017
		3rd year: Energy Savings, Wastewater line segregation and installation sanitary work, WTP new reserve tank for backwash water storage, Magneto hydro dynamic Installation 4th year: Waste water recycling 1st phase 5th year: Salt recovery plant installation, Waste water recycling 2nd phase (RO), STP installation	☒ Rain water harvesting ☑ Low liquor ratio in dyeing machine ☑ Servo motor for all sewing machine ☑ EVC (Electronic Volume Control meter) ☑ LED light for energy saving ☑ Boiler within built Economizer ☒ RO unit ☒ Salt recovery plant ☒ STP
Z10		Data not available	☑ Primary treatment unit ☑ Flocculation tank ☑ RO unit ☑Treated and RO outlet water tank of capacity 500 m^3 for reuse in washing M/C as per process requirement ☑ Flash water tank of capacity 125m^3 for toilet flashing. ☑ Final treated water tank of dimension 0.98m x 0.75m x 0.88m

From Table E.6, it is evident that although the ten industries were selected as ZLD-ETP industries after reviewing their approved 3R plans, in reality, except for one industry (Z10), none of the industries has ZLD units (such as RO, Evaporation unit, Salt Recovery Plant, Micro Filter, etc.). Industry Z-10 has installed RO unit with ETP and it is the only industry that is reusing the final treated water in its process. Therefore, the other nine industries should not be treated as ZLD-ETP industries; they are ETP industries in reality.

Although most of the industries (90%) have not implemented the units/ components mentioned in their 3R plans yet, many industries have adopted various measures to reduce the discharge and emission and are recovering some heat energy and recycling some amount of ETP treated water in different purposes. The most common features are recycling a certain percentage (varies from 5% to 30%) of treated water for gardening, fire-fighting and toilet flushing. Industry Z-6 has adopted many measures such as heat recovery in finishing, hot water recovery from boiler and condensate recovery. It uses Low Liquor Machine in dyeing which consumes less water. It has installed boiler with built equalizer for less gas use. It is using cooling water in dyeing unit. There is newly installed Rain Water Harvesters (RWH) to store rain water for use as process water. Some of their energy conservation measures include LED lights, sewing machines requiring less energy, heat trap in ironing machine, soft-start washing machines, etc. According to them, a small portion of treated water is used in chemical mixing and use of low volume toilet flush and water tap also help save water. It appears that this industry is very active in reduce, reuse and recovery processes. Industry Z-9 also adopted similar types of measures in reduce, reuse and recovery (Table E.6). The total reuse and recycle achievement of Z-10 is 63% because of employing RO with ETP. In addition to that, industry Z-10 uses water and energy saving washing machines in washing unit and water saving sanitary fixtures. It also recovers and reuses condensate. The performance of Industry Z-3 and Z-5 is very poor in achieving 3R goals. Industry Z-8 has received approval in January, 2017 and it has two and a half year remaining to implement the proposed plan.

The DoE started giving approval of ZD/3R plan in 2014. The industries have to implement the plan phase by phase in 3 years' timeline. The present study was undertaken with a view to find out how the industries have progressed with the implementation of their proposed plan to achieve Zero Liquid Discharge. One of the objectives was to assess the consistency of the proposed 3R plan with the actual scenario. It has been found during this research that although the industries have proposed implementing ZLD units in their industry, very little progress have been achieved so far. Of the ten selected industries as ZLD-ETPs, only one industry was found to have RO system, the other nine industries have yet to start implementing. Some industry time line has already expired and others are approaching the end. There are many reasons behind this poor level of progress. It was learnt from the industries that despite all the good intention they are unable to implement the proposed plans because of many constraints. Some industries have huge space limitations, especially those located in BSCIC Industrial area. Some industries have financial constraint, whereas, other industries are struggling with the running of ETP smoothly. A few are investing in expanding their production capacity, giving less priority on ZLD implementation. The research team held dialogues with the ETP personnel and learnt that the industries have many queries and confusions regarding the ZLD system.

According to them, the ZLD technologies are highly sophisticated, advanced system requiring skilled and experienced staff to run. There is a serious dearth of skilled personnel. Capacity building through training and hands-on teaching in this sector should be given priority. The effectiveness and sustainability of ZLD units mostly depend on the efficient performance of ETP. Otherwise any advanced system such the RO system will need frequent membrane replacement. Unfortunately, performance of the ETPs of many industries is not even good enough to comply with the national standard, let alone achieving 100% zero liquid discharge. Another reason for not achieving much progress in ZLD is that many industries have submitted the plans to get the clearance from DoE, but they do not know how to proceed with the implementation process or are not yet ready to implement those plans.

During the survey, it was observed that the industries without ZD plans are also practicing reduce, reuse/recycle and recovery measures in running their industries. Table E.7 shows some 3R measures adopted in industries with only ETPs.

Table E.7: 3R measures adopted in industries with ETPs only

Industry ID	3R Measures
E-1	• Systematic vegetation to increase water retention and recharge of groundwater, • plantation of red oak tree which releases highest O_2 • white road surface to reduce radiation, • cogeneration • Use of hot steam chiller. • Treated water recycles in flushing, gardening, road cleaning, aquaculture etc. • Provision of stone pits for vertical draining, resulting in increased aquifer recharge. • Composting plant using organic waste to make fertilizer. • Liquid indigo is used instead of powder indigo to reduce toxicity and load on ETP. • Around 30 m^3/hr water is saved in finishing unit and reused in WTP • Recovery of condense from boiler and reused. • LED lighting • Total reuse and recycle is around 40% including 18% from ETP water • Paper less policy to reduce the waste and thus conserving the resource. • ETP sludge is recycled in brick making
E-2	• Hot water produced in boiler is recovered. This system was introduced in January 2016
E-3	• Hot water produced in boiler is recovered.
E-4	• No mentionable 3R activities in practice

Industry ID	3R Measures
E-5	• Reuse of dyeing water in boiler. • Use of Low liquor ratio machine reduces amount of water consumption.
E-6	• Hot water produced in boiler is recovered and this system was introduced since 1993.
E-7	• Rain water harvesting RCC reservoir tank of 10,000L capacity was installed in October 2016 which reduces water consumption.
E-8	• Solar panel of capacity 1200 Watt was introduced which reduces energy consumption.
E-9	• No mentionable 3R activities currently.
E-10	• No mentionable 3R activities currently.

From this study, it was found that not only the industries which have received approval from DoE but also the industries which are yet to submit plans have adopted many 3R measures. One of the industries, E-1 which has not submitted 3R plan, is presently recycling around 40% of its treated water that is being used for many purposes. Other ETP industries are practicing some forms of reduce and recycling measures (Table E.7).

Therefore, it can be said that if the ETP runs effectively, producing improved quality of treated water, then a considerable amount of water can be recycled if the industry is willing.

Regarding the time frame mentioned in the proposed plan to achieve 3R goals, it is found that almost none of the industries comply with the time line mentioned in introducing ZLD units. There may be several reasons behind this: the industries are bit confused about how to proceed with this, some industries have future plans in expanding their business and this may require the extension /up gradation of their ETP which may take time, official complexities, financial constraints etc. If there is any mechanism so that the industry could inform DoE explaining the reason of not complying with 3R goals in proposed time frame, then DoE may help them in resolving their issues.

Assessment of Performance based on technologies

Different types of technologies were observed in textile industry ETPs. Common technologies include physico-chemical (aeration, coagulation-flocculation, clarification and filtration, Dissolved Air Flotation (DAF, electro-chemical coagulation) and activated sludge process (biological). Most common are coagulation and ASP. Few industries were found to use return sludge in their biological treatment process (ASP). Most of the industries have only clarifier/settling tank with long detention time along with chemical treatment (coagulation-flocculation) units which facilitates in decomposing organic load and thus removed by biological process. Due to the wide variation of technologies, it will be very difficult and unrealistic to recommend from this study that one technology is better compared to other or generalized it for treating the wastewater effectively. The reason is that every industry is different in terms of its type, production capacity, wastewater flow rate, raw materials and chemicals use in the process etc. However, some observations were made from the findings of this study and based on these observations, comments can be made which may guide in selecting the right technology. It has found that in some industries, many units are included and the test results show that inclusion of these units is not reducing the contaminants, rather contributing to the pollution load. As for example industry E-6 has two flocculation tanks (one before SBR and another after SBR,) two ozonization tanks (one before SBR and one after SBR), two sets of inclined plate settler (one before SBR and one after SBR), Activated Carbon Filter and Multi-grade Filter in the ETP. To study the effectiveness of these additional treatment units in this ETP, one extra sample was collected at the outlet of SBR in excess of influent and final effluent samples and was analyzed at BUET Laboratory. The test results are shown in Table E.8.

Table E.8: Test Results of Additional Sample at the SBR unit of Z-6

Parameters	Inlet	Before Recycle (after SBR)	Outlet (Final disposal)	Removal Efficiency (%)	
				After SBR	At the outlet
pH	10.54	7.75	7.6	--	---
Color Pt-Co	484	287	284	41%	41%
Turbidity (NTU)	66.6	11.9	11	82%	83%
DO (mg/L)	5.14	0.33	0.15	- 94%	- 97%
BOD_5 (mg/L)	187.5	24	26	87%	86%
COD (mg/L)	505	66	80	87%	84%
EC (µS/cm)	2660	4540	4550	-71%	-71%
Cl^- (mg/L)	205	290	295	-41%	-44%
NH_3-N (mg/L)	1.197	2.19	3.06	-83%	-156%
PO_4^{3-} (mg/L)	0.299	0.738	0.81	-147%	-171%
TDS (mg/L)	1848	3164	3173	-71%	-72%
TSS (mg/L)	53	28	31	47%	42%

From Table E.8, it has been found that the additional units in the ETPs are not so effective in reducing the contaminants, instead the removal efficiency decreased for almost all parameters. Therefore, these units seem unnecessary in ETPs and increase the investment cost and operational cost to ETP. However more tests should be done for establishing this fact.

Performance of the UASB type ETP (Industry E-10) was found to be very promising (Table E.9), specially the color removal (efficiency 100%) and TDS (89%) compared to other industries.

Table E.9: Test Results of UASB system at Industry E-10

Parameters	Inlet	Before UASB	After UASB	Outlet	Removal Efficiency of Neutralization Tank (%)	Removal Efficiency of UASB (%)	Removal Efficiency of Biofilter (%)	Overall Removal Efficiency (%)
pH	11.52	6.90	6.99	7.48	40%	---	---	---
Color Pt-Co	8500	1300	620	10	85%	52%	98%	100%
Turbidity (NTU)	744	60.9	24	1.2	92%	61%	95%	100%
DO (mg/L)	0.05	0.05	0.05	5.39	0%	0%	10680%	10680%
BOD_5 mg/L	1160	550	230	0.40	53%	58%	100%	100%
COD (mg/L)	2078	1234	498	5	41%	60%	99%	100%
EC (µS/cm)	7370	2800	2690	264	62%	4%	90%	96%
Cl^- mg/L	520	540	500	80	-4%	7%	84%	85%
NH_3-N mg/L	14.46	19.60	33.125	0.224	-36%	-69%	99%	98%
PO_4^{3-} mg/L	2.35	15.65	40	0.445	-566%	-156%	99%	81%
TDS mg/L	1078	1734	1532	173	-61%	12%	89%	84%
TSS mg/L	396	90	49	11	77%	46%	78%	97%

It has been found from the study that the performance of UASB and Biofilter is very good, especially in treating BOD_5, COD and color (almost 100%) removal.

The only industry which has RO system as a tertiary treatment is Z-10. Samples were also collected before and after RO unit to assess the performance of RO. Table E.10 shows the performance of RO system.

Table E.10: Test Results of RO system installed at Industry Z-10

Parameters	Inlet	Before RO (after Ion-exchange, coagulation-flocculation)	Outlet	Removal efficiency of ETP (%)	Removal efficiency of RO (%)	Overall Removal efficiency (%)
pH	7.88	6.64	6.52	---	---	---
Color Pt-Co	78	45	10	42%	78%	87%
Turbidity (NTU)	85.1	15.7	0.72	82%	95%	99%
DO (mg/L)	5.59	3.09	3.67	-45%	19%	34%
BOD_5 mg/L	100	11.2	0.4	89%	96%	100%
COD (mg/L)	320	30	5	91%	83%	98%
EC (µS/cm)	540	1369	367	-154%	73%	32%
Cl^- mg/L	165	315	187	-91%	37%	-21%
NH_3-N mg/L	2.258	1.564	0.465	31%	70%	79%
PO_4^{3-} mg/L	0.058	0.162	0.055	-179%	66%	5%
TDS mg/L	341	855	200	-151%	78%	45%
TSS mg/L	129	27	7	79%	74%	95%

Performance of conventional ETP units (coagulation-flocculation and ion-exchange) in this industry is not good regarding color and TDS removal (Table E.10). Instead of reducing TDS, it has increased TDS and the reason might be the use of PAC and Polymer in coagulation-flocculation unit. It is known that RO is very effective in removing TDS and the test results also support that. However, the industry is a washing industry and its influent quality is not as poor as the dyeing industries. Again, the industry has introduced its RO in August, 2016 and as per their records it has not faced the problem of replacing the membrane yet.

It is worthy to mention here that many ETPs (conventional) are performing well and practicing 3R measures (reduce, recycle, recovery) (up to 40%) in their industries. Therefore, if the industry can run their ETP effectively, they can recycle a considerable amount of water without increasing the cost. The ZLD concept is to convert the liquid into solid phase. Unfortunately, this only transfers the problem from liquid phase to solid phase.

Assessment of Cost

An attempt was made to evaluate the cost involvement in wastewater treatment. The study team found it very difficult to get the information on cost involved in ETPs (both capital cost and operational cost) from the industries. Most of the industries could not provide these data since they do not have this in record. Whatever data collected from some of the industries seem to be unrealistic and unreliable (Table E.11). It is observed from the Table E.11, that the investment cost of ETP of all twenty industries varies in a wide range depending on the technology, space and facility but the variation in operational cost of most of the industries is not much different (5.0 – 38.0 Taka/m^3 of water), except for two industries, Z-3 and E-10. Industry E-10 has implemented UASB technology and biofiltration in treating its wastewater in a huge area. Therefore, its investment cost is very high compared to the other industries but the reason for its high operational cost is not known since, it is not using any chemicals, sludge recycling and mechanical aeration in UASB technology. There might be some mistakes in providing the data of operational cost from other industry.

Table E.11: Capital Investment and Operational Cost of Selected ETPs

Industry Name	ETP Operational Cost (BDT/m^3)	ETP Capital Cost (BDT)
Z-1	12-14	10 Crs
Z-2	8	90 Lacks
Z-3	2	2 Crs
Z-4	10	4 Crs
Z-5	20	70-80 Lacks
Z-6	17	6 Crs
Z-7	Data not available	170 Crs
Z-8	12.5	6 Crs
Z-9	24	3 Crs
Z-10	48	Data not available
E-1	23-25	10 Crs
E-2	12-14	2 Crs
E-3	10	3 Crs
E-4	22	2.5 Crs
E-5	37	1.2 Crs
E-6	38	Data not available
E-7	6	40 Lacks
E-8	10	25-30 Lacks
E-9	5	2.5 Crs
E-10	75	34 Crs

It has been found from the study that the land area and treatment technology (includes equipment) dominates capital cost. In addition, lack of skilled manpower in handling of ETP is a major factor influencing operational and maintenance cost. And as industry tends to use more advanced and sophisticated technologies like RO, MEE, Crystallizers, etc, the need of skilled man power in this area will be increasing.

To achieve ZLD, the industry is in need of financial support and technological support from the Government and capacity building should be given priority in this sector.

Assessment of Sludge Management

One of the objectives of this research was to identify the handling mechanism of reject/concentrate of wastewater from ZLD units. Since only one industry in the present study has ZLD (RO) system and they have installed this unit in last year August. Therefore, they have not faced any problem with the disposal of reject/concentrate yet. Again, if there are more industries with RO system in operation, it is quite possible that those are also recent. However, the disposal of this reject will be a concern if more industries are going to install this to obtain the treated water quality as potable water and 100% reuse them in process water.

Regarding the sludge management of ETPs, it has been observed that, few industries have filter press, sludge digester and sludge drying bed for dewatering and decreasing the volume of generated sludge at the ETP. Most of the industries dry the sludge in open air naturally and then store it for days and finally dispose of the sludge in landfills. It has been found from the study that two industries dispose of their sludge with municipal solid wastes. One industry has conducted a research on sludge to investigate the presence of hazardous elements; subsequently is using in agricultural filed. Another industry is using their sludge in brick manufacturing. Amount of sludge generated at ETP is significant occupying large space. The amount of sludge generated in UASB is considerably less than ASP and chemical treatment processes. On the other hand, sludge generated in ASP is less than that in chemical process. Therefore, it is evident that volume of sludge generation also depends on the type of adopted treatment technology. Sludge disposal is still a major problem for the textile industries. The introduction of ZLD units in treatment processes will generate more sludge and disposal of this sludge will be another concern for the industries

Discussion on Operation and Maintenance of ETP

During this study, discussions were held with industries regarding the operation and maintenance related problems in running ETPs. A few of these problems mentioned by the industry personnel are listed below:

- High operational cost;
- Insufficient lab facility and shortage of skilled manpower;
- Consumes huge amount of chemicals in physico-chemical process;
- High volume of sludge generation in physico-chemical process;
- Limited sludge disposal options;

- Lack of landfilling sites for sludge disposal;
- Reduction of TDS in treated effluent is extremely difficult and involves tertiary treatment increasing the cost of operation.

CONCLUSIONS

The major conclusions drawn from this research are as follows:

- The study findings show that the overall scenario of wastewater treatment of textile industries in Bangladesh is fairly good. The randomly selected all the twenty industries have ETPs and the concentration of all tested parameters of most of the industries' treated effluent are within the allowable limit of ECR,97 except DO and TDS.
- Of the twenty industries treated effluent concentration, seven industries comply with the minimum DO requirements and thirteen industries fail to comply; considering BOD_5 concentration, seventeen industries comply and three industries fail; sixteen industries meet the allowable limit of COD and four industries fail to meet; regarding TDS, twelve industries comply with the ECR,97 standards and eight industries fail to comply.
- Nine out of ten selected industries who have approved zero discharge plan, have not implemented ZLD units yet as proposed.
- Although most of the industries do not have ZLD units with their ETPs according to their proposed plan, six industries out of ten such industries, are practicing many 3R measures (reduce, reuse, recovery) at their facility. The common measures are use of water and energy saving machines in the process, use of less toxic chemicals, boiler with built-in economizer, reuse of water in gardening, toilet flushing, fire fighting, condense recovery, heat recovery in finishing, LED lighting, RWH, water saving sanitary fixtures etc.
- The industries without zero discharge plans also have 3R measures in place. Seven industries out of ten are practicing measures such as hot water recovery from boiler, reuse of boiler water in dyeing, use of solar panel, RWH, LED lighting, Low liquor ratio machine etc.
- For the lone ZLD-ETP (RO system with ETP) industry in this research, the total reuse and recycling of treated water is found around 63%.
- The amount of recycled water is found in the range of 5% to 40% considering the industries (nineteen) with conventional (physico-chemical and biological processes) ETP only. The percentage of this reuse is achieved only by applying different measures. It is observed in this study that the industry's good intention is the main driving force of attaining zero discharge.
- The operational cost of ETP varies in the range of Tk. 5.0- 38.0 per m^3 of wastewater treated. No correlation is found between the operational cost of ETP and the production capacity and the technology/processes being used in the treatment process.

- The study observed that attitude of the industry is a major factor in reducing the pollution created by the industry. If the industry feels the responsibility of protecting the environment along with its economic contribution, and act accordingly, only then they will be successful in achieving zero discharge.

RECOMMENDATIONS

Based on the research findings and discussion, following recommendations are made.

- DoE should introduce use of flow meter at the inlet and outlet of every industry. Only by doing this, the amount of reused/recycled treated water can be determined and monitored.
- As ZLD technology is very expensive, there should be some incentive from government in form of subsidy or soft loan for the industry to implement the technology and reduce the pollution.
- If the ETP treated wastewater of the industries can be collected and then treated in a centralized ZLD system, the cost will be less and industries will be able to secure their business as well as the environment
- Before implementing ZLD technology, every industry should ensure that their ETP is performing effectively, otherwise ZLD will not work properly.
- The industries which are in shortage of land (specially in BSCIC area) for accommodating biological and ZLD units, alternative arrangements should be made from the government to treat their wastewater i.e. arrangement for CETP.
- The success of achieving zero discharge also depends on source reduction. Use of less toxic chemicals and advanced machineries in the process reduces the water consumption. Financial support should be given to the industry to promote this, specially for small scale industries.
- There is a dearth of skilled man power in handling, operating and maintaining the advanced technology and sophisticated machines in ETP and ZLD units. Capacity building in this area is strongly recommended.
- There should be some mechanisms/arrangement between DoE and industry so that the industry could inform DoE explaining the reason of not complying with 3R goals in proposed time frame, then DoE may help them in resolving their issues.

The research findings emphasize that if the abovementioned recommendations can be implemented, both the industry and DoE will be benefited and pollution created by textile industries can be managed sustainably and the pollution scenario of the country will improve significantly.

ABBREVIATIONS

ACF	Activated Carbon Filter
ASP	Activated Sludge Process
BOD	Biochemical Oxygen Demand
BTMA	Bangladesh Textile Mills Association
COD	Chemical Oxygen Demand
CEE	Centre for Environment Education
DAF	Dissolved Air Floatation
DoE	Department of Environment
DFID	Department for International Development
ETP	Effluent Treatment Plant
EMS	Environmental Management System
EDR	Electro Dialysis Reversal
GDP	Gross Domestic Product
IFC	International Finance Corporation
MEE	Multi Effect Evaporators
MGF	Multi-Grade Filter
MVR	Mechanical Vapor Reactor
NF	Nano Filtration
PI	Principal Investigator
PSF	Pressure Sand Filter
RO	Reverse Osmosis
RFP	Request for Proposal
SBR	Sequential Bach Reactor
TDS	Total Dissolved Solid
TSS	Total Suspended Solid
TS	Total Solid
UASB	Up-flow Anaerobic Sludge Blanket
WRG	Waterway Recovery Group
WDF	Washing Dyeing Finishing
ZD	Zero Discharge
ZLD	Zero Liquid Discharge
ZWD	Zero Waste Disposal
3R	Reduce Reuse Recycle

Chapter 1

Introduction

1.1 INTRODUCTION

Textile industry is one of the most significant industries in Bangladesh whose contribution in national economy is enormous. This sector currently accounts for more than 80% of Bangladesh's export earnings and more than 10% of the GDP (Sagris and Abott, 2015). The industry however is faced with many challenges due to high resource (energy, water and chemical) use and its consequent environmental impacts, threatening its survival in the long run. Textile industries are heavily dependent on water environment. Figure 1.1 shows the water demand for this sector up to 2030. Most of its water is extracted from groundwater source and a small fraction is from surface water source. The country has around 1700 wet processing units in the textile sector that consumes around 1500 billion liters of groundwater annually (Ashraf, 2015). The huge water is consumed mainly in washing, dyeing and finishing (WDF) units of a composite textile industry. In addition to huge water requirement, the textile industry poses a great threat in relation to environmental management and pollution. Untreated and poorly treated effluent from this industry is commonly disposed of into land or surface water and thus impacting on local communities and ecosystem.

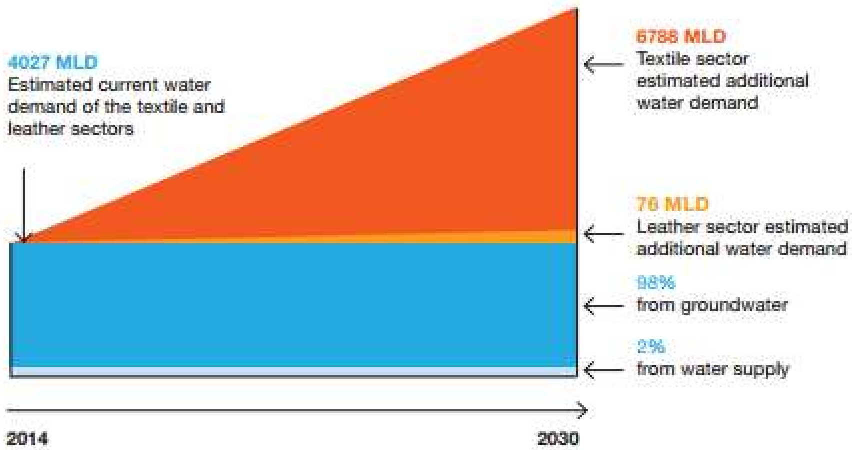

Figure 1.1: Projected water demand in 2030 for the textile and leather sectors (Sagris and Abott, 2015)

Realising the scale of these issues and the urgent need for addressing them, Bangladesh Government has issued the Zero Discharge (ZD) Regulation for the textile sector since early 2014 (DFID, n.d). Development of 3R (reduce, reuse and recycle) strategies will enable the textile sector to achieve its expected target of 50 billion dollar exports by 2021 (Sagris and Abott, 2015) and ensure enhanced economic growth of the country. The 3R concept is related to the conservation of resources in the environment and incorporates sustainable technologies in different industrial processes. The 3R strategy promotes to incorporate aspects of reduce, reuse and recycle in different phases of production through optimization and modification of existing processes and adoption of more green and environmental friendly technologies.

So far different textile industries have submitted their respective 3R plan to Department of Environment (DoE) since 2014 (DoE, 2016). A major focus of these submitted 3R plans involves achieving a Zero Discharge (ZD) as well as Environmental Management System (EMS) in the respective industries over a time period of 3 to 5 years for environmental protection. A number of industries have already adopted ZD approach in their effluent treatment plants (ETPs) and is achieving a portion of treated water from the ETPs and recycling (both process and non-process purpose) that in the industry (DoE, 2016). At this point, most of the industries have adopted various treatment schemes to achieve ZD, which vary from one industry to the other depending on budget, location, and types of industries (DoE, 2016).

The successful implementation of ZD in textile industries is likely to bring several benefits in environmental, economic and social sectors but the industries will face many challenges such as i) technological and financial viability of various options ii) practical implementation issues like lack of space iii) disposal of increased solid wastes/sludge, reject water, etc.

Textile industry generates a huge volume of wastewater from its processes covering a major portion of the total wastes. Therefore, to achieve ZD, the main challenge for a industry is how to treat the wastewater in such a way so that there will be no discharge of liquid waste in the environment, i.e. almost 100% recycling/reusing of treated water (ZLD) should be accomplished. Implementing only ETP will be not enough to achieve this Zero Liquid Discharge (ZLD); some advanced technologies (ZLD system) should be introduced with conventional ETP to achieve this level of treatment. If an industry can run ETP-ZLD system efficiently and practice the reduction, recovery and conservation measures at the facility, only then it can achieve zero discharge.

Almost three years have passed since the introduction of ZD concept to industries by DoE. It is imperative to assess how the industries are coping with this newly introduced concept in terms of its effluent treatment and recycling. In this context, the present research work has been undertaken to get a clear understanding of the issues that the industries are experiencing in the practical field while implementing the ZD system. There is also a need to determine the efficiency of different proposed ZLD systems adopted in different textile industries, since introducing ZLD system plays a major role in achieving zero discharge. Moreover, it is essential to assess the progress of different textile industries in terms of achievement of ZD with respect to their 3R plan. Such action research work will enable regulatory authorities like DoE to understand maximum level of ZLD achievable for a particular textile industry, the barriers in adopting ZLD system and also provide an idea on the time required to achieve the target.

1.2 OBJECTIVES OF THE PROJECT

The main objective of the present action research is to assess the status of textile industries in Bangladesh regarding their performance in wastewater treatment and their progress in achieving zero discharge under 3R plan and also to develop an idea on the technological achievability of ZLD systems both in terms of required time frame of installation and amount/percentage of recycled wastewater.

The specific objectives of the present research are to:

(a) Analyze 3R plans of different types of textile industries (e.g., dyeing plant, washing plant, composite plan etc.) to assess technological schemes to achieve ZLD

(b) Evaluate the consistencies of present ZLD-ETP status with the proposed 3R plan (both in terms of design layout and time frame of installation) and monitor the performance of the ZLD-ETP system.

(c) Assess the baseline condition of industry's treated effluent quality and water use and reuse scenario.

(d) Evaluate performance of different ZLD technologies in terms of cost and level of treatment achieved

(e) Identify the handling and disposal system of sludge, specially the reject/concentrate from ZLD units in different industries

(f) Develop a database for different ZLD technologies for easier understanding of performance and suitability of technologies for different types of textile industries

(g) Evaluate the overall drop of groundwater extraction (qualitatively, if not possible quantitatively) in respective industries due to implementation of 3R plan and evaluate how implementation of the ZLD system is contributing to the reduction of groundwater extraction.

The outcome of this research will be a baseline of textile industry's wastewater treatment scenario. It will provide an insight into the treatment efficiency of existing industrial wastewater technologies, its applicability in terms of cost and recycling potential to achieve zero discharge.

1.3 SCOPE OF THE RESEARCH WORK

The scope of this research includes reviewing the industry's approved 3R plan to assess the proposed technological schemes to achieve ZLD system. The activities such as industry visit, collecting information on cost, water use, treatment technology, reuse practices and sampling and laboratory analysis provide an insight into the existing situation of wastewater treatment and progress on 3R measures to achieve zero discharge. The dialogue with the stakeholders provides an understanding of the challenges to achieve zero liquid discharge.

1.4 ORGANISATION OF THE REPORT

The report is presented in eight chapters. The first chapter provides an introduction of the project along with its objectives. Chapter 2 presents general information on textile industries in Bangladesh and literature related to treatment technologies of industry's wastewater, specially ZLD system. Chapter 3 describes the methodology followed in carrying out this research. Chapter 4 includes the outcome of the meetings with the stakeholders regarding the ZLD-ETP issue. Chapter 5 is the compilation of the baseline data, questionnaire survey and laboratory test results of the wastewater samples collected from the industries. Analysis of the data and test result is depicted in Chapter 6. Chapter 7 provides a detail discussion on the research findings, in the light of the goals of the project. The final chapter (Chapter 8) presents the conclusion of this research along with the recommendations.

Chapter 2

Literature Review

2.1 INTRODUCTION

The exact number of textile industries in Bangladesh could not be verified. According to WRG (2015) report, the number of wet processing textile units is in the range of 500-700. It has been found that around 241 Dyeing-Printing-Finishing Textile Mills are registered with the Bangladesh Textile Mills Association (www.btmadhaka.com). The number of wet processing units is expected to increase significantly over the next few years. It is estimated that around 70% of the Washing, Dyeing and Finishing (WDF) textile processing units, which are responsible for a considerable portion of the water demand and water pollution, are located in the Greater Dhaka area (Figure 2.1). The remaining units are located in Mymensing (north of Dhaka) and in Chittagong.

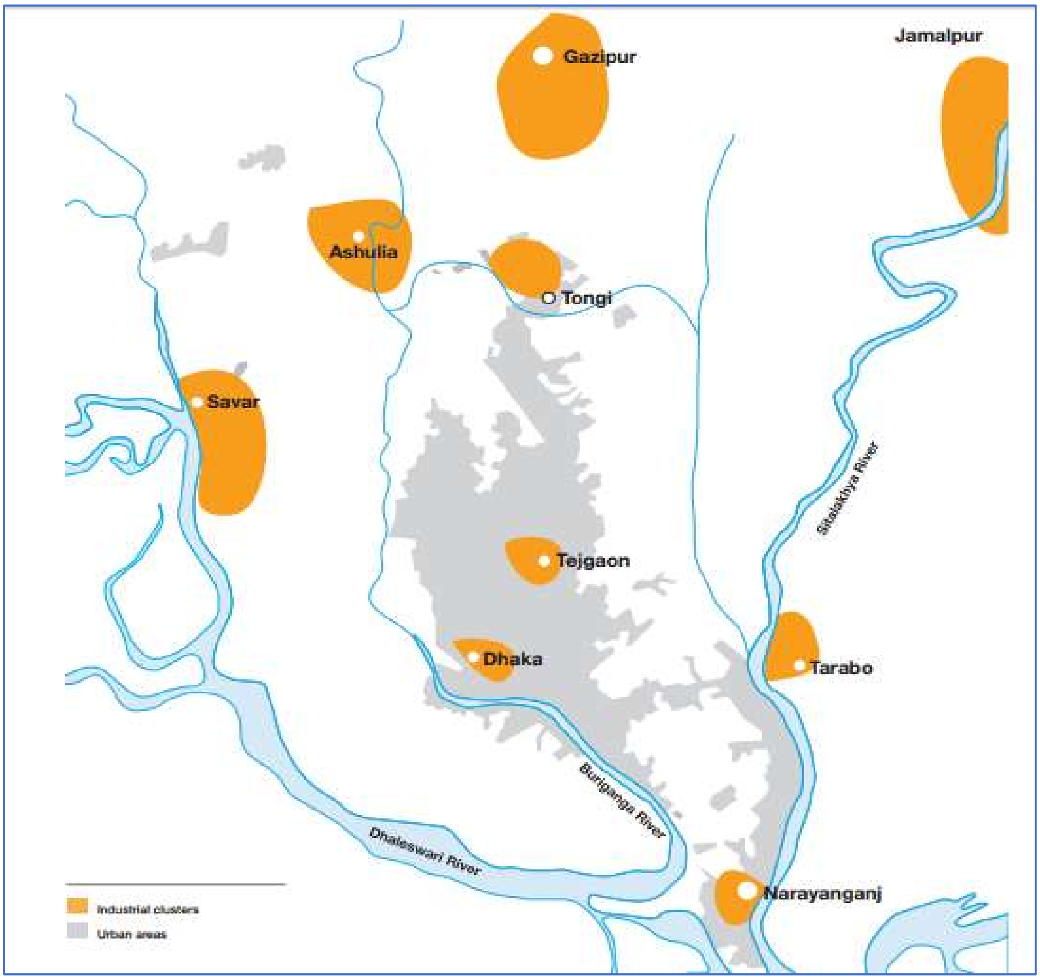

Figure 2.1: Industrial Clusters in Greater Dhaka Area (Sagris and Abott, 2015)

Textile industry makes a significant water footprint in the environment. Most of its water is used and discharged in the wet processing stage. According to IFC, the average factory water consumption in Bangladesh is estimated to be up to 250 to 300 litres of water per kilogram of fabric produced. This is the equivalent to the daily water use for two people in Dhaka. For comparison, the global benchmark for fabric production is 100 litres of water per kilogram (Sagris and Abott, 2015) The effluent discharges from the WDF factories are heavily polluted with high levels of dissolved solids and chemicals which needs proper treatment before disposing of into the environment. Estimates on the number of factories with Effluent Treatment Plants (ETPs) vary from 40 to 80% (Sagris and Abott, 2015) although it is widely acknowledged that many of the installed plants are poorly designed or not operated in an appropriate and responsible manner. The disposal of this poorly treated wastewater is polluting the land, groundwater resource and surface water bodies and thus poses a great threat to human health and ecosystem.

Against this backdrop, the main driving factors for introducing ZLD system in industries are to i) comply with the environmental regulation issued by DoE on discharge of effluent ii) prevent environmental pollution iii) meet the water scarcity by reducing the dependency on water source iv) promote reuse, recycle of water v) growing social responsibility and education towards awareness of environmental issues.

The following sections present a brief description of the commonly adopted treatment technologies for textile effluents along with ZLD system.

2.2 TECHNOLOGY FOR TREATMENT OF TEXTILE INDUSTRY'S WASTEWATER

The treatment technologies commonly adopted in treating textile industry's wastewater consist of mainly preliminary, primary, secondary (biological/chemical) and sometimes tertiary treatment processes. Figure 2.2 shows the units of an Effluent Treatment Plant (ETP) of a textile industry. Preliminary treatment involves removal of large solids such as rags, sticks, grit and grease that may result in damage to equipment or operational problems. It may consist of screening, oil and grease removal units. Primary treatment is the removal of floating and settleable materials i.e. suspended solids and organic matter. Secondary treatment involves removal of biodegradable organic matter and suspended solids (biological and chemical). Tertiary treatment goes beyond the level of conventional secondary treatment to remove significant amounts of nitrogen, phosphorus, heavy metals, excess color, biodegradable organics, bacteria and viruses.

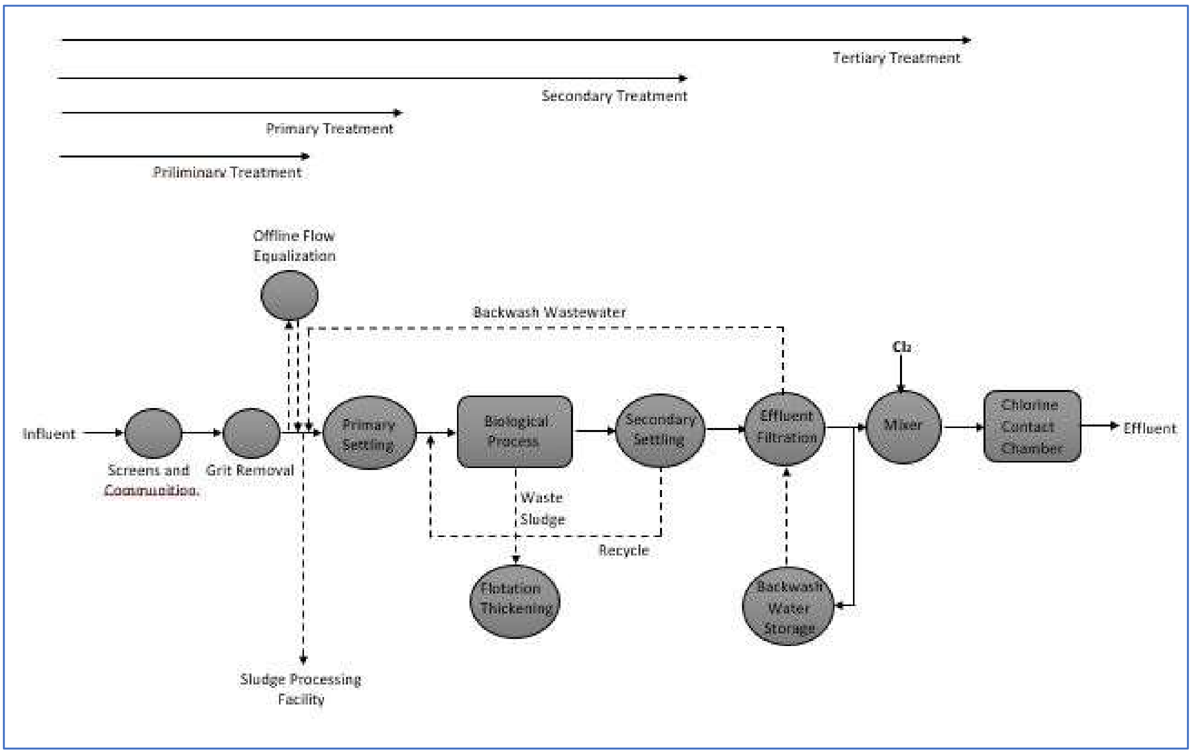

Figure 2.2: Various treatment levels in ETP

Primary treatment is the physico-chemical treatment of wastewater which includes sedimentation, equalization, neutralization, chemical coagulation and mechanical flocculation units. The first step in the process is to mix and equalize the waste water streams that are discharged at different time and different intervals from different stages in the processes. Equalization ensures that the effluent have uniform characteristics in terms of pollution load, pH and temperature. The effluent is then subjected to flash mixing for the addition of coagulants such as lime, alum, ferrous sulphate, ferric chloride, and poly-electrolyte and processed through clari-flocculator or flocculator and settling tank. Selection of appropriate coagulants and doses of chemicals is determined on the basis of treatability study of effluent samples. The chemical treatment helps in reduction of color and suspended solids. A significant reduction in BOD and COD values is also observed in this stage.

Secondary treatment is mainly biological treatment process. It can be aerobic or anaerobic. Different treatments technologies such as aerated lagoons, activated sludge process, trickling filter, Sequential Bach Reactor (SBR), Upflow Anaerobic Sludge Blanket (UASB), Oxidation ponds etc. are used in secondary treatment process to reduce the organic loads (BOD and COD) of the wastewater. The textile process which undertakes chemical processing does not usually have much organic load in their effluents. In such cases, the recent trend is to set up an activated adsorption system or an Ozonation unit instead of biological treatment (CEE, 2016).

Depending on the characteristics of the treated effluent and the required compliance standards, some industries adopt tertiary treatment technologies such as ion exchange, reverse osmosis, carbon adsorption to remove excess color, dissolved solids, nitrogen, phosphorous, heavy metals etc.

2.3 TECHNOLOGY FOR ZLD SYSTEM

Most textile industries in Bangladesh use conventional ETP to treat wastewater generated from industrial processes. The treatment provided by ETP is mainly physico-chemical and biological which reduces the organic load of the wastewater to a great extent before discharging to the environment. But the concern is the dissolved solids (salt content) in treated water. As textile industries use variety of chemicals during their production process the wastewater contains a high concentration of salts. Discharge of this treated wastewater pollutes ground and surface waters thus posing a threat to environment. Hence, installation of a ZLD system may improve the final discharge quality as well as reduce the water use by recycling part of the treated water. Zero Liquid Discharge (ZLD) refers to installation of facilities and system which will enable industrial effluent for absolute recycling of permeate and converting solute (dissolved organic and in-organic compounds/salts) into residue in the solid form by adopting method of concentration and thermal evaporation. ZLD is recognized and certified based on two broad parameters those are, water consumption versus wastewater re-used or recycled (permeate) and corresponding solids recovered (percent total dissolved / suspended solids in effluents). Inclusion of ZLD plant to effluent treatment plant (ETP) will treat water from both salinity and organic matter. The water from ZLD have the potential to be reused for different purposes thus fulfilling the 3R (reduce, reuse and recycle) policy of Bangladesh Government.

2.3.1 Design Considerations

One of the main problems when designing a ZLD system is how to describe the waste stream. Contamination of the water (the feed chemistry), the flow rate and the level of purity of the water are other factors that are essential when designing a ZLD-system. Because the waste stream is so varying, it is almost impossible to design a general ZLD-system. Every ZLD-system is unique and has to be custom made each time. Any zero discharge treatment system design should consider the following facts/requirements:

- ✓ Quantity of the effluent to be treated;
- ✓ Variability in time of the quantity as well as quality of the effluent;
- ✓ 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;
- ✓ The upper and lower limits of performance of each unit process;
- ✓ The durability of the system to be adopted;
- ✓ The feasibility of establishing suitable collection and conveyance system in the case of a common treatment facility. (Islam et al, 2011)

2.3.2 Treatment Units in ZLD System

For over 30 years, vapor compression evaporation has been the most useful technology to achieve zero liquid discharge. Evaporation recovers about 95% of a wastewater as distillate for reuse. Waste brine can then be reduced to solids in a crystallizer/dewatering device. However, evaporation alone can be an expensive option when flow rates are considerable. One way to solve this problem is to integrate membrane processes with evaporation. These technologies are nowadays often combined to provide complete ZLD-systems. The most common membrane processes used so far are reverse osmosis (RO) and electro dialysis reversal (EDR). By combining these technologies with evaporation and crystallization, ZLD-systems have become less expensive (Tillberg, 2004).

A typical ZLD system (Figure 2.3) in textile industry comprises of the following components:

- Pre-treatment (Physico-chemical & Biological treatment in ETP)
- Reverse Osmosis (Membrane Processes)
- Evaporator & Crystallizer (Thermal Processes)

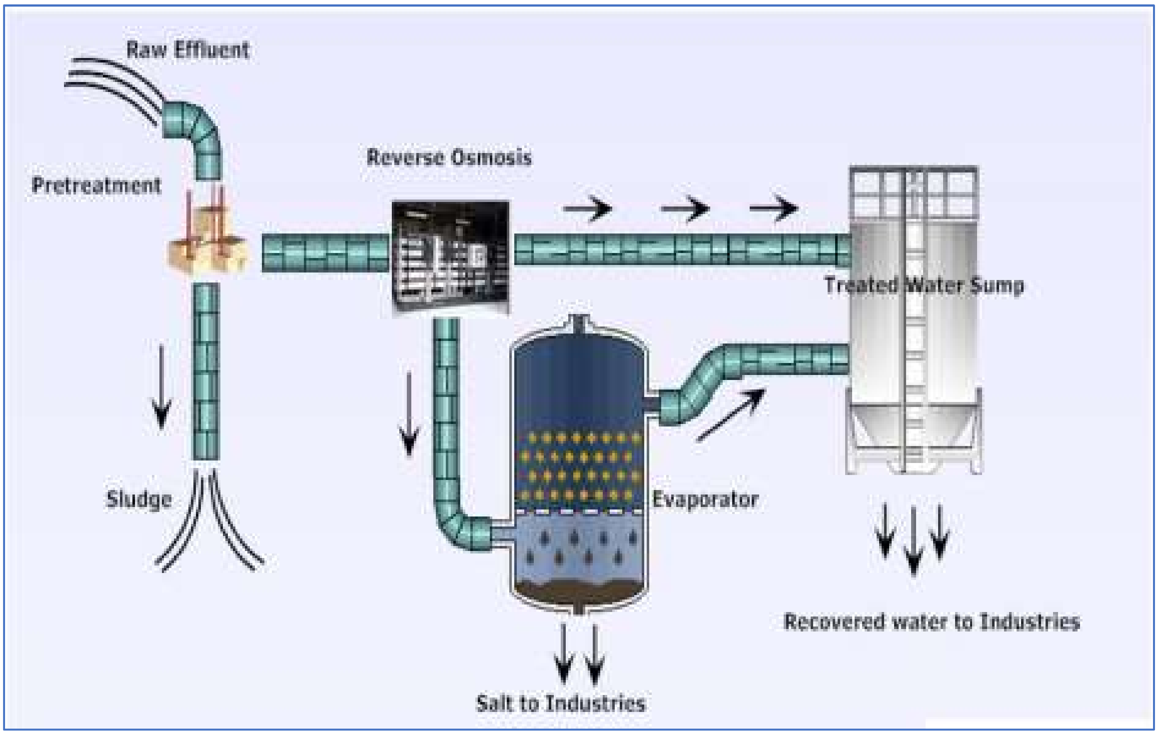

Figure 2.3: ZLD system in Textile Industry

Pre-requisite for ZLD accomplishment would be physical and chemical treatment and followed by biological system (treatment units involved in conventional ETP as described in Section 2.2) to remove organic load. The treated effluents can be then subjected to concentration and evaporation. The concentration method quite often involves the adoption of Reverse Osmosis (RO) and Nano Filtration (NF), Ultra-filtration methods. The evaporation methods involve incineration/ drying / evaporation of effluent in multi effect evaporators (MEE).

Reverse Osmosis (RO)

The process of reverse osmosis is based on the ability of certain specific polymeric membranes, usually cellulose acetate or nylon to pass pure water at fairly high rates and to reject salts. To achieve this, water or wastewater stream is passed at high pressures through the membrane. The applied pressure has to be high enough to overcome the osmotic pressure of the stream, and to provide a pressure driving force for water to flow from the reject compartment through the membrane into the clear water compartment. RO membranes are susceptible to fouling due to organics, colloids and microorganism. In a typical reverse osmosis system, the feed water is pumped through a pre-treatment section which removes suspended solids and if necessary, irons and manganese which may foul the system. The feed water is then passed through the reverse osmosis modules at high pressure (CEE, 2016).

Evaporator

Evaporators produce a distillate stream that is very clean, typically containing less than 10 ppm of TDS, one of the main reasons why evaporators are used in a ZLD-system. This evaporator can treat RO concentrates to a total solids (TS) concentration of 300,000 ppm (Tillberg, 2004). At this value the boiling point rises of the brine results in either an excessively large heat-transfer area (large capital cost) or an excessively large temperature difference (large operating cost). Values higher than this makes the combination of a crystallizer and an evaporator more economical than an evaporator alone (Tillberg, 2004).

Crystallizer

The crystallizer reduces highly saturated wastewater to dry solids for disposal. High purity water is recovered from the crystallizer for recycling. A crystallizer may also recover specific salts from a mixed salt waste stream. The crystallizer is a forced circulation evaporator which uses a mechanical vapor compressor or plant steam as the energy source. (Tillberg, 2004)

Figure 2.4 gives an example of a complete flow diagram (including conventional ETP and ZLD) of ZLD-ETP system in a textile industry. Here the effluent from the secondary clarifier is charged into the quartz filters, resin filters for ultra-filtration to reduce the load on RO system. The softened effluent is then fed to RO modules to get permeate and concentrate. The RO permeate is stored in recovered water tanks and concentrate is fed to the evaporation section for further treatment and recovery. In the Mechanical Vapor Reactor (MVR) the filtration is achieved by indirect thermal heat transfer between heating media and the treated effluent inside the reactor. The steam is circulated in the outer jacket of the reactor as a heat source. The condensate collected is the output of the system. The concentrate of evaporator is further crystallized and salt is recovered after the centrifuge governed separation of Glauber salt. The residual effluent is sent to the solar evaporation panels.

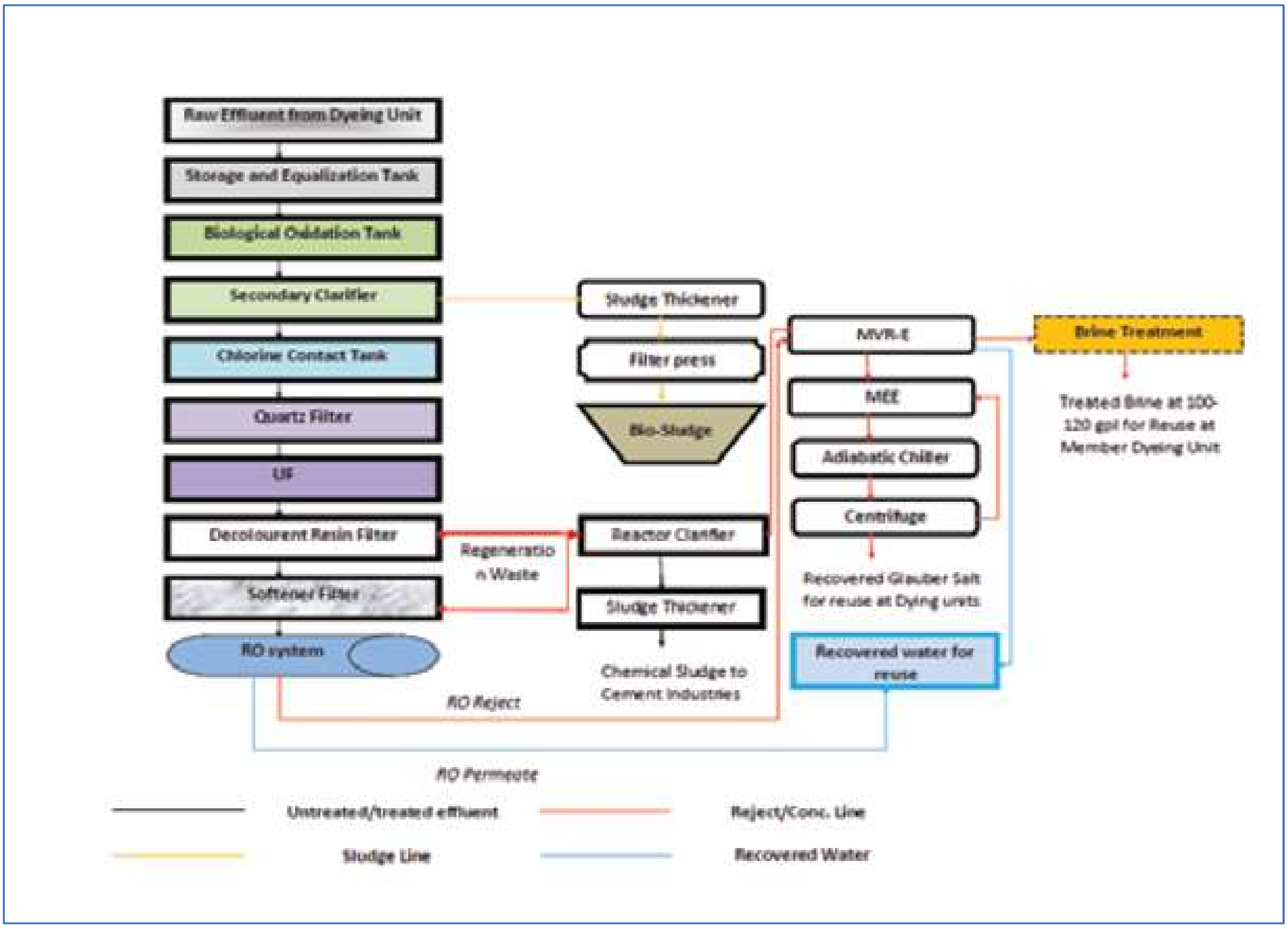

Figure 2.4: Process flow diagram of a Typical ZLD Plant in a Textile Industry (Ashraf, 2015)

2.4 CHALLENGES AND OPPORTUNITIES OF ZLD SYSTEM

The successful implementation of ZLD in textile industries is likely to bring several benefits in environmental, economic and social sectors, whereas implementing ZLD system is a big challenge for industries.

2.4.1 Challenges in ZLD

- ✓ ZLD results in generation of hazardous solid wastes creating disposal challenges- need to think of Zero Waste Disposal (ZWD) Plants.
- ✓ Economic viability- cost and availability of water, regulatory pressure are the real driving force.
- ✓ High Carbon foot print.
- ✓ Technology shortcomings (Hussain, 2014)
- ✓ High Operating cost and financial impact on the industry and its Regional/ National/Global competitiveness

2.4.2 Benefits of ZLD

- ✓ Installing ZLD technology is beneficial for the plant's water management; encouraging close monitoring of water usage, avoiding wastage and promotes recycling by conventional and far less expensive solutions.
- ✓ High operating costs can be justified by high recovery of water (>90-95%) and recovering of several by products from the salt.
- ✓ A more sustainable growth of the industry while meeting most stringent regulatory norms.
- ✓ Possibility of use of sewage for recovery of water, for industrial and municipal use, using ZLD technologies.
- ✓ Reduction in water demand from the industry frees up water for Agriculture and Domestic demands (Hussain, 2014).

Chapter 3

Methodology

3.1 INTRODUCTION

The present research is planned and designed in such a way so that the objectives of this research can be achieved within the project time. In this regard, the cooperation and support from Department of Environment (DoE) and the industries are important. The present chapter describes the methodology adopted in conducting this research to achieve the goals.

3.2 METHODOLOGY

The present action-research required support from DoE for carrying out initial document (3R plans) review and then water sampling collection from ZLD-ETPs in different industries. Firstly, DoE approved 3R plans of different industries (about 25) have been collected from different zonal offices of DoE to review the zero discharge/3R plans, timeline of implementation of proposed 3R plan, and water reuse scenario in the industry. This review work has helped the study team in identifying the industry type, ZLD technologies proposed, timeline of implementation, and enhancement of water reuse due to implementation of 3R plan.

After this initial review, 20 industries have been selected considering industry types, ZLD technologies and time frames, for field visit. Among the 20 industries, 10 industries represent those industries that have submitted their plan for zero discharge and approved by DoE and specified as ZLD-ETP industries in the present report. The other selected 10 industries are those who do not have approved 3R plan and are running with only conventional ETP and is specified as ETP industries in the present research. The field visit has been planned to evaluate the progress of work in the industries regarding its wastewater treatment and to find out the consistencies with the 3R plan (both in terms of design layout and time frame of installation). The field visit was conducted between 06/05/2017 and 17/06/2017. During the visit, wastewater samples were collected from different locations of the ZLD-ETP, as shown in Figure 3.1, to assess the treatment efficiency of the combined primary and secondary (conventional ETP treatment units) and tertiary treatment units (proposed ZLD units). Here, the influent raw wastewater quality and treated effluent quality from ZLD units were used to assess the overall treatment efficiency of the ZLD-ETP system. On the other hand, water characteristics from secondary treatment units and treated effluent from ZLD unit was used to determine the treatment efficiency of the ZLD technology.

A questionnaire survey has also been conducted while visiting the industry. The sample of the questionnaire is shown in Annex A. The survey involved discussion with industrial ETP operators and managers to assess the cost of treatment in the overall treatment process and in the ZLD units. The cost assessment included both initial investment cost and operational cost such as cost for chemical use, electricity use, cartridge use, staff salary etc. Moreover, the total percentage of flow from the ETP reused/recycled in the process and non-process purposes has also been assessed from the field visit.

Disposal of sludge and handling mechanism of reject/concentrate wastewater from ZLD units in different industries has been noted and relevant cost association was recorded during the field visit. These data would has enabled development of a database for different ZLD treatment technologies in terms of treatment efficiencies, cost, and suitability for a particular type of industry in future.

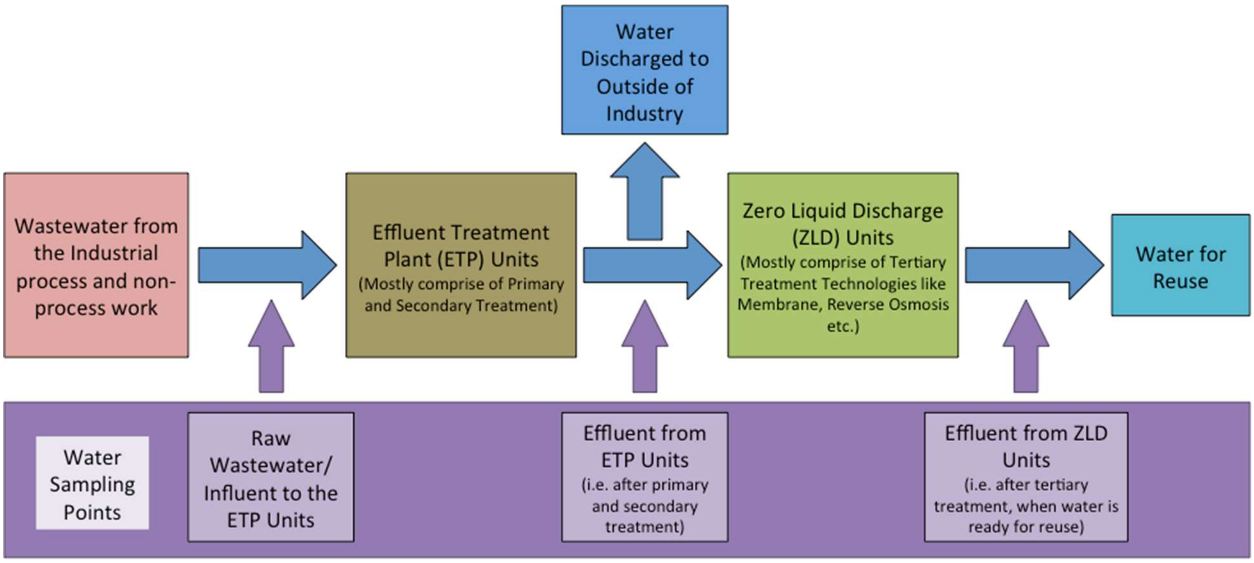

Figure 3.1: Simplified layout of a Zero Liquid Discharge Effluent Treatment Plant (ZLD-ETP) showing locations of water sampling in the present action research

The survey included the collection of information on overall water reuse practices in the respective industries. This has enabled to assess whether the industries are recycling the treated water from ZLD units to process or non-process works. Reduction of ground water extraction by a particular industry can be attributed to a number of issues (e.g., use of machineries requiring less amount of water, recycle of wastewater to industrial process works, use of environment friendly production processes etc.). An attempt has been made to evaluate the overall reduction of groundwater extraction in respective industries due to implementation of 3R plan to identify the impacts of ZLD systems in reduction of groundwater extraction. Finally, analysis has been done with the collected information, data and laboratory test results to reach the stated goals of the research.

Chapter 4

Meeting and Workshop with Stakeholders

4.1 INTRODUCTION

The research team understands that the textile industries and Department of Environment are the main stakeholders related to the project. The research team therefore initiated an informal meeting with textile industry professionals on April 11, 2017 at BUET with a view to informing the industries about the project and gets their views on the possibility of adopting Zero Liquid Discharge approach to wastewater treatment. An inception workshop was also held at the Department of Environment on April 18, 2017 with DoE personnel to give an overview of the project, so that the suggestions and recommendations provided by the DoE could be incorporated in the project methodology to achieve the expected outcomes. This chapter presents the details of the meeting and the workshop with the stakeholders.

4.2 MEETING WITH INDUSTRY PROFESSIONALS

An informal meeting was arranged by Center for Environmental and Resource Management (CERM), BUET with leading textile industries of Bangladesh and service providers for them to share their ideas and views on ZLD-ETP treatment plants. About 26 personnel from the industries and the service providers were present in the meeting on April 11, 2017 held in the Civil Engineering Seminar Room-2 on 3rd floor of Civil Engineering Building, BUET (Figure 4.1). The participants were mainly executives, engineers, ETP in-charge personnel and operators. The list of the participants of the meeting is provided in Annex B.

Figure 4.1: Meeting with Industry professionals

The team leader of the project (PI1) inaugurated the program stating the purpose of the meeting to the participants. A presentation was given by PI2 of the project about the objectives, available technologies of wastewater treatment, technologies of ZLD system and the issues regarding implementing ZLD system in textile industries.

This was followed by an open discussion held with the participants on the technologies they are using, their output, the progress on implementing ZLD technologies, their problems in operating as well as their ideas to improve ZLD technologies. The participants responded positively and showed interest in cooperating with this research project. They also assured to provide all necessary documents and access to their facility if needed.

The following issues were discussed in the meeting:

- What technologies are the textile industries using for wastewater treatment?
- Are the existing technologies sufficient for wastewater treatment?
- What are the guidelines of the Department of Environment for implementing Zero Discharge Plans in textile industries?
- Does the Department of Environment provide any subsidy for implementing this new technology?
- Have the textile industries started operating ZLD plants along with ETP?
- Are they familiar with the technologies related to a ZLD plant?
- How much industrial wastewater is treated by a ZLD plant?
- What problems are the industries facing in implementing and operating ZLD technologies?
- Are ZLD technologies feasible in the context of Bangladesh and is there any other way to achieve the 3R goals?
- Is there any opportunity or training program available for capacity building of the industry personnel?
- Is there any possibility of utilizing the amount of money (in penalties) collected from the offending industries?

The responses of the participants on the above mentioned issues are listed below. These are solely the views of the participants on ZLD system.

- Most of the textile industries have Effluent Treatment Plants (ETPs) for treating their wastewater.
- The DoE doesn’t provide any specific guidelines for implementing ZLD technology. There are no prescribed guidelines on the values of the parameters of ZLD treated water to be adhered to by the industries.
- There is no subsidy or soft loan from IFC for implementing ZLD. They suggested that the money collected from the offending industries (in penalties) may be utilized for this kind of innovative programs.

- Space (land) is a major constraint for many small scale industries to install biological ETP
- Depending on an industry's type, the technology of ZLD may vary. Therefore, it is not practical for DoE to provide a common guideline of ZLD plant for all the industries. That is why; the industries are trying to evaluate which technologies are needed to achieve 3R goal and the feasibility of ZLD in their treatment system.
- Most of the industries are at a planning stage of implementing the ZLD system. They are analyzing cost-benefit ratio to decide whether a ZLD system will be profitable for business. At this stage, only a few industries have operational ZLD plants.
- Most of the industries with ZLD are using Reverse Osmosis (RO) technology in their ZLD system.
- RO is a very sensitive technology and has the possibility to get fouled frequently. Therefore, industries are only treating wastewater from washing and finishing units with the RO as they have comparatively lower chemical load. 90% of the water from washing and finishing units are reusable after treatment. This water is mainly used for car washing, toilet flushing, gardening, cleaning and cooling water. The remaining 10% water contains high salt content which cannot be treated with the existing technologies. ZLD technologies have waste water and fresh water separation system though most industries with ZLD don't follow it.
- ZLD technologies are much more expensive than the conventional technologies in use. Using only RO in the system adds an additional cost of 78 BDT/m^3. A leading industry has advised that for installing an ETP with Cloth Filtration for 67% reuse of water will cost them EUR 500,000 and installing ZLD (RO) will cost around EUR 1.6m. This doesn't include operational and maintenance costs. This excess cost may cause significant reduction of profit or even drive them to incur loss. Besides, there is a shortage of skilled personnel for operating ZLD plants.
- Most industries think 3R goal of the Department of Environment can be achieved by source water reduction. Using advanced chemicals and advanced machineries can also reduce the amount of water consumption in the process. Some industries are already using advanced technologies but they aren't getting 100% output as there is a shortage of trained personnel. DoE with the help of BUET can arrange seminars or training programs to solve this problem.
- Industries in China have recently started using radiation technique to distract all kinds of fouls from industrial wastewater. But this might be hazardous for Bangladesh unless properly managed.
- One of the main problems of ZLD implementation is sludge management. Every ZLD technology produces a lot of sludge at the end of the process which requires a proper arrangement for treatment and subsequent disposal. ZLD technology is just transferring the problem from waste water to solid waste. A subsequent ZDHC plant is required to treat the sludge produced from a ZLD plant.

The outcomes of the meeting are summarized below.

- Requirement of ZLD system in textile industry varies on the technology and process the industry is using. Instead of making ZLD a general requirement, DoE should consider it on a case by case basis.
- There is no specific guideline of Zero Discharge Plans provided by DoE.
- As ZLD technology is very expensive, subsidy or soft loan from government would be very helpful.
- If the wastewater treated by ETP is collected and then treated in a centralized ZLD the cost would be much lower and industries will be able to secure their business as well as the environment.
- The sludge from ZLD is hazardous and requires proper dumping. It would be convenient if DoE provides an arrangement for safe sludge disposal.
- Before implementing ZLD technology, every industry should run their ETP effectively; otherwise ZLD will not work properly.
- Financial assistance should be provided by the Government to implement Zero Discharge system in the industries.

4.3 INCEPTION WORKSHOP AT DoE

An inception workshop was arranged by DoE at their Agargaon Office on April 18, 2017. The workshop was presided over by the DG of DoE. The directors of different Cell of DoE and directors of different zonal offices along with other DoE personnel were present in the workshop. The project team gave a presentation featuring mainly the objectives, methodology and expected outcomes of the project in the workshop.

Several issues were discussed in this workshop. One of the main issues raised by the project team was 'What does DoE understand by ZLD?' The participants responded with different understanding of the issue and it was observed that there are various views within the personnel of the DOE about ZLD. Some think 100% reuse should be done in ZLD system. Others opined that 70% water reuse could be viable for Bangladesh context. Dr. Sultan Ahmed, Director of NRM suggested that if 60-75% water could be reused using such a technology at an affordable cost, even with using only effective ETP, that could be considered. The other issues discussed in the workshop were water use in the process, change in chemicals, equipment that reduce water use at source, water auditing, imposing water rates, reuse of water, sludge disposal, information on dyes from the chemicals suppliers etc.

The participants in the workshop made some suggestions regarding the outcomes of the project. These are summarised below.

- The project should present a baseline scenario of the textile industries in Bangladesh
- There should be information on cost involvement in the implementation of ZLD-ETP system
- If there is any potential to reuse the dyeing bath water

Chapter 5

Baseline Information of Surveyed Industries

5.1 INTRODUCTION

After reviewing the industry's approved plans of Zero Discharge under 3R policy, the visits to the selected industries have been carried out during the period between 06/05/17 and 17/06/17.During the visit, questionnaire survey was conducted and wastewater samples were collected for analysis to evaluate the performance of the ZLD-ETP of the industries. The present chapter shows the baseline information and data collected from the studied industries. For the sake of the industries, the name and address of the industries are not mentioned in this report; the industries are designated by numbers. The industries with approved zero discharge plans are represented by Z-1 to Z-10 and industries without zero discharge plans but with only ETPs are represented by E-1 to E-10. The collected information and the wastewater samples test results of the selected industries are presented in the following sections.

5.2 SUMMARY OF ZLD-ETP INDUSTRIES' INFORMATION

The information collected on industry type, capacity, water consumption, ETP and ZLD units, cost, water reuse practices etc. and the laboratory test results of collected wastewater samples (according to Figure 3.1) of selected twenty industries are summarized and presented in the following sub sections.

5.2.1 Industry Z-1

Table 5.1: General Information of Industry Z-1

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
Z-1	Fatullah, Narayanganj	Composite (Knitting, Dyeing, finishing, Yarn dyeing, Zipper Dyeing and RMG)	20 ton/day	3000 m^3/day

Table 5.2: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	2400 m^3/day	Physico-Chemical followed by biological process (Screening, Equalization, Electro Contaminant Removal (ECR) unit, Flocculation tank, Clarifier, Aeration	43 ton/ year	Filter pressed sludge is stored for several months and then disposed

			tank, Sludge drying bed, Filter Press)		of by land filling

The flow diagram and photos of different units of ETP of Industry Z-1 are shown in Figure 5.1 to 5.6.

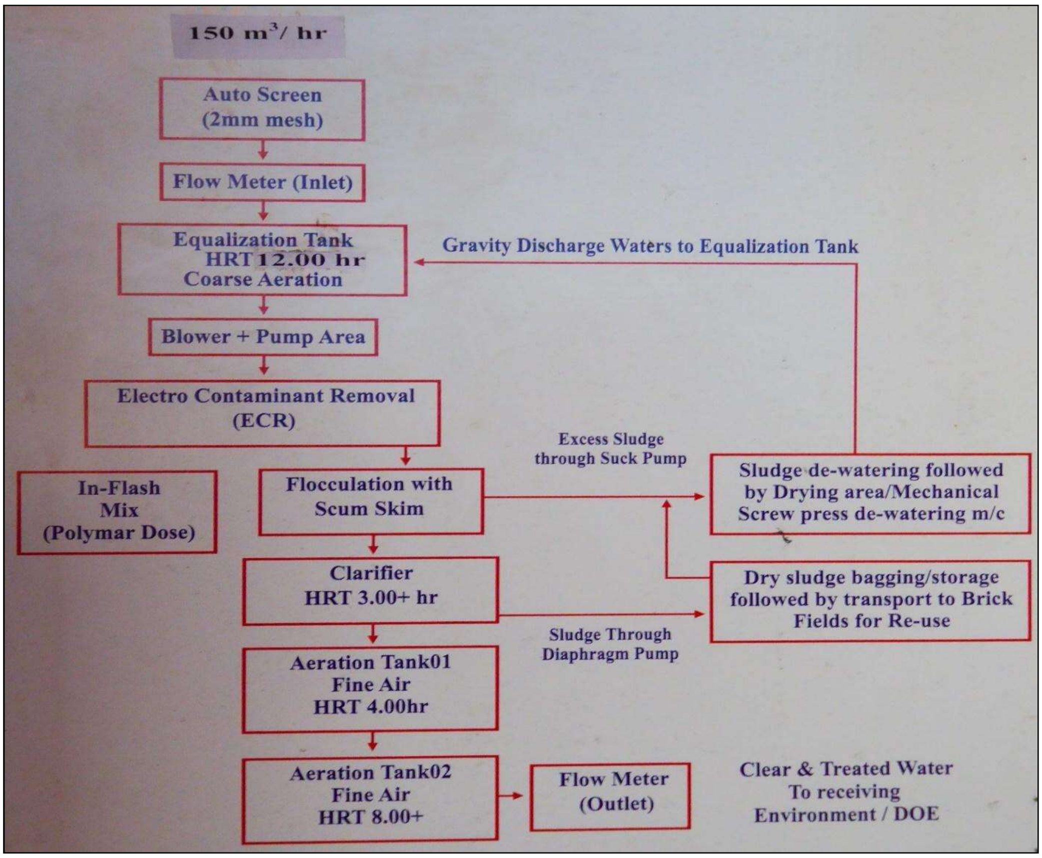

Figure 5.1: Flow Diagram of ETP units of Industry Z-1

Figure 5.2: Screening Unit of Z-1

Figure 5.3: ECR unit of Z-1

Figure 5.4: Recycled ETP water for Fire Fighting

Figure 5.5: Filter Press of Z-1

Figure 5.6: Sludge Drying Bed in Z-1

Table 5.3: Characteristics of Wastewater samples of Industry Z-1

Parameters	Inlet	Outlet	ECR'97			Minimum Detection Limit (MDL)
			Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	7.51	8.13	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	256	125	-	-	-	0.01
Turbidity (NTU)	55.3	14.9	-	-	-	0.01
DO (mg/L)	0.31	1.87	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5(mg/L)	240	10	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD(mg/L)	541	70	≤ 200	≤ 400	≤ 400	0.2
EC(µS/cm)	1772	2280	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^-(mg/L)	180	180	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	0.942	0.338	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-}(mg/L)	1.38	0.08	-	-	-	0.04
TDS (mg/L)	1410	1542	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	65	51	≤ 150	≤ 500	≤ 200	5

3R Activities in Z-1:

A storage tank of capacity 180.5 m^3(Figure 5.4) has been built to recycle the treated water for fire fighting.

5.2.2 Industry Z-2

Table 5.4: General Information of Industry Z-2

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
Z-2	Fatullah, Narayanganj	Composite (Dyeing and RMG)	6 ton/day	800 m^3/day

Table 5.5: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	640 m^3/day	Physico-Chemical followed by biological process (Screening, Equalization Tank, Reaction Tank, Primary Clarifier, Aeration tank, Secondary Clarifier, Clear Water Tank, Multi-grade Filter, Outlet)	200 kg/day	Landfill after storing 4-5 months

The flow diagram and photos of ETP units are shown in Figures 5.7 to 5.10.

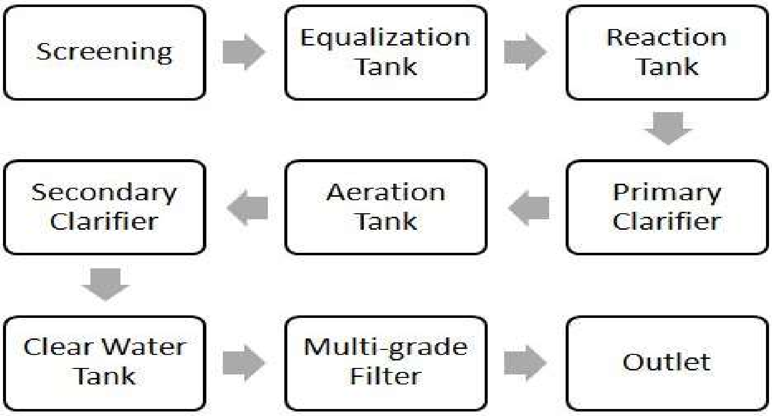

Figure 5.7: Flow Diagram of ETP of Industry Z-2

Figure 5.8: Equalization tank of Z-2

Figure 5.9: Reaction tank of Z-2

Figure 5.10: Outlet of industry Z-2

Table 5.6: Characteristics of Wastewater samples of Industry Z-2

Parameters	Inlet	Outlet	ECR'97			Minimum Detection Limit (MDL)
			Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	7.40	8.09	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	186	87	-	-	-	0.01
Turbidity (NTU)	94.7	9.04	-	-	-	0.01
DO (mg/L)	0.16	4.08	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5(mg/L)	116	9.6	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD(mg/L)	228	42	≤ 200	≤ 400	≤ 400	0.2
EC(µS/cm)	1240	2460	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^-(mg/L)	390	510	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	1	1.69	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-}(mg/L)	0.325	0.492	-	-	-	0.04
TDS (mg/L)	669	1610	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	94	52	≤ 150	≤ 500	≤ 200	5

3R measures in Z-2:

No mentionable activities in achieving 3R goals.

5.2.3 Industry Z-3

Table 5.7: General Information of Industry Z-3

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
Z-3	BSCIC, Narayanganj	Dyeing	8-9 ton/day	600 m^3/day

Table 5.8: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	800 m^3/day	Physico-Chemical followed by biological process (Screening, Equalization Tank, Flush Mixing Tank, Aeration tank, Clarifier, Post Aeration Tank, Outlet)	10 cft/day	Land filling in industry compound after 1 month drying.

The flow diagrams and photos of ETP are shown in Figure 5.11 to 5.14.

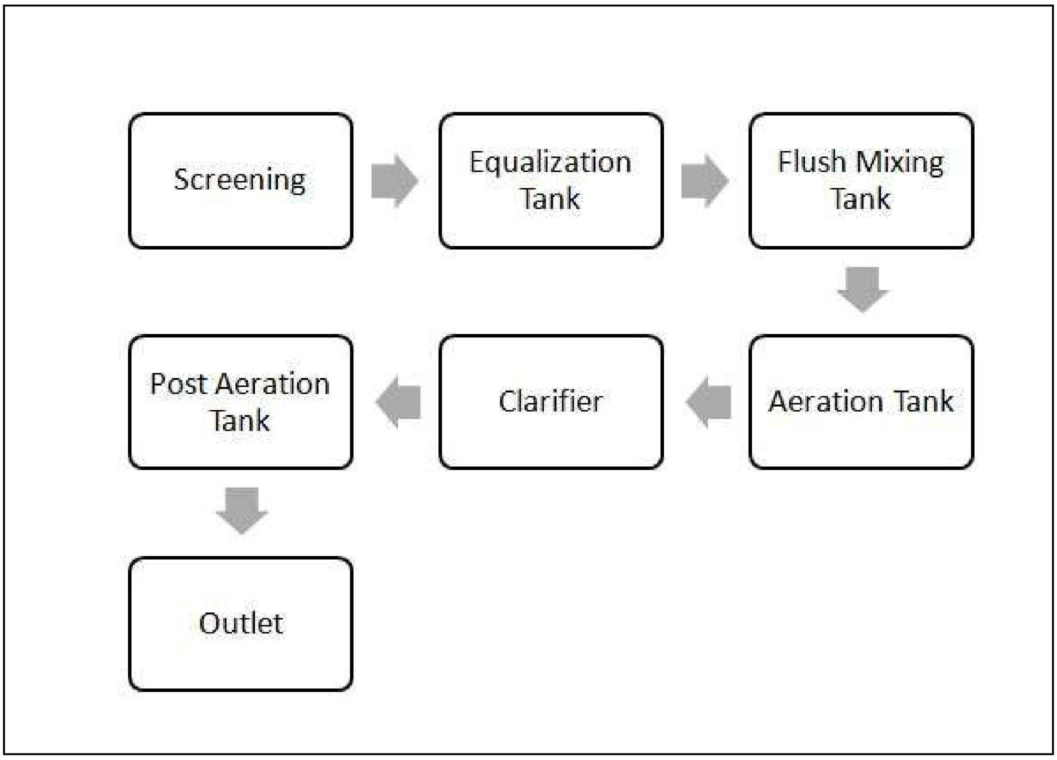

Figure 5.11: Flow Diagram of ETP of Industry Z-3

Figure 5.12: Aeration Tank of Z-3 **Figure 5.13: Clarifier of Z-3**

Figure 5.14: Post Aeration Tank of ETP of Industry Z-3

Table 5.9: Characteristics of Wastewater samples of Industry Z-3

Parameters	Inlet	Outlet	ECR '97			Minimum Detection Limit (MDL)
			Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	9.83	8.24	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	1150	55	-	-	-	0.01
Turbidity (NTU)	27.1	11.2	-	-	-	0.01
DO (mg/L)	0.09	5.08	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5(mg/L)	104	8	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD(mg/L)	328	67	≤ 200	≤ 400	≤ 400	0.2
EC(μS/cm)	4520	1841	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^-(mg/L)	150	455	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	2.21	0.55	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-}(mg/L)	0.95	0.105	-	-	-	0.04
TDS (mg/L)	3402	1184	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	93	18	≤ 150	≤ 500	≤ 200	5

Progress in 3R Plan:

No noteworthy progress towards implementing 3R plans.

5.2.4 Industry Z-4

Table 5.10: General Information of Industry Z-4

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
Z-4	Rupgonj, Narayanganj	Composite (Knitting, Dyeing and Finishing)	40 ton/day	6044 m^3/day

Table 5.11: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	4800 m^3/day	Physico-Chemical followed by biological process (Screening, Equalization Tank, Neutralization Tank, Distribution Tank, Biological Oxidation Tank (2), Sedimentation Tank, Clarifier, Post Oxidation Tank, Outlet, Sludge Thickener Tank, Filter Press)	3 ton/month	Delivered to 3rd party for disposal in land filling and others.

The flow diagrams and photos of ETP are shown in Figure 5.15 to 5.19.

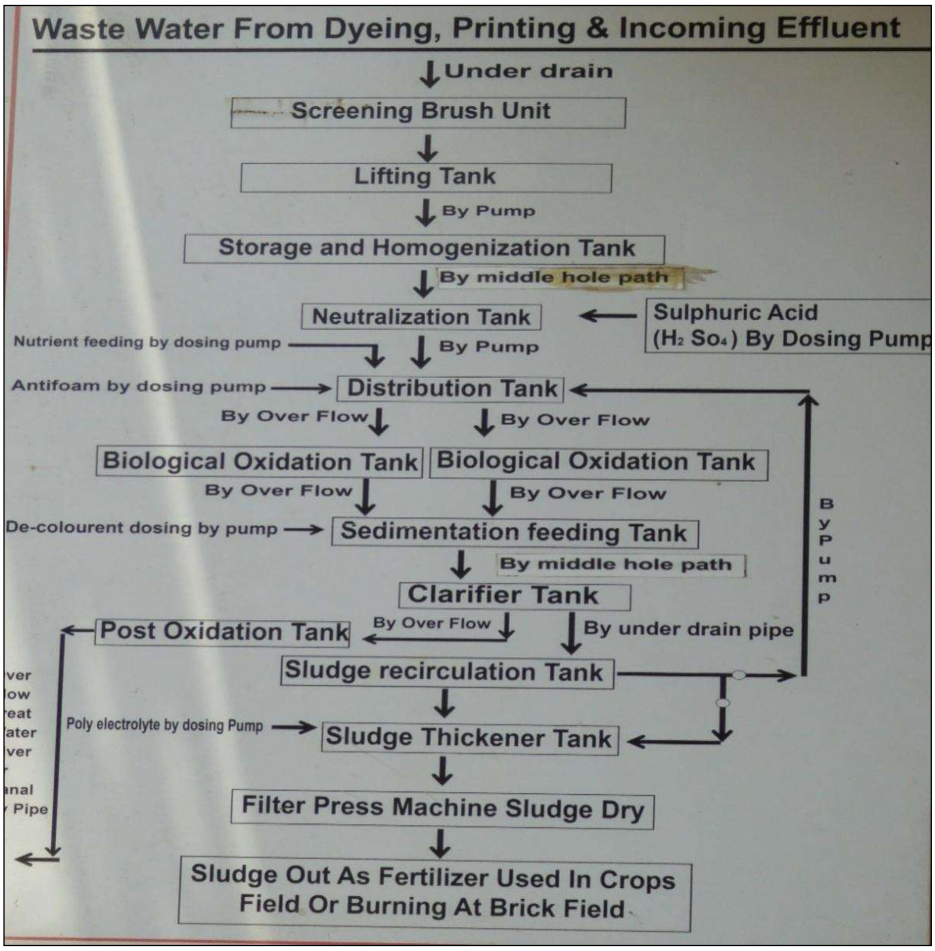

Figure 5.15: Flow Diagram of ETP of Industry Z-4

Figure 5.16: Biological Oxidation Tank

Figure 5.17: Clarifier Tank of ETP of Z-4

Figure 5.18: Filter Press of ETP of Z-4

Figure 5.19: Clear Water Tank of Z-4

Table 5.12: Characteristics of Wastewater sample of Industry Z-4

Parameters	Inlet	Outlet	ECR '97			Minimum Detection Limit (MDL)
			Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	8.98	7.71	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	4000	920	-	-	-	0.01
Turbidity (NTU)	49.7	8.23	-	-	-	0.01
DO (mg/L)	2.73	3.79	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5(mg/L)	160	24	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD(mg/L)	816	283	≤ 200	≤ 400	≤ 400	0.2
EC(µS/cm)	13700	3590	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^-(mg/L)	7400	405	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	5.94	1.05	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-}(mg/L)	0.147	2.435	-	-	-	0.04
TDS (mg/L)	10710	2622	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	128	20	≤ 150	≤ 500	≤ 200	5

Progress in 3R Plan:

Although the industry has not yet implemented any 3R measures at the facility, they are trying to minimize water consumption by process control and planning to reuse boiler water in the process.

5.2.5 Industry Z-5

Table 5.13: General Information of Industry Z-5

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
Z-5	Rupgonj, Narayanganj	Dyeing& Finishing	120000 Yards/day	300 m^3/day

Table 5.14: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacit y	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	240 m^3/day	Physico-Chemical followed by biological process (Screening, Equalization Tank,	Not determin ed	Used for land filling

			Reaction Tank, Aeration tank, Clarifier, Outlet)		

The flow diagrams and photos of ETP are shown in Figure 5.20 to 5.25.

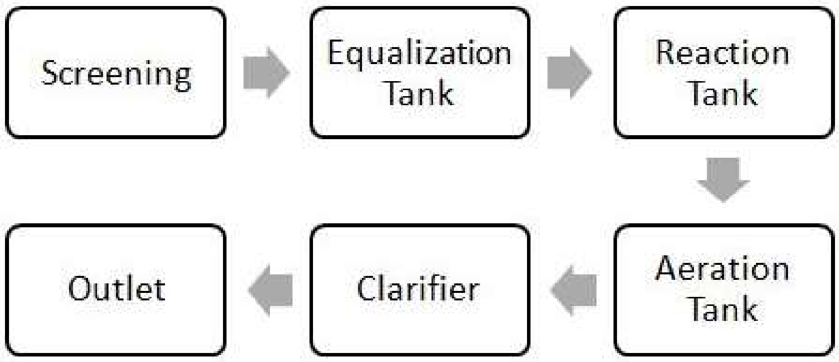

Figure 5.20: Flow Diagram of ETP of Industry Z-5

Figure 5.21: Inlet of ETP of Industry Z-5

Figure 5.22: Reaction Tank of Z-5

Figure 5.23: Sludge Tank of ETP of Z-5

Figure 5.24: Equalization Tank of Z-5

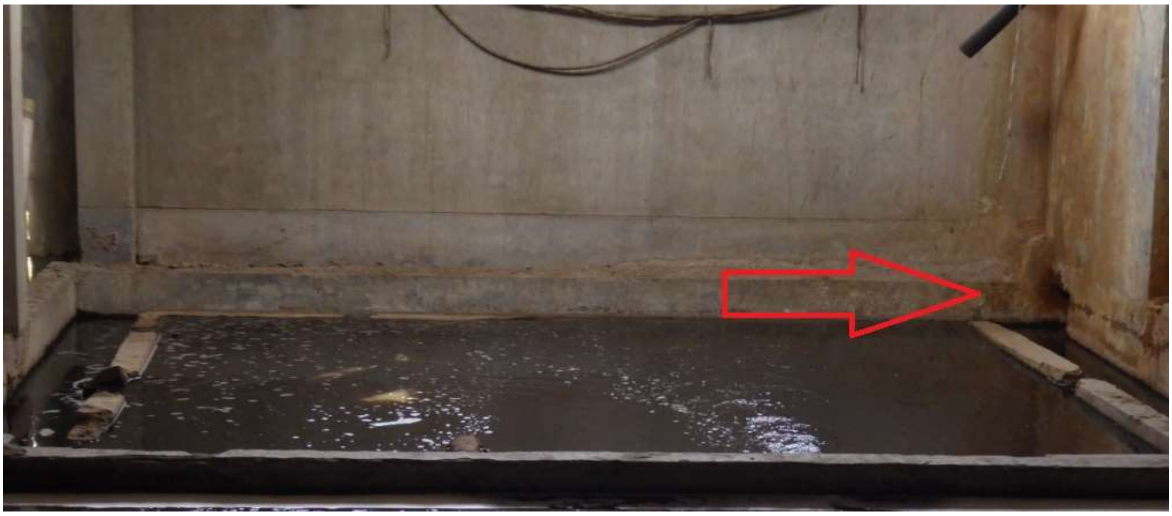

Figure 5.25: Outlet of ETP of Z-5

Table 5.15: Characteristics of Wastewater samples of Industry Z-5

Parameters	Inlet	Outlet	ECR'97			Minimum Detection Limit (MDL)
			Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	10.07	7.81	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	2340	400	-	-	-	0.01
Turbidity (NTU)	361	60.2	-	-	-	0.01
DO (mg/L)	0.19	0.26	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5(mg/L)	720	140	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2

Parameters	Inlet	Outlet	ECR'97			Minimum Detection Limit (MDL)
			Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
COD(mg/L)	3600	553	≤ 200	≤ 400	≤ 400	0.2
EC(µS/cm)	1264	1148	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^-(mg/L)	135	365	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	5.315	1.5	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-}(mg/L)	0.298	0.095	-	-	-	0.04
TDS (mg/L)	1021	840	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	402	72	≤ 150	≤ 500	≤ 200	5

Progress in 3R Plan:

No noteworthy progress in achieving 3R goals.

5.2.6 Industry Z-6

Table 5.16: General Information of Industry Z-6

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
Z-6	Shafipur, Gazipur	Composite (Dyeing, Finishing and RMG)	22 ton/day	3000 m^3/day

Table 5.17: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	3300 m^3/day	Bio-Chemical followed by biological Process (Screening, Equalization Tank, O_3 Contact Tank-1, Flocculation Tank-1, SBR, Intermediate Tank, O_3 Contact Tank-2, Flocculation Tank-2, Outlet, Sludge Conditioning Tank, Filter Press)	1300 kg/day	Land filling with partial treatment after 6-8 months storing

The flow diagrams and photos of ETP are shown in Figure 5.26 to 5.31.

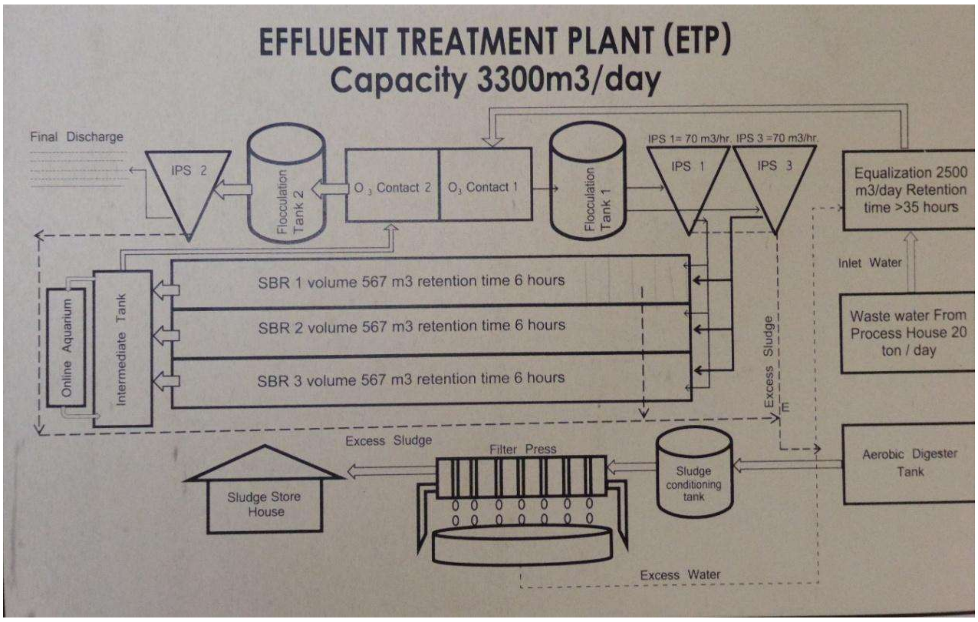

Figure 5.26: Flow Diagram of ETP of Industry Z-6

Figure 5.27: Flocculation Tank of Z-6

Figure 5.28: SBR of Z-6

Figure 5.29: ACF of Z-6

Figure 5.30: MGSF of Z-6

Figure 5.31: Cooling Tower and post natural aeration at Industry Z-6

Table 5.18: Characteristics of Wastewater samples of Industry Z-6

Parameters	Inlet	Before Recycle	Outlet	ECR'97			Minimum Detection Limit (MDL)
				Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	10.54	7.75	7.60	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	484	287	284	-	-	-	0.01
Turbidity (NTU)	66.6	11.9	11	-	-	-	0.01
DO (mg/L)	5.14	0.33	0.15	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5(mg/L)	187.5	24	26	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD(mg/L)	505	66	80	≤ 200	≤ 400	≤ 400	0.2
EC(μS/cm)	2660	4540	4550	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^-(mg/L)	205	290	295	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	1.197	2.19	3.06	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-}(mg/L)	0.299	0.738	0.810	-	-	-	0.04
TDS (mg/L)	1848	3164	3173	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	53	28	31	≤ 150	≤ 500	≤ 200	5

Progress Achieved in 3R Plan:

Industry Z-6 has already installed the following elements to achieve their 3R goals-

- ✓ Exhaust Gas Boiler (EGB)
- ✓ Economizer in built with boiler
- ✓ Rainwater Harvesting
- ✓ Heat recovery in finishing
- ✓ LED and Energy Saving Light
- ✓ Hot Water Chiller
- ✓ Servo Motor in Sewing M/C saving 40-45% energy
- ✓ Condensed recovery from dyeing, finishing and washing
- ✓ Instead of mechanical aeration, the industry has introduced natural aeration (Figure 5.31) to increase DO before the final discharge
- ✓ Low liquor ratio machine
- ✓ Inverter in compressor which reduces energy
- ✓ Hot water recovery in dyeing machine.
- ✓ ETP water reuse in flashing < 10%.
- ✓ Electron beam+ salt recovery in future plan.

5.2.7 Industry Z-7

Table 5.19: General Information of Industry Z-7

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
Z-7	Tongi, Gazipur	Dyeing and Printing	6, 00,000 meter/day	Couldn't be determined

Table 5.20: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	7500 m^3/day	Biological Process (Screening, Homogenization Tank, Neutralization Tank, Cooling Tower, De-nitrification Tank, Aeration tank, Activated Sludge, Clarifier, Post Aeration Tank, Outlet)	Couldn't be determined	Used for land filling

The flow diagrams and photos of ETP are shown in Figure 5.32 to 5.38.

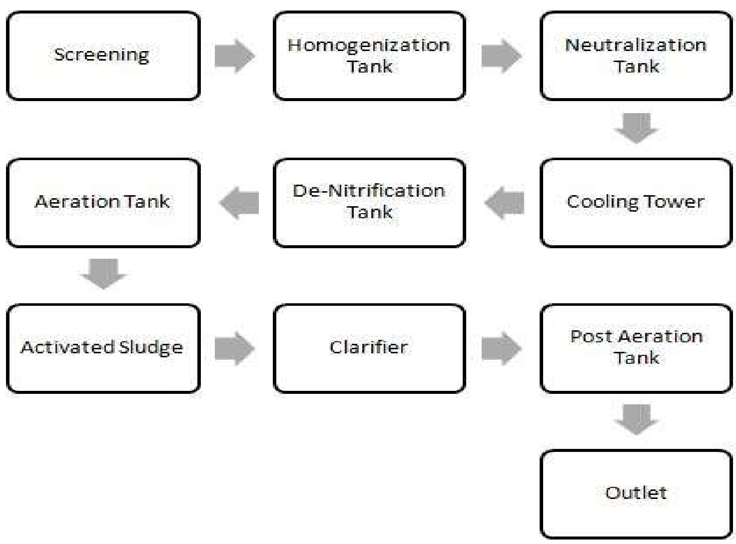

Figure 5.32: Flow Diagram of ETP of Industry Z-7

Figure 5.33: Screening Unit

Figure 5.34: Homogenization Tank of Z-7

Figure 5.35: Cooling Tower of Z-7

Figure 5.36: Aeration Tank

Figure 5.37: Post Aeration Tank of Z-7

Figure 5.38: Clarifier of Z-7

Table 5.21: Characteristics of Wastewater samples of Industry Z-7

Parameters	**Inlet**	**Outlet**	**ECR'97**			**Minimum Detection Limit (MDL)**
			Inland Surface Water	**Public sewerage system connected to treatment at 2nd stage**	**Irrigated Land**	
pH	11.56	7.32	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	4500	1020	-	-	-	0.01
Turbidity (NTU)	249	4.36	-	-	-	0.01
DO (mg/L)	0.81	0.32	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5(mg/L)	700	18	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD(mg/L)	1232	122	≤ 200	≤ 400	≤ 400	0.2
EC(µS/cm)	4410	4360	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^-(mg/L)	380	90	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	11.63	1.712	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-}(mg/L)	4.74	3.2	-	-	-	0.04
TDS (mg/L)	3756	3364	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	428	34	≤ 150	≤ 500	≤ 200	5

Progress Achieved in 3R Plan:

No measures were undertaken to achieve 3R goals.

5.2.8 Industry Z-8

Table 5.22: General Information of Industry Z-8

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
Z-8	Shafipur,Gazipur	Composite (Knitting, Dyeing, Washing, Finishing)	100000 Metric ton/day	4870 m^3/day

Table 5.23: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	4080 m^3/day	Biological Process (Screening, Equalization Tank, Neutralization Tank, Distribution Tank, Biological Tank, Clarifier, Outlet, Filter Press)	4800 kg/month	Storing sludge on temporary basis.

The flow diagram and photos of ETP are shown in Figure 5.39 to 5.46.

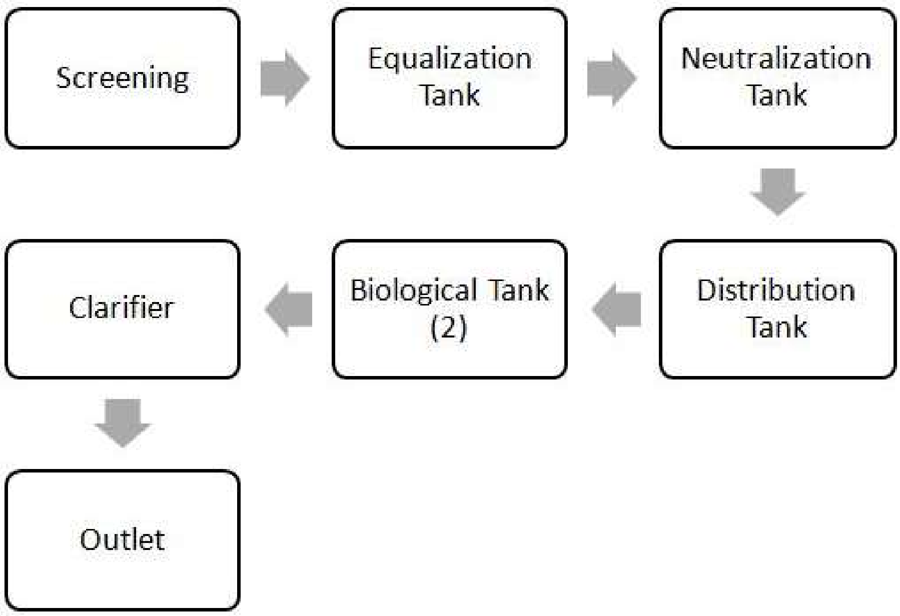

Figure 5.39: Flow Diagram of ETP of Industry Z-8

Figure 5.40: ETP Inletof Z-8

Figure 5.41: Storage of Water before ETP

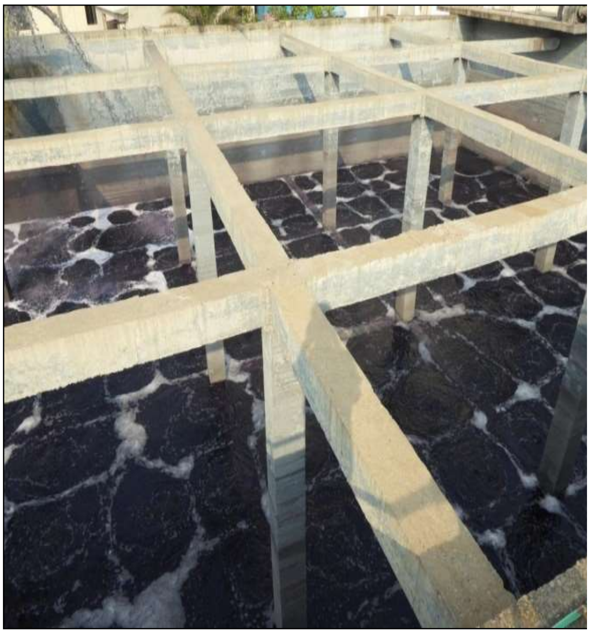

Figure 5.42: Equalization Tank of Z-8

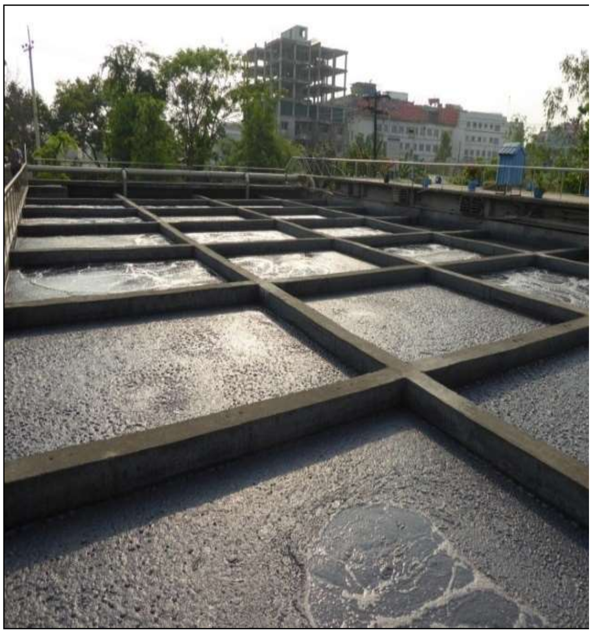

Figure 5.43: Oxidation Tankof Z-8

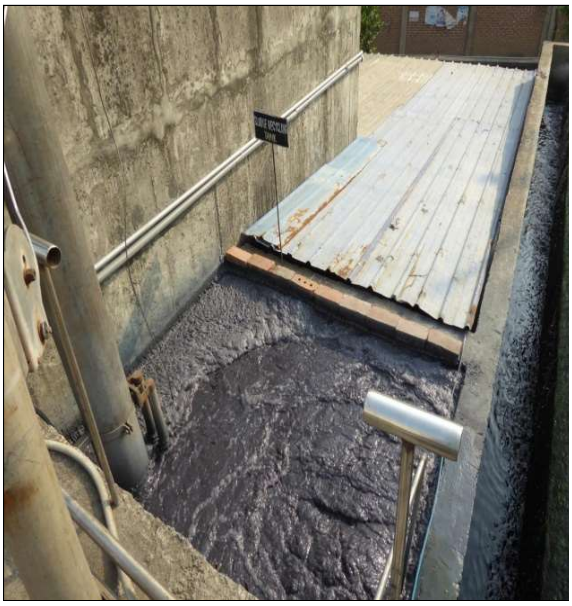

Figure 5.44: Clarifier of Z-8

Figure 5.45: Sludge Bed of Z-8

Figure 5.46: Filter Press of Z-8

Table 5.24: Characteristics of Wastewater sample of Industry Z-8

Parameters	Inlet	Outlet	ECR'97			Minimum Detection Limit (MDL)
			Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	10.99	7.49	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	2650	1150	-	-	-	0.01
Turbidity (NTU)	746	5.58	-	-	-	0.01
DO (mg/L)	1	4.23	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5(mg/L)	140	5	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD(mg/L)	561	57	≤ 200	≤ 400	≤ 400	0.2
EC(μS/cm)	2140	3330	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^-(mg/L)	290	325	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	5.235	1.295	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-}(mg/L)	1.5	2.5	-	-	-	0.04
TDS (mg/L)	1418	2289	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	128	45	≤ 150	≤ 500	≤ 200	5

Progress in 3R Plan:

No noteworthy progress in achieving 3R goals.

5.2.9 Industry Z-9

Table 5.25: General Information of Industry Z-9

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
Z-9	Kashimpur, Konabari, Gazipur	Composite (Knitting, Dyeing and RMG)	12 ton/day	2900 m^3/day

Table 5.26: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	1440 m^3/day	Physico- chemical followed by Biological process (Screening, Equalization Tank, Reaction Tank, Clarifier, SBR, Outlet, Filter Press)	700-800 kg/day	Land filling after storing for 6 months

The flow diagrams and photos of ETP are shown in Figure 5.47 to 5.51.

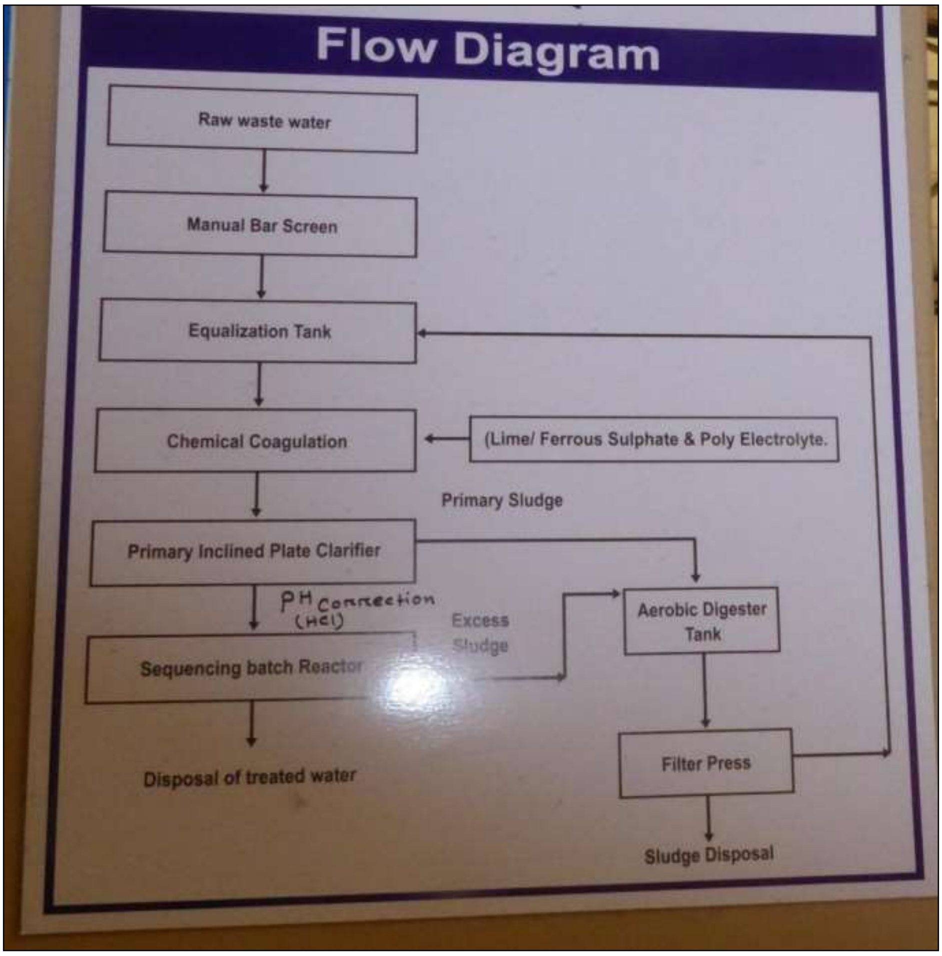

Figure 5.47: Flow Diagram of ETP units of Industry Z-9

Figure 5.48: Coagulation Tank of Z-9

Figure 5.49: Primary Clarifier of Z-9

Figure 5.50: SBR units of Z-9

Figure 5.51: Filter Press of Z-9

Table 5.27: Characteristics of Wastewater samples of Industry Z-9

Parameters	Inlet	Outlet	ECR'97			Minimum Detection Limit (MDL)
			Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	9.74	6.90	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	3780	310	-	-	-	0.01
Turbidity (NTU)	59.9	25.5	-	-	-	0.01
DO (mg/L)	0.08	5.39	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5(mg/L)	840	32.5	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD(mg/L)	1728	95	≤ 200	≤ 400	≤ 400	0.2
EC(µS/cm)	7870	5650	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^-(mg/L)	150	395	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	7.625	0.483	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-}(mg/L)	4.82	13.21	-	-	-	0.04
TDS (mg/L)	6226	4137	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	350	61	≤ 150	≤ 500	≤ 200	5

Progress Achieved in 3R Plan:

Industry Z-9 has already installed the following elements to achieve their 3R goals:

- ✓ Low liquor ratio machinery has been installed
- ✓ Hot water recovery process is running
- ✓ EVC, Economizer, condenser, LED light for energy consumption reduction.
- ✓ Cooling water reuse.
- ✓ GOTS approved Servo motor installation.

5.2.10 Industry Z-10

Table 5.28: General Information of Industry Z-10

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
Z-10	Adamjee EPZ, Narayanganj	Washing and RMG	20,000 pieces/day	370 m^3/day

Table 5.29: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ZLD-ETP	Ground water	280 m^3/day	Physico-Chemical followed by biological process (Screening, Equalization Tank, ECR, Reaction Tank, Clarifier, PSF, Bag Filter, Post Aeration Tank, RO, Sludge Thickening Tank, Filter Press)	2800 kg/month	Land filling after storing for 6 months

The flow diagrams and photos of ETP are shown in Figure 5.52 to 5.58.

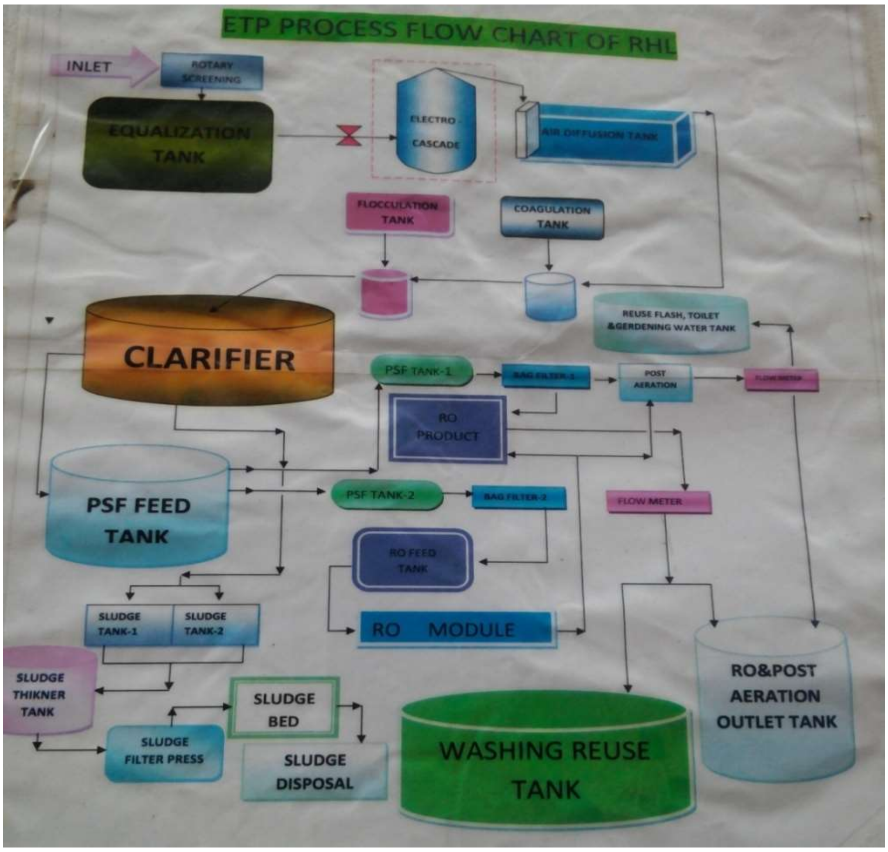

Figure 5.52: Flow Diagram of ETP of Industry Z-10

Figure 5.53: Equalization Tank of Z-10

Figure 5.54: ECR of Z-10

Figure 5.55: Reaction Tank of Z-10

Figure 5.56: Clarifier of Z-10

Figure 5.57: Reverse Osmosis System of Z-10

Figure 5.58: Sludge Thickening Tank of Z-10

Table 5.30: Characteristics of Wastewater samples of Industry Z-10

Parameters	Inlet	Before RO	Outlet	ECR'97			Minimum Detection Limit (MDL)
				Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	7.88	6.64	6.52	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	78	45	10	-	-	-	0.01
Turbidity (NTU)	85.1	15.7	0.72	-	-	-	0.01
DO (mg/L)	5.59	3.09	3.67	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5(mg/L)	100	11.2	0.4	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD(mg/L)	320	30	5	≤ 200	≤ 400	≤ 400	0.2
EC(µS/cm)	540	1369	367	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^-(mg/L)	165	315	200	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	2.258	1.564	0.465	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-}(mg/L)	0.058	0.162	0.055	-	-	-	0.04
TDS (mg/L)	341	855	187	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	129	27	7	≤ 150	≤ 500	≤ 200	5

Progress Achieved in 3R Plan:

- ✓ Recycle 1358 m^3 water per month using RO and use it as process water.
- ✓ Reuse 3642 m^3 ETP water per month in Toilet flashing and Gardening.

5.3 SUMMARY OF ETP INDUSTRIES' INFORMATION

The information and test results of ETP industries are presented in following sub sections.

5.3.1 Industry E-1

Table 5.31: General Information of Industry E-1

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
E-1	Valuka, Mymensing	Dyeing, Washing & Finishing	1,40,000 Yards/day	4800 m^3/day

Table 5.32: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	4800 m^3/day	Physico-chemical followed by biological process (Screening, Equalization Tank, Reaction Tank, Primary Clarifier, Bio-reactor, PSF, Secondary Clarifier, Outlet)	574 ton/yr	Used for brick production

The flow diagram and photos of ETP are shown in Figure 5.59 to 5.68.

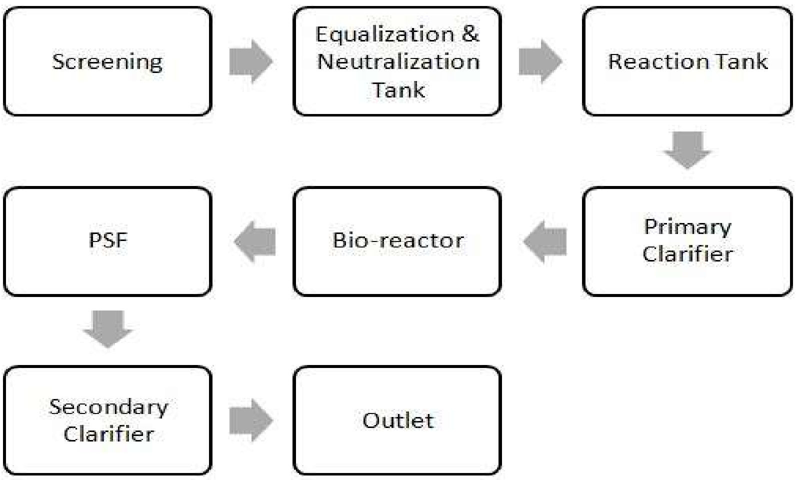

Figure 5.59: Flow Diagram of ETP of Industry E-1

Figure 5.60: Primary Clarifierof E-1

Figure 5.61: Reaction tank of E-1

Figure 5.62: Bio-reactor of E-1

Figure 5.63: ETP Outlet tank

Figure 5.64: Pressure sand filter

Figure 5.65: Secondary clarifier of E-1

Figure 5.66: Sludge storage tank

Figure 5.67: Filter press of E-1

Figure 5.68: ETP treated water reservoir in Industry E-1

Table 5.33: Characteristics of Wastewater samples of Industry E-1

Parameters	Inlet	Outlet	Before Reuse	ECR'97			Minimum Detection Limit (MDL)
				Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	11.51	7.32	7.14	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	800	32	40	-	-	-	0.01
Turbidity (NTU)	303	8.62	5.54	-	-	-	0.01
DO (mg/L)	0.31	5.25	4.26	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5 (mg/L)	920	12.8	9.6	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD (mg/L)	1856	68	53	≤ 200	≤ 400	≤ 400	0.2
EC (μS/cm)	3760	2160	1958	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^- (mg/L)	340	680	610	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	0.468	0.469	0.69	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-} (mg/L)	0.908	0.505	0.766	-	-	-	0.04
TDS (mg/L)	2736	1354	1208	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	242	43	47	≤ 150	≤ 500	≤ 200	5

3R Activities in E-1:

Industry E-1is practicing many measures in the industry to reuse, recycle and recovery. According to them, these are follows:

- ✓ Annual natural resource (gas+ diesel) saving 67, 10,160m^3which equals 29, 83,656USD in terms of financial aspect.2.09% water consumption reduction for dyed knitted fabric production.
- ✓ Overall factory gas consumption reduction 0.89%.
- ✓ 0.21% Steam reduction in dyed knitted fabric production.
- ✓ 10 Water trigger nozzle was installed which saves water approximately 6,158 m^3/yr.
- ✓ Cooling water recover from gas singeing machine approximately 10,264 m^3/yr.
- ✓ Condensate recovery of water approximately 8,870 m^3/yr.
- ✓ Air trigger nozzle save electricity approximately 46,800 m^3/yr.

- ✓ Installing energy efficient lighting saves electricity approximately 87,000 m^3/yr.
- ✓ Overall percentage of reuse and recovery of water 40%.
- ✓ Overall percentage of reuse and recovery of ETP water 18%.

- ✓ Tree plantation. Planning to plant red oak tree which generates more oxygen.
- ✓ White road surface for less radiation.
- ✓ Per 5 sec monitoring system BMS.
- ✓ Water reused in fire fighting, road cleaning and toilet flashing.
- ✓ Use of stone pits to increase infiltration rate.

5.3.2 Industry E-2

Table 5.34: General Information of Industry E-2

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
E-2	Konabari, Gazipur	RMG Washing	20,000 piece/day	1890 m^3/day

Table 5.35: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	1440 m^3/day	Physico-Chemical followed by biological process (Screening, Equalization Tank, Flush Mixing Tank, Flocculation tank, Clarifier, Clear Water Tank, Dual Media Filter, Color Removal Unit, Aeration Tank, Outlet)	14-15 ton/ month (Dewatered Sludge)	Used for land filling and brick kiln

The flow diagram and photos of ETP are shown in Figure 5.69 to 5.74.

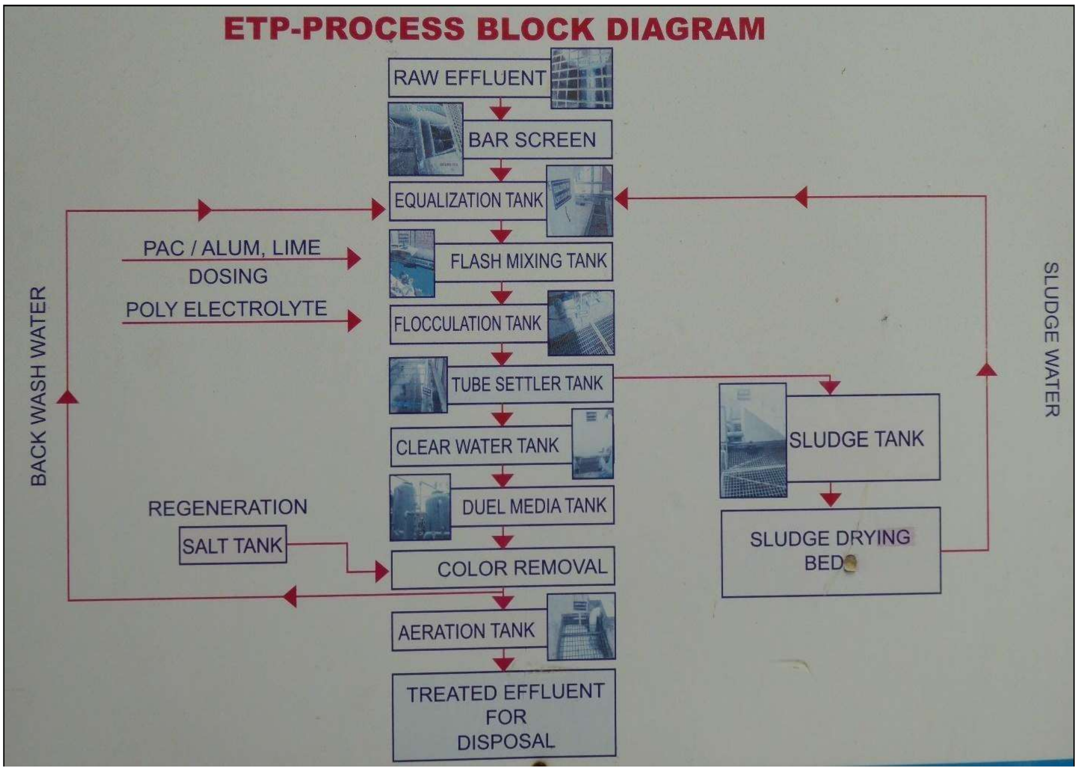

Figure 5.69: ETP Flow Diagram

Figure 5.70: Screening unit of E-2

Figure 5.71: Flush Mixing tank of E-2

Figure 5.72: Clarifier tank

Figure 5.73: ETP Outlet

Figure 5.74: Dual media filter of E-2

Table 5.36: Characteristics of Wastewater samples of Industry E-2

Parameters	Inlet	Outlet	ECR'97			Minimum Detection Limit (MDL)
			Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	7.03	6.99	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	360	110	-	-	-	0.01
Turbidity (NTU)	371	14.3	-	-	-	0.01
DO (mg/L)	5.64	0.25	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5 (mg/L)	240	56	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD (mg/L)	687	159	≤ 200	≤ 400	≤ 400	0.2
EC (μS/cm)	755	1235	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^- (mg/L)	240	540	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	1.462	1.103	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-} (mg/L)	0.162	0.073	-	-	-	0.04
TDS (mg/L)	678	858	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	586	28	≤ 150	≤ 500	≤ 200	5

3R Activities:

Industry E-2 has implemented following measures:

- ✓ Using Ozone in dyeing process to reduce water consumption
- ✓ PLC inverter
- ✓ Flow meter
- ✓ Recovering hot water to use within the process
- ✓ Reuse water in car and road washing
- ✓ Planning to use treated water in toilet flush

5.3.3 Industry E-3

Table 5.37: General Information of Industry E-3

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
E-3	Konabari, Gazipur	Composite (Knitting, Dyeing, Washing, Finishing)	8 ton/day	768 m^3/day

Table 5.38: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	960m^3/day	Physico-chemical followed by Biological process (Screening, Equalization Tank, Flush Mixing Tank, Flocculation Tank, Tube Settler (2), Biological Tank, Treated Water Tank, Multi-grade Filter, Outlet)	470 kg/day	Used for land filling and brick field (after drying for 6 months)

The flow diagram and photos of ETP are shown in Figure 5.75 to 5.78.

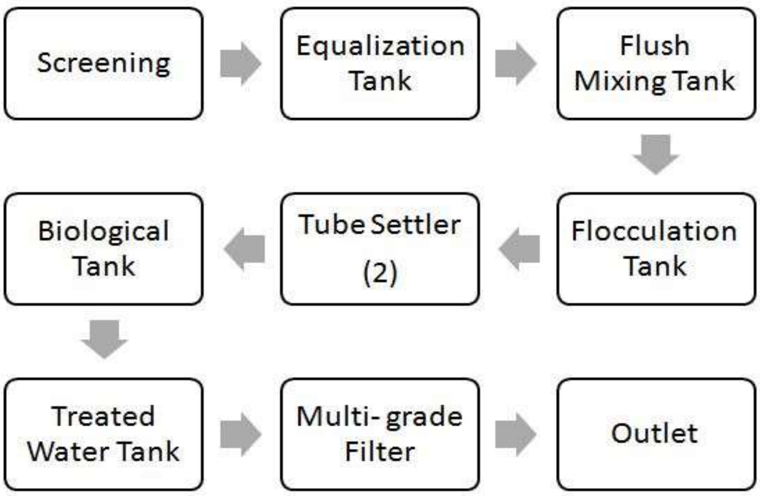

Figure 5.75: Flow Diagram of ETP of Industry E-3

Figure 5.76: Screening unit of E-3

Figure 5.77: Flocculation tank of E-3

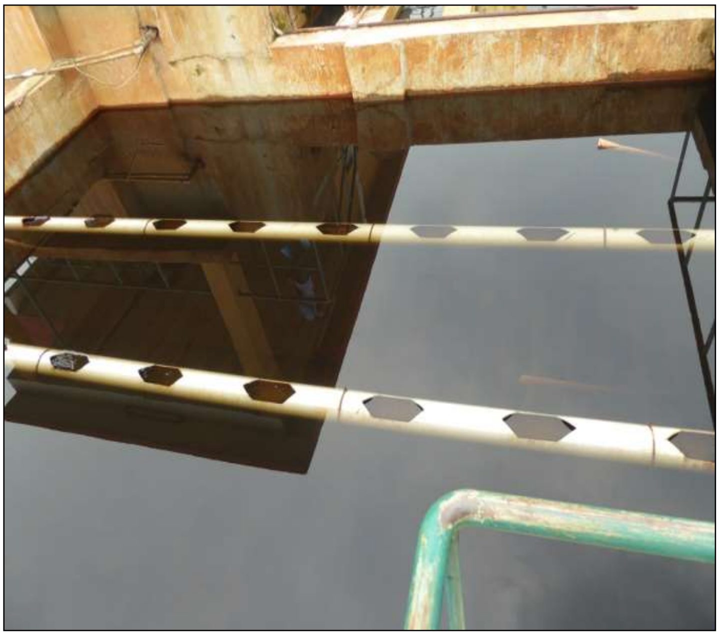

Figure 5.78: Tube settler of Industry E-3

Table 5.39: Characteristics of Wastewater samples of Industry E-3

Parameters	Inlet	Outlet	ECR'97			Minimum Detection Limit (MDL)
			Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	9.50	7.72	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	1700	148	-	-	-	0.01
Turbidity (NTU)	88.2	8.62	-	-	-	0.01
DO (mg/L)	0.11	5.39	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5 (mg/L)	112	8	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD (mg/L)	372	44	≤ 200	≤ 400	≤ 400	0.2
EC (μS/cm)	3700	1560	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^- (mg/L)	230	300	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	1.994	1.170	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-} (mg/L)	1.09	0.132	-	-	-	0.04
TDS (mg/L)	2804	1107	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	240	35	≤ 150	≤ 500	≤ 200	5

3R Activities in E-3:

No mentionable measures other than hot water recovery from boiler are observed in the industry.

5.3.4 Industry E-4

Table 5.40: General Information of Industry E-4

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
E-4	Tongi, Gazipur	Dyeing, Washing	10-11 ton/day	1200 m^3/day

Table 5.41: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	1200 m^3/day	Physico-Chemical followed by biological process (Screening, Equalization Tank, Reaction Tank, Settling Tank, Aeration Tank (Sprinkler), Outlet)	25-27 m^3/day	Land filling (after 6 month of drying in RCC reservoir)

The flow diagram and photos of ETP are shown in Figure 5.79 to 5.83.

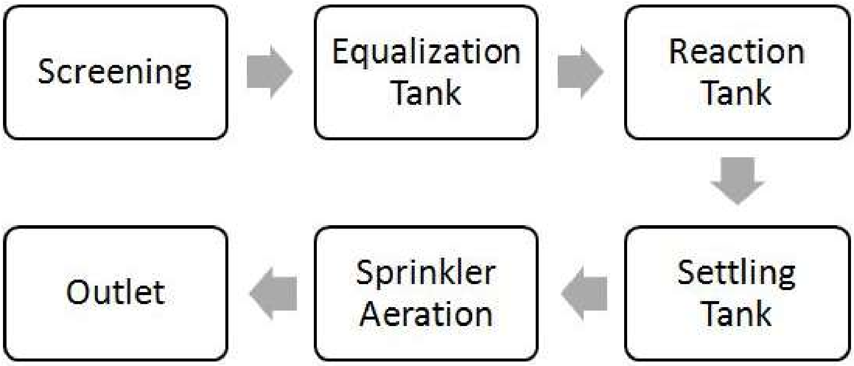

Figure 5.79: ETP Flow Diagram of industry E-4

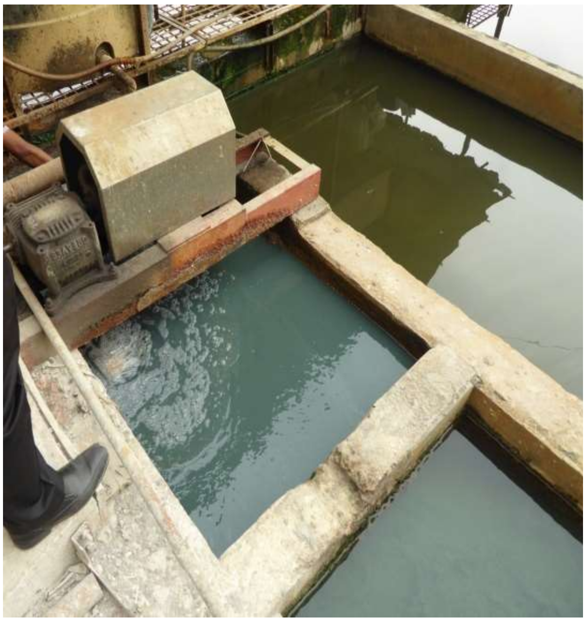

Figure 5.80: Reaction tank of E-4

Figure 5.81: Primary Settling tank

Figure 5.82: Aeration tank of E-4

Figure 5.83: Secondary Settling tank

Table 5.42: Characteristics of Wastewater samples of Industry E-4

Parameters	Inlet	Outlet	ECR'97			Minimum Detection Limit (MDL)
			Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	9.15	7.12	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	1420	335	-	-	-	0.01
Turbidity (NTU)	219	57.4	-	-	-	0.01
DO (mg/L)	0.1	0.06	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5 (mg/L)	256	192	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD (mg/L)	704	359	≤ 200	≤ 400	≤ 400	0.2
EC (µS/cm)	4320	4090	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^- (mg/L)	540	470	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	2.09	0.457	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-} (mg/L)	0.275	0.082	-	-	-	0.04
TDS (mg/L)	3302	3051	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	226	60	≤ 150	≤ 500	≤ 200	5

3R Activities in E- 4:

No 3R measures were observed in the industry.

5.3.5 Industry E-5

Table 5.43: General Information of Industry E-5

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
E-5	Tongi BSCIC, Gazipur	Dyeing	4.5 ton/day	450-500 m^3/day

Table 5.44: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	840 m^3/day	Physico-Chemical process (Screening, Equalization Tank, Reaction Tank, Primary Settling Tank, Aeration Tank, Secondary Settling Tank, Outlet, Filter Press)	Couldn't be determin ed	Dispose like municipal solid waste

The flow diagram and photos of ETP are shown in Figure 5.84 to 5.88.

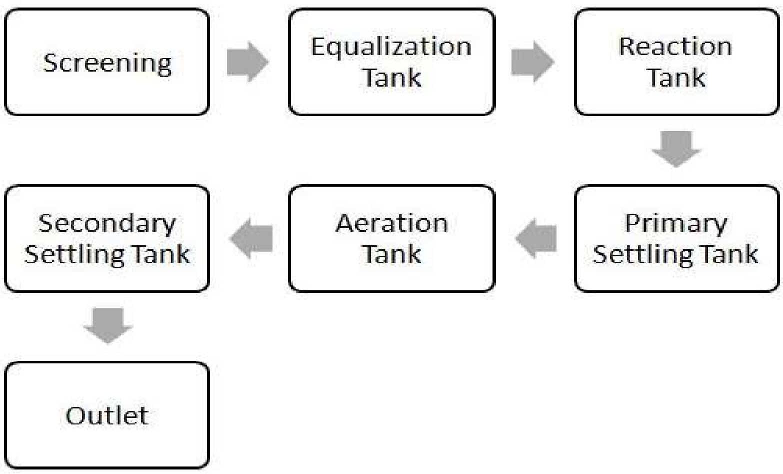

Figure 5.84: Flow Diagram of E-5

Figure 5.85: Equalization tank of E-5

Figure 5.86: Reaction tank of E-5

Figure 5.87: Aeration tank of E-5

Figure 5.88: Filter press of industry E-5

Table 5.45: Characteristics of Wastewater samples of Industry E-5

Parameters	Inlet	Outlet	ECR'97			Minimum Detection Limit (MDL)
			Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	7.77	7.40	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	202	113	-	-	-	0.01
Turbidity (NTU)	74.3	33.2	-	-	-	0.01
DO (mg/L)	0	0.05	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5 (mg/L)	220	40	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD (mg/L)	443	119	≤ 200	≤ 400	≤ 400	0.2
EC (μS/cm)	2710	2660	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^- (mg/L)	140	135	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	0.539	0.652	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-} (mg/L)	1.042	0.242	-	-	-	0.04
TDS (mg/L)	2000	1790	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	72	45	≤ 150	≤ 500	≤ 200	5

3R Activities in E-5:

Industry E-5 is practicing following 3R measures:

- ✓ Reusing hot dyeing water in boiler
- ✓ New dyeing machine Installed (Liquor ratio 1:4 to 1:5)

5.3.6 Industry E-6

Table 5.46: General Information of Industry E-6

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
E-6	Tongi, Gazipur	Knitting, Dyeing, Finishing	8 ton/day	806 m^3/day

Table 5.47: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	720 m^3/day	Physico-Chemical process (Screening, Equalization Tank, Flocculation Tank, Settling Tank, Aeration tank, Multi-grade Filter, Activated Carbon Filter, Outlet)	Couldn't found	Disposes with municipal solid waste

The flow diagram and photos of ETP are shown in Figure 5.89 to 5.93.

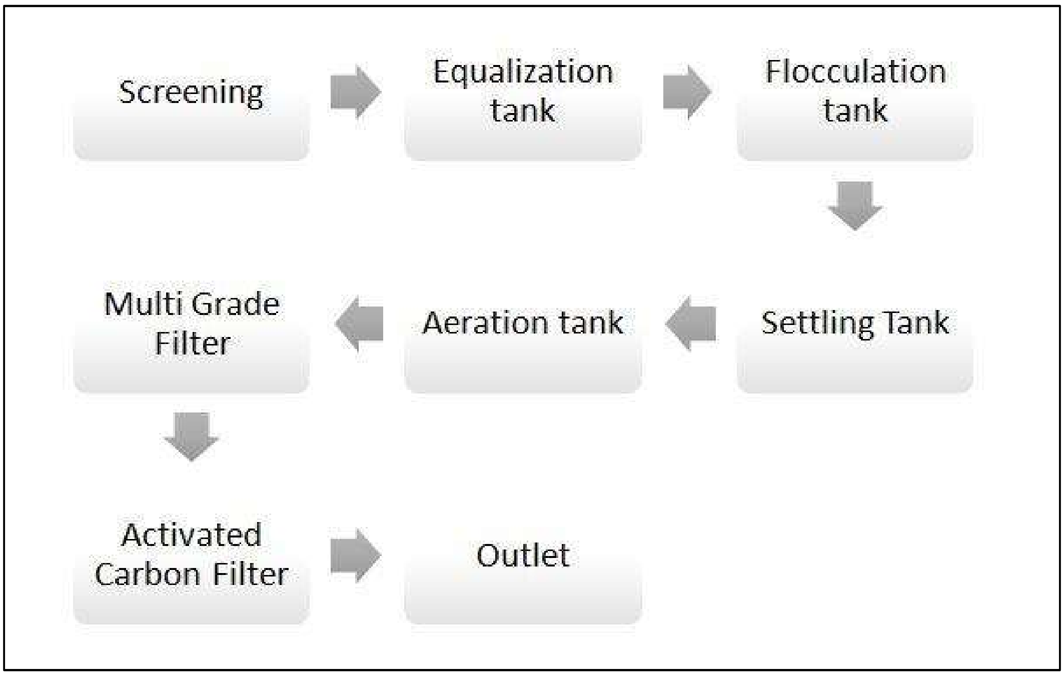

Figure 5.89: Flow Diagram of ETP

Figure 5.90: Equalization tank of E-6

Figure 5.91: Settling tank of E-6

Figure 5.92: Multi-grade filter of E-6

Figure 5.93: Aeration tank of E-6

Table 5.48: Characteristics of Wastewater samples of Industry E-6

Parameters	Inlet	Outlet	ECR'97			Minimum Detection Limit (MDL)
			Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	7.72	7.43	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	1396	231	-	-	-	0.01
Turbidity (NTU)	101	25.2	-	-	-	0.01
DO (mg/L)	0.05	0.05	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5 (mg/L)	300	220	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD (mg/L)	794	389	≤ 200	≤ 400	≤ 400	0.2
EC (µS/cm)	7120	7000	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^- (mg/L)	350	600	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	2.025	2.9	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-} (mg/L)	0.392	0.256	-	-	-	0.04
TDS (mg/L)	5550	5224	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	231	28	≤ 150	≤ 500	≤ 200	5

3R Activities:

Industry E-6 has implemented following measures:

- ✓ Boiler water returned to boiler after condensed
- ✓ Practicing Low consumption in Dyeing process (60% reuse) for 3 years
- ✓ Water reuse only in floor washing (irregular)

5.3.7 Industry E-7

Table 5.49: General Information of Industry E-7

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
E-7	Gazipur	Dyeing	800-1000 kg/day	5 m^3/day

Table 5.50: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	15 m^3/day	Physico-Chemical process (Screening, Equalization Tank, Sedimentation Tank, Sand Filter, Activated Carbon Filter, Sprinkler Aeration Tank, Outlet)	40-50 kg/month	Stored inside the industry

The flow diagram and photos of ETP are shown in Figure 5.94 to 5.98.

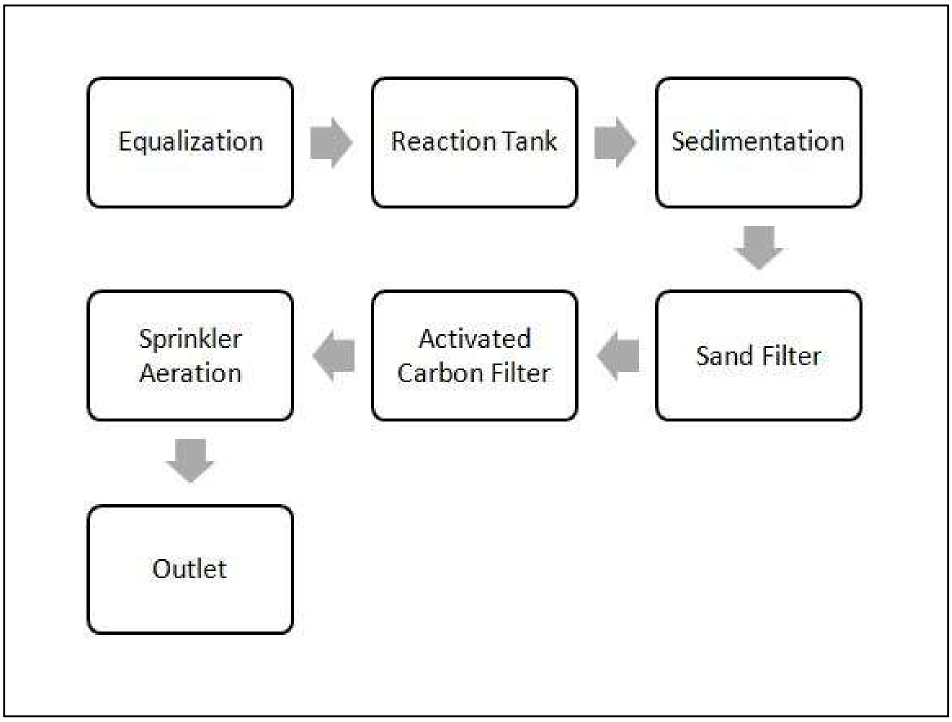

Figure 5.94: Flow Diagram of ETP

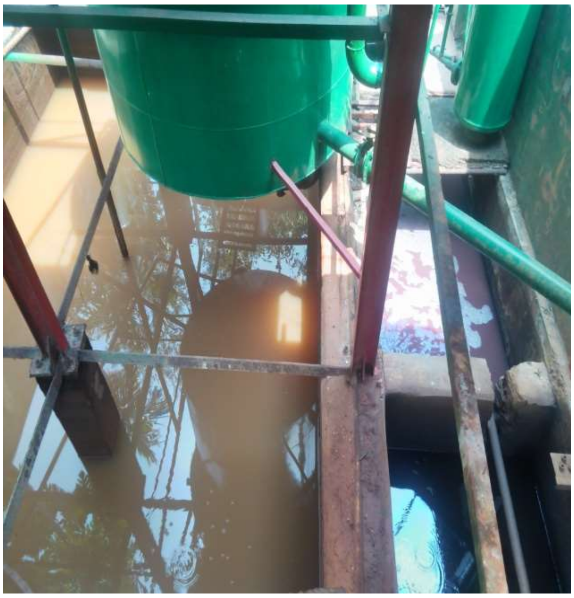

Figure 5.95: Equalization Tank of of E-7

Figure 5.96: Reaction tank of E-7

Figure 5.97: Sand Filter of E-7

Figure 5.98: Aeration tank of E-7

Table 5.51: Characteristics of Wastewater samples of Industry E-7

Parameters	Inlet	Outlet	ECR'97			Minimum Detection Limit (MDL)
			Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	7.68	7.30	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	1070	85	-	-	-	0.01
Turbidity (NTU)	98.6	4.07	-	-	-	0.01
DO (mg/L)	0.08	0.38	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5 (mg/L)	80	10	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD (mg/L)	660	67	≤ 200	≤ 400	≤ 400	0.2
EC (μS/cm)	755	1020	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^- (mg/L)	165	275	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	2.77	1.275	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-} (mg/L)	0.02	0.05	-	-	-	0.04
TDS (mg/L)	634	775	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	36	42	≤ 150	≤ 500	≤ 200	5

3R Activities in E-7:

Industry E-7 has implemented following 3R measures:

- ✓ Rain water harvesting was installed in 2016
- ✓ 10 m^3/day water reuse in dying process.

5.3.8 Industry E-8

Table 5.52: General Information of Industry E-8

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
E-8	Tejgaon, Dhaka	Washing	0.1-0.2 ton /month	4-5 m^3/day

Table 5.53: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	5 m^3/day	Physico-Chemical followed by biological process (Screening, ECR, Aeration tank, Lamella Clarifier, PSF, Outlet)	Data not available	Sludge drying bed

The flow diagram and photos of ETP are shown in Figure 5.99 to 5.102.

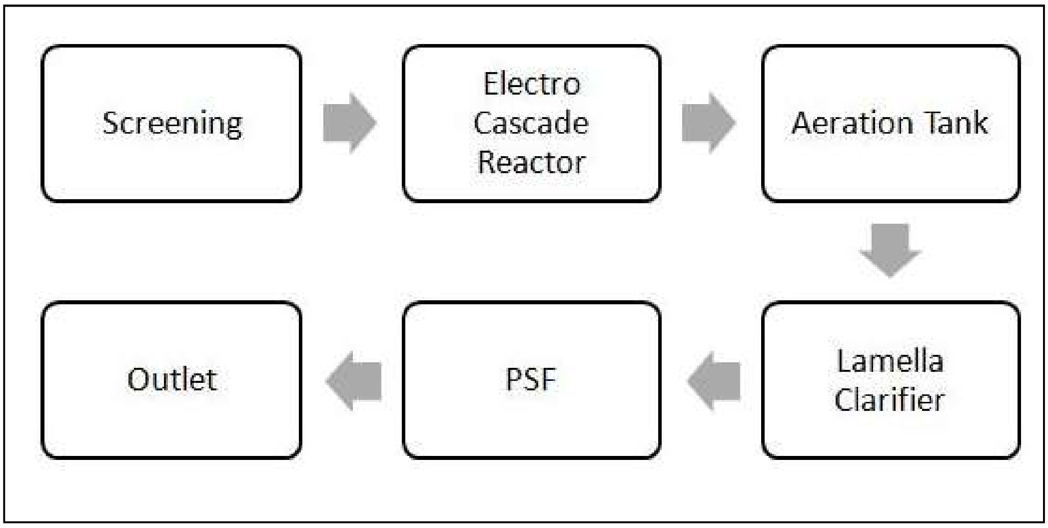

Figure 5.99: ETP Flow Diagram of industry E-8

Figure 5.100: Lamella Clarifier of E-8

Figure 5.101: ECR of E-8

Figure 5.102: Aeration tank of industry E-8

Table 5.54: Characteristics of Wastewater samples of Industry E-8

Parameters	Inlet	Outlet	ECR'97			Minimum Detection Limit (MDL)
			Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	5.63	7.64	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	53	13	-	-	-	0.01
Turbidity (NTU)	51	1.29	-	-	-	0.01
DO (mg/L)	4.25	6.07	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5 (mg/L)	28	1.2	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD (mg/L)	137	7	≤ 200	≤ 400	≤ 400	0.2
EC (μS/cm)	863	1533	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^- (mg/L)	125	265	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	1.23	0.567	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-} (mg/L)	0.038	0.2	-	-	-	0.04
TDS (mg/L)	601	989	≤ 2100	≤ 2100	≤ 2100	5

Parameters	Inlet	Outlet	ECR'97			Minimum Detection Limit (MDL)
			Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
TSS (mg/L)	93	15	≤ 150	≤ 500	≤ 200	5

3R Activities in E-8:

Industry E-8 has implemented following 3R measures:.

- ✓ Solar Panel was installed in 2013.
- ✓ RO unit will be installed soon.

5.3.9 Industry E-9

Table 5.55: General Information of Industry E-9

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
E-9	Shyampur, Dhaka	Knitting, Dyeing, Finishing	10 ton/day	960 m^3/day

Table 5.56: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	1200 m^3/day	Physico-chemical followed by biological process (Screening, Equalization Tank, Cooling Tower, Reaction Tank, DAF (Dissolved Air Floatation), Aeration Tank (2), Secondary Clarifier (2),Outlet)	2 ton/month	Dispose as Municipal Solid Waste

The flow diagram and photos of ETP are shown in Figure 5.103 to 5.109.

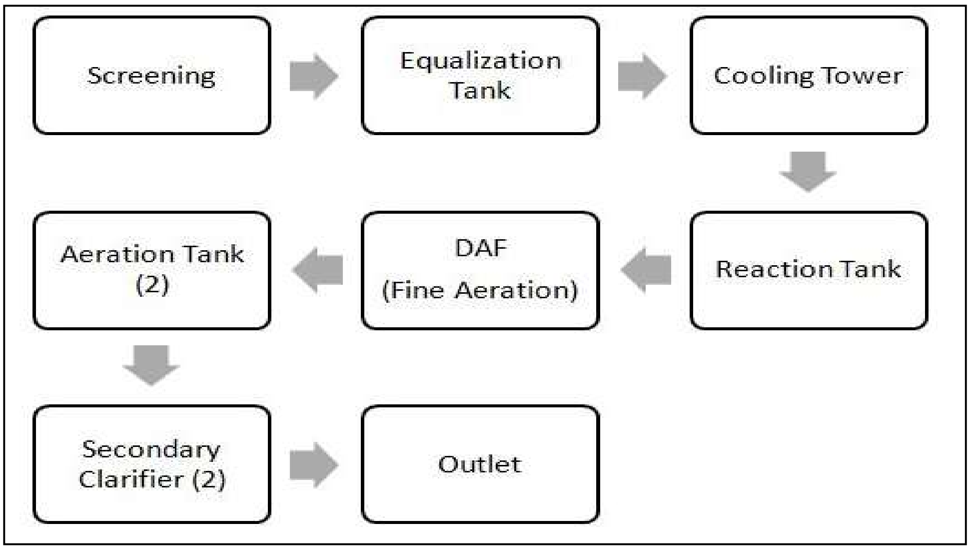

Figure 5.103: ETP Flow Diagram of industry E-9

Figure 5.104: Screening of industry E-9

Figure 5.105: Cooling tower of E-9

Figure 5.106: DAF Scrapper of E-9

Figure 5.107: Sludge Drying bed of E-9

Figure 5.108: Clarifier of industry E-9

Figure 5.109: Sludge holding tank of E-9

Table 5.57: Characteristics of Wastewater samples of Industry E-9

Parameters	Inlet	Outlet	ECR'97			Minimum Detection Limit (MDL)
			Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	6.85	7.47	6.0-9.0	6.0-9.0	6.0-9.0	0

Parameters	Inlet	Outlet	ECR'97			Minimum Detection Limit (MDL)
			Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
Color (Pt-Co)	5500	820	-	-	-	0.01
Turbidity (NTU)	56	23.9	-	-	-	0.01
DO (mg/L)	5.21	5.24	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5 (mg/L)	128	7	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD (mg/L)	698	53	≤ 200	≤ 400	≤ 400	0.2
EC (µS/cm)	6320	3280	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^- (mg/L)	110	260	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	11.5	1.825	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-} (mg/L)	0.37	2.32	-	-	-	0.04
TDS (mg/L)	708	2298	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	124	27	≤ 150	≤ 500	≤ 200	5

3R Activities in E-9

No mentionable 3R measures are in practice in the industry.

5.3.10 Industry E-10

Table 5.58: General Information of Industry E-10

Industry Id	Location	Type of Industry	Production Capacity	Water consumption (Total)
E-10	Gazipur	Dyeing	1,50,000 Yards /day	2500 m^3/day

Table 5.59: Information on ETP

Wastewater Treatment Plant	Source of Process water	ETP Capacity	Unit operations	Amount of Sludge	Disposal of sludge
ETP only	Ground water	2400 m^3/day	Anaerobic Biological (UASB)	UASB technology	Not known yet

			(Screening, Reservoir Tank, Equalization Tank, Feed Tank, UASB, Bio-filter, Aeration Tank, Clarifier, Outlet)	has been installed recently. So amount of sludge will be known after 6 or 8 months	

The flow diagram and photos of ETP are shown in Figures 5.110 to 5.116.

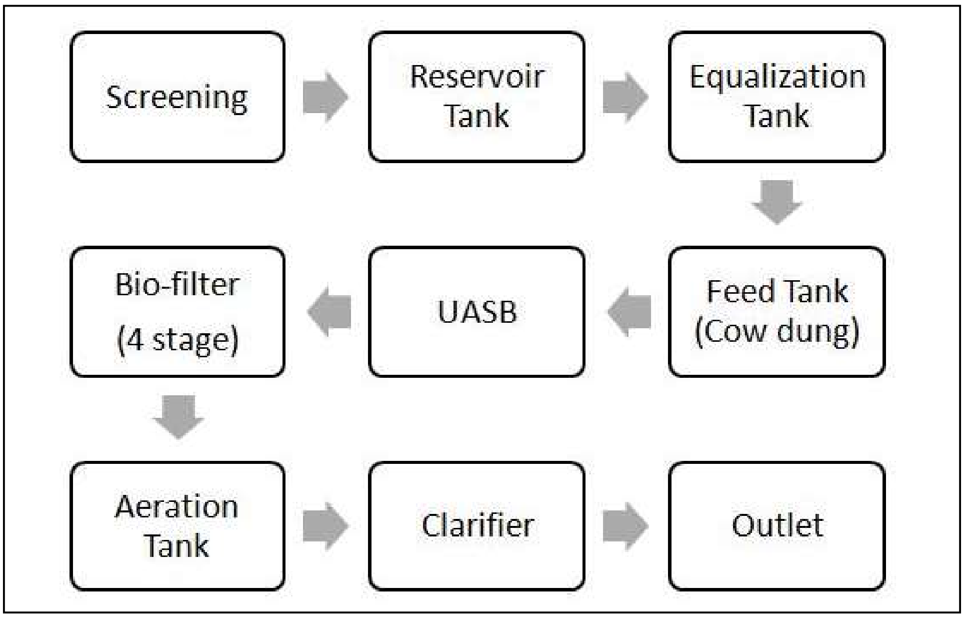

Figure 5.110: ETP Flow Diagram of Industry E-10

Figure 5.111: Equalization tank of E-10

Figure 5.112: Feeding tank of E-10

Figure 5.113: UASB of industry E-10

Figure 5.114: Bio-filtration of E-10

Figure 5.115: Aeration tank of E-10

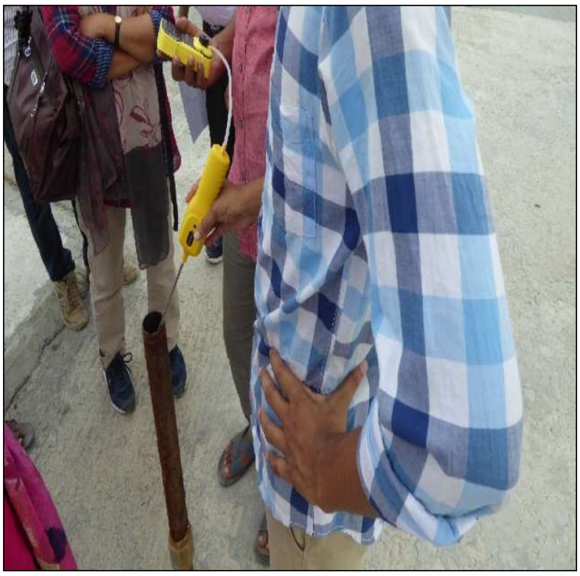

Figure 5.116: Gas vent Pipe of UASB E-10

Table 5.60: Characteristics of Wastewater samples of Industry E-10

Parameters	Inlet	Before UASB	After UASB	Outlet	ECR'97			Minimum Detection Limit (MDL)
					Inland Surface Water	Public sewerage system connected to treatment at 2nd stage	Irrigated Land	
pH	11.52	6.90	6.99	7.48	6.0-9.0	6.0-9.0	6.0-9.0	0
Color (Pt-Co)	8500	1300	620	10	-	-	-	0.01
Turbidity (NTU)	744	60.9	24	1.2	-	-	-	0.01
DO (mg/L)	0.05	0.05	0.05	5.39	4.5-8.0	4.5-8.0	4.5-8.0	0.1
BOD_5 (mg/L)	1160	550	230	0.40	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)	0.2
COD (mg/L)	2078	1234	498	5	≤ 200	≤ 400	≤ 400	0.2
EC (µS/cm)	7370	2800	2690	264	≤ 1200	≤ 1200	≤ 1200	0.1
Cl^- (mg/L)	520	540	500	80	≤ 600	≤ 600	≤ 600	1
NH_3-N (mg/L)	14.46	19.60	33.125	0.224	≤ 5	≤ 5	≤ 15	0.017
PO_4^{3-} (mg/L)	2.35	15.65	40	0.445	-	-	-	0.04
TDS (mg/L)	1078	1734	1532	173	≤ 2100	≤ 2100	≤ 2100	5
TSS (mg/L)	396	90	49	11	≤ 150	≤ 500	≤ 200	5

3R Activities in E-10

No 3R measures were observed in the industry. Since the ETP is an anaerobic one and produces CO_2 (48%), CH_4 (1%) and H_2S (3 ppm), therefore, there is a potential of recovery of gas and use that as an alternative energy source.

Chapter 6

Analysis

6.1 INTRODUCTION

As noted in Chapter 1, the main objective of this action research project was to evaluate the progress and performance of ZLD-ETP systems in Textile industries of Bangladesh in order to achieve the zero discharge under 3R plan. With this objective in view, first relevant informationwas collected from the selected industries. Subsequently, samples were collected from those industries, which were then analyzed at the Environmental Engineering Laboratory of the Department of Civil Engineering, BUET and are presented in Chapter 5. This present chapter provides a detail analysis of the collected information and data in order to get a clear understanding of the existing status of ZLD-ETP systems of textile industries which will help in achieving the goals of the project.

6.2 PERFORMANCE OF ZLD-ETPs

To assess the performance of ZLD-ETPs in treating the wastewater, samples were collected at the inlet and final outlet (Figure 3.1) of the industry and analyzed.The quality of individual parameters of ZLD-ETP industries are presented in Figure 6.1 to 6.8.

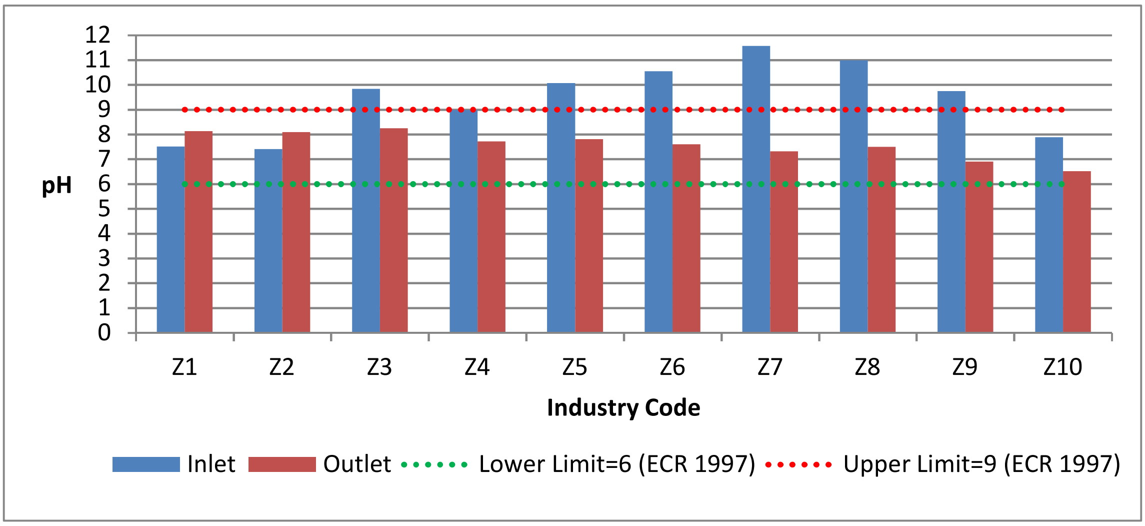

Figure 6.1: pH Comparison of Selected ZLD-ETP Industries

From Figure 6.1, it has been found that the pH values of all ten industries' effluent are within the allowable range of pH (6 – 9) set by ECR, 1997.

Among the ten industries, the treated effluent's dissolved oxygen content of four industries (Figure 6.2) are much below the minimum DO value set by ECR,97 (4.5 mg/L). Only two industries satisfy the standard limit (ECR, 97) and four remaining industry's DO value is just below the minimum limit.

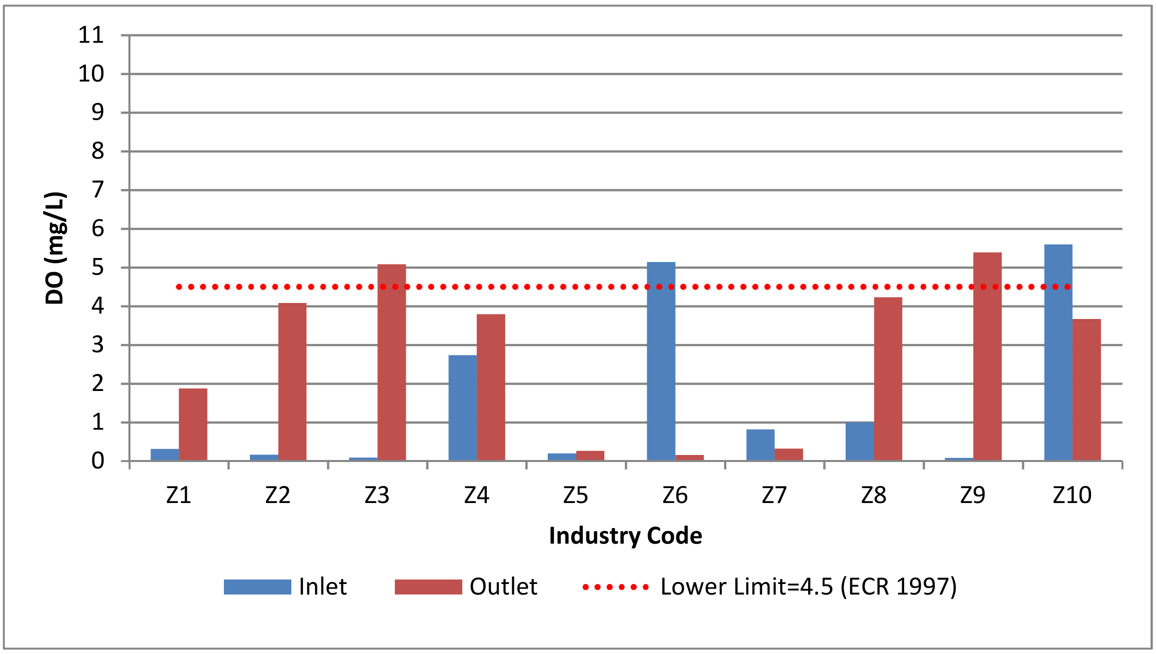

Figure 6.2: Variation of DO Content of Selected ZLD-ETP Industries

Figure 6.3 shows the BOD_5 of influent and effluent of ten ZLD-ETP industries. Among the ten industries, nine industries comply with the allowable limit set by ECR,97 (50 mg/L), only one industry fails to comply. Thus it is apparent that the ETPs of these nine industries are performing well under the present operating conditions.

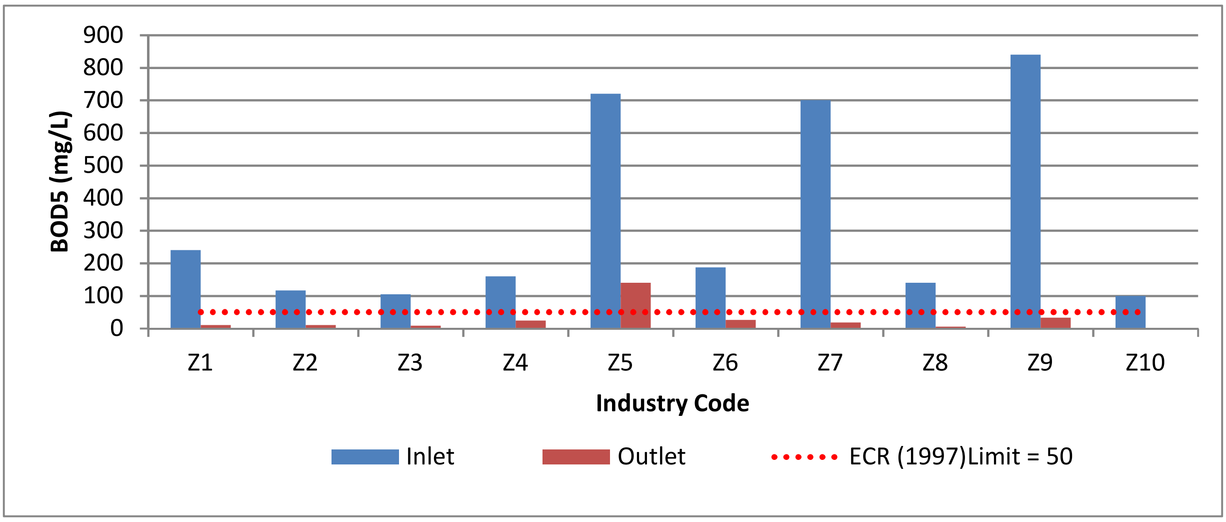

Figure 6.3: Variation of BOD_5 Concentration of Selected ZLD-ETP Industries

Performance of the ETPS of these industries in reducing COD is also found to be effective (Figure 6.4). Only two industries fail to comply with the corresponding Bangladesh standard (200 mg/L) and rest of the industries are well below the ECR,'97 limit. The industry designated with code Z5 failed to comply with both the corresponding BOD_5 and COD discharge standards of ECR '97. It should be noted that both the influent BOD_5 and COD of this industry are very high. The $20m^3/hr$ capacity ETP, installed at the Z5 industry, is inadequte for the treatment of its effluent having very high BOD_5 and COD loadings resulting from the dyeing and finishing activities.

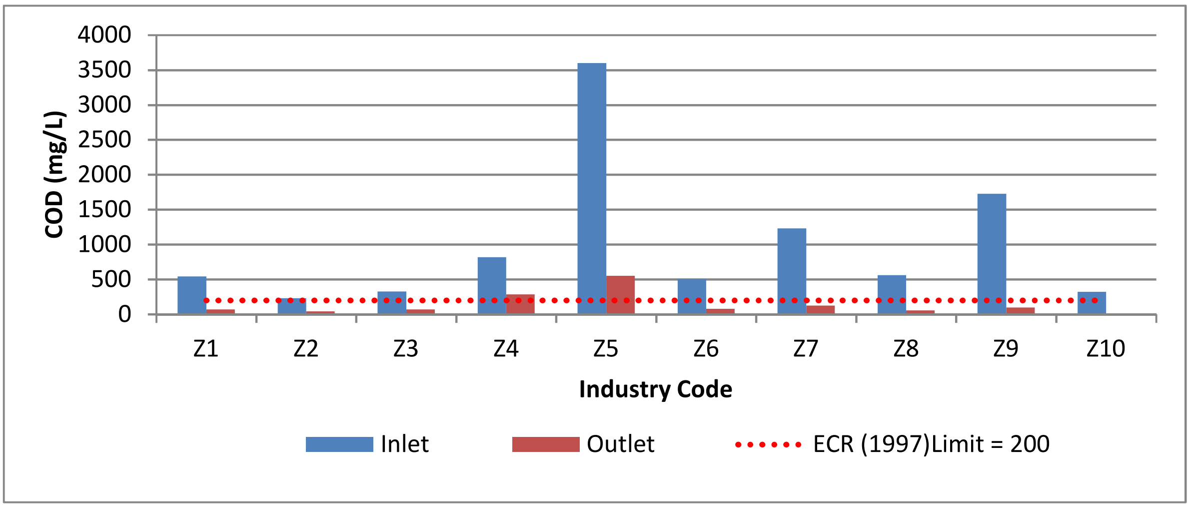

Figure 6.4: Variation of COD Concentration of ZLD-ETP Industries

The total dissolved solids concentration (TDS) of the ZLD-ETP industries is shown in Figure 6.5. Five industries comply with the allowable value set by ECR, 97 (2100 mg/L) and five industries fail to comply. Although the effluent TDS values are within the allowable limit, TDS of these five industries effluent is higher than those of respective influent concentrations. The main reason for non-compliance and higher TDS concentration in the outlet is that, most of the industries use a number of chemicals usually of large amounts (e.g., PAC, Polymer, Polyelectrolyte, Decoloring agent, Lime, etc.) in the treatment process which may reduce the organic load but generally increase the dissolved solids content.

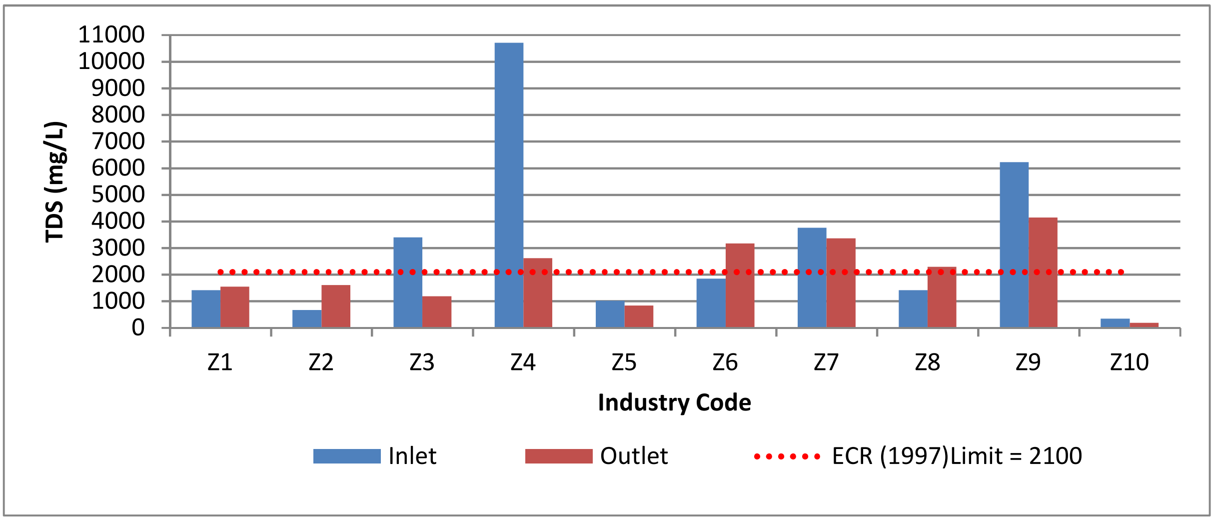

Figure 6.5: TDS Variation among the ZLD-ETP Industries

The Total Suspended Solids (TSS) of all the ten industries is much below the corresponding ECR, 97 limits of 150 mg/L (Figure 6.6). The clarification and filtration (Sand, AC, MGF) processes seem to be very effective in removing suspended particles.

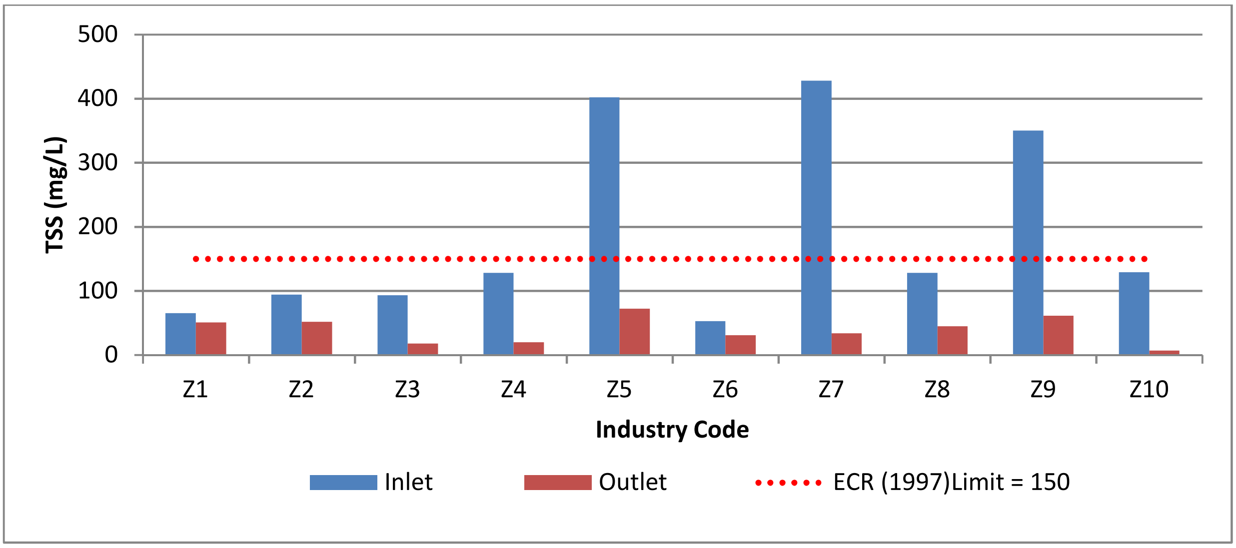

Figure 6.6: TSS Variation among the ZLD-ETP Industries

Although the chloride concentrations of treated effluents are within the allowable limit of ECR, 97 (600 mg/L) for all the ten industries, seven industries effluent concentration is higher than their respective influent concentrations (Figure 6.7). The reason behind this is the use of chloride based compounds in treatment process.

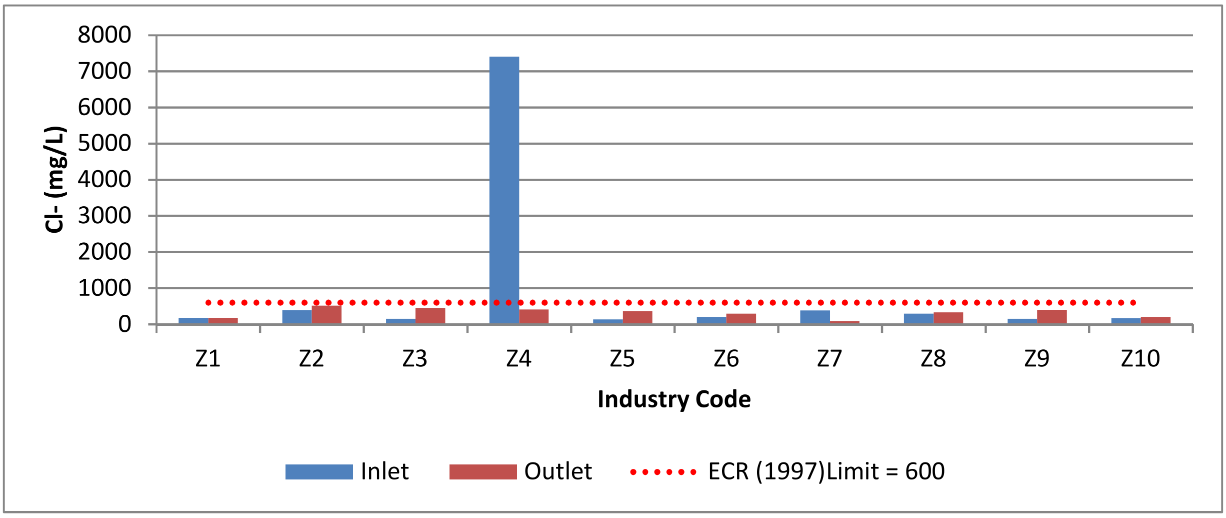

Figure 6.7: Cl^- Concentration of Selected ZLD-ETP Industries

Although ECR, 97 has no limit for Color and industries don't have to comply the Color standard, the research team thinks that color is a significant indicator representing industrial pollution. Figure 6.8 presents the influent and effluent color concentration of ten industries. It has been found from the Figure 6.8 that the effluent color concentration is low for only those industries that have less color content at the influent. Other industries have considerable color (around 1000 Pt-Co units) even after treatment. Therefore, it is evident that existing technologies are not so effective in removing color of the wastewater.

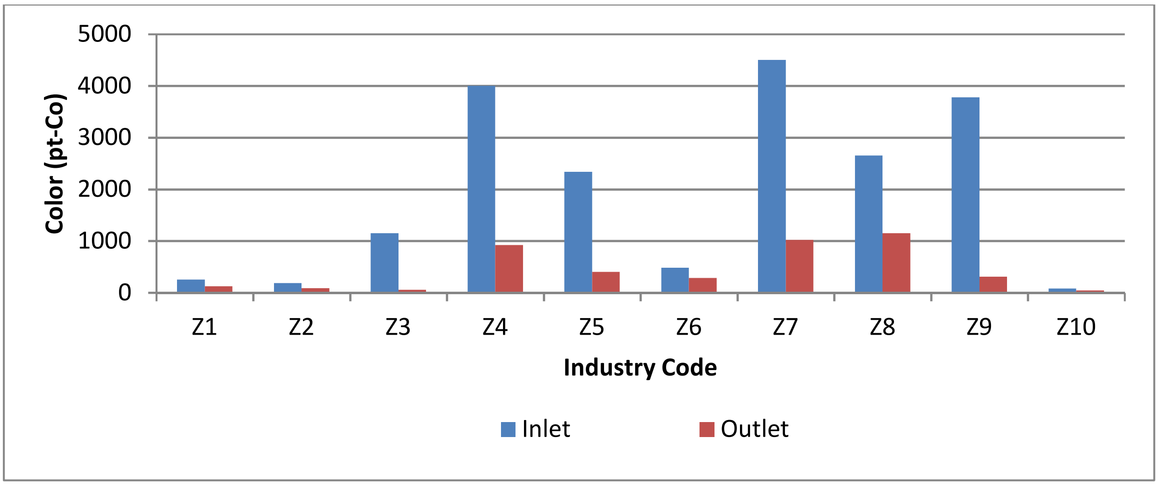

Figure 6.8: Color Comparison of Selected ZLD-ETP Industries

In addition to the comparative analysis of the performance of ZLD-ETPs for each water quality parameters, variation of concentrations of influent and effluent quality of all ten of these ZLD-ETPs have been provided in Tables 6.1 and 6.2.

Table 6.1: Influent characteristics of ten ZLD-ETP industries

Water Quality Parameters	Concentration of inlet wastewater at Various Industries										Range (minimum - maximum)	Standard Limit from ECR'97 (Inland Surface Water)	Standard Limit from ECR'97 (Public sewerage system)	Standard Limit from ECR'97 (Irrigated Land)
	Z1	Z2	Z3	Z4	Z5	Z6	Z7	Z8	Z9	Z10				
pH	7.51	7.4	9.83	8.98	10.07	10.54	11.56	10.99	9.74	7.88	7.4 – 11.56	6.0-9.0	6.0-9.0	6.0-9.0
Color (Pt-Co)	256	186	1150	4000	2340	484	4500	2650	3780	78	78 - 4500	-	-	-
Turbidity (NTU)	55.3	94.7	27.1	49.7	361	66.6	249	746	59.9	85.1	27.1 - 746	-	-	-
DO (mg/L)	0.31	0.16	0.09	2.73	0.19	5.14	0.81	1.0	0.08	5.59	0.08 – 5.59	4.5-8.0	4.5-8.0	4.5-8.0
BOD_5(mg/L)	240	116	104	160	720	187.5	700	140	840	100	100 - 840	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)
COD (mg/L)	541	228	328	816	3600	505	1232	561	1728	320	228 - 3600	≤ 200	≤ 400	≤ 400
EC (µs/cm)	1772	1240	4520	13700	1264	2660	4410	2140	7870	540	540 - 13700	≤ 1200	≤ 1200	≤ 1200
Cl^- (mg/L)	180	390	150	7400	135	205	380	290	150	165	135 - 7400	≤ 600	≤ 600	≤ 600
NH_3-N (mg/L)	0.942	1	2.21	5.94	5.315	1.197	11.63	5.235	7.625	2.258	0.942 – 11.63	≤ 5	≤ 5	≤ 15
PO_4^{3-}(mg/L)	1.38	0.325	0.95	0.147	0.298	0.299	4.74	1.5	4.82	0.058	0.058 – 4.82	-	-	-
TDS (mg/L)	1410	669	3402	10710	1021	1848	3756	1418	6226	341	341 - 10710	≤ 2100	≤ 2100	≤ 2100
TSS (mg/L)	65	94	93	128	402	53	428	128	350	129	53 - 428	≤ 150	≤ 500	≤ 200

From Table 6.1, it is observed that the concentration (minimum and maximum value) of all parameters vary within a wide range. It also shows that the textile industries' wastewater is heavily polluted with high organic load and solids content and very low dissolved oxygen. Therefore, it can be said that this wastewater must not be discharged into the environment without proper treatment to save the environment.

Table 6.2 shows the characteristics of treated effluent of ten ZLD-ETP industries. Among the ten industries, most of them performed efficiently in removing BOD_5, COD, TSS, Chloride, PO_3^4, and NH_3-N. The performance of removing TDS and achieving DO according to the ECR 97 limit is not quite satisfactory for many industries.

Table 6.2: Treated Effluent characteristics of ten ZLD-ETP industries

Water Quality Parameters	Concentration at Various Industries										Range (minimum – maximum)	Standard Limit from ECR'97 (Inland Surface Water)	Standard Limit from ECR'97 (Public sewerage system)	Standard Limit from ECR'97 (Irrigated Land)
	Z1	Z2	Z3	Z4	Z5	Z6	Z7	Z8	Z9	Z10				
pH	8.13	8.09	8.24	7.71	7.81	7.6	7.32	7.49	6.9	6.52	6.52 – 8.24	6.0-9.0	6.0-9.0	6.0-9.0
Color (Pt-Co)	125	87	55	920	400	284	1020	1150	310	10	10 - 1150	-	-	-
Turbidity (NTU)	14.9	9.04	11.2	8.23	60.2	11	4.36	5.58	25.5	0.72	0.72 – 60.2	-	-	-
DO (mg/L)	1.87	4.08	5.08	3.79	0.26	0.15	0.32	4.23	5.39	3.67	0.15 – 5.39	4.5-8.0	4.5-8.0	4.5-8.0
BOD_5(mg/L)	10	9.6	8	24	140	26	18	5	32.5	0.4	0.4 - 140	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)
COD (mg/L)	70	42	67	283	553	80	122	57	95	5	5 - 553	≤ 200	≤ 400	≤ 400
EC (μs/cm)	2280	2460	1841	3590	1148	4550	4360	3330	5650	367	367 - 5650	≤ 1200	≤ 1200	≤ 1200
Cl^- (mg/L)	180	510	455	405	365	295	90	325	395	200	90 - 510	≤ 600	≤ 600	≤ 600
NH_3-N (mg/L)	0.338	1.69	0.55	1.05	1.5	3.06	1.712	1.295	0.483	0.465	0.338 – 3.06	≤ 5	≤ 5	≤ 15
PO_4^{3-}(mg/L)	0.08	0.492	0.105	2.435	0.095	0.81	3.2	2.5	13.21	0.055	0.055 – 13.21	-	-	-
TDS (mg/L)	1542	1610	1184	2622	840	3173	3364	2289	4137	187	187 - 4137	≤ 2100	≤ 2100	≤ 2100
TSS (mg/L)	8.13	8.09	8.24	7.71	7.81	7.6	7.32	7.49	6.9	6.52	7 - 72	≤ 150	≤ 500	≤ 200

6.3 PERFORMANCE OF ETPs

The wastewater quality of individual parameters of industries running with ETPs only (without ZLD plan) are shown in Figures 6.9 to 6.16.From Figure 6.9, it has been found that the pH values of effluent of all ten industries are within the allowable range of pH (6 – 9) set by ECR, 1997.

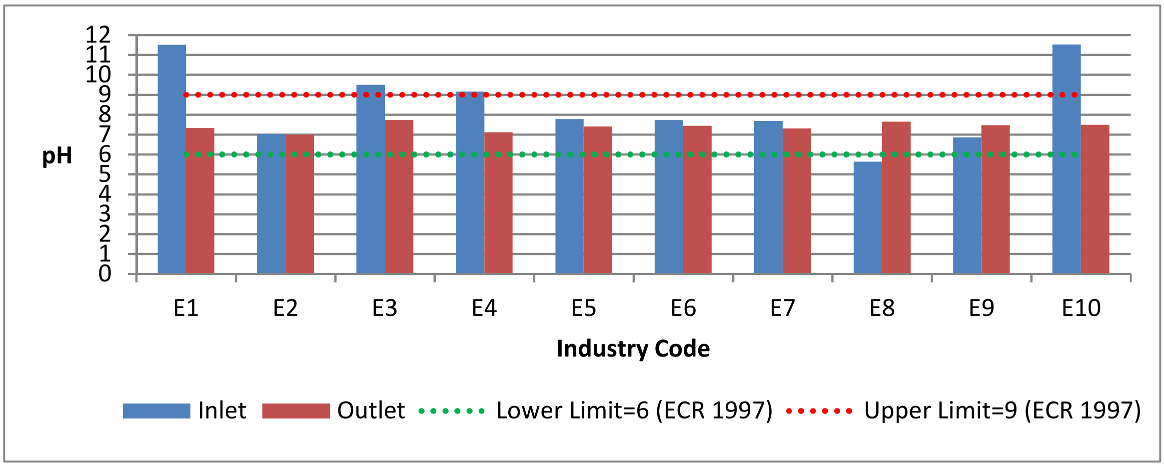

Figure 6.9: pH Comparison of among the studied ETP Industries

Among the ten industries with only ETP, the effluent dissolved oxygen contents of five industries (Figure 6.10) are much below the minimum DO value set by ECR, 97 (4.5 mg/L), whereas, five remaining industries satisfy the minimum requirement.

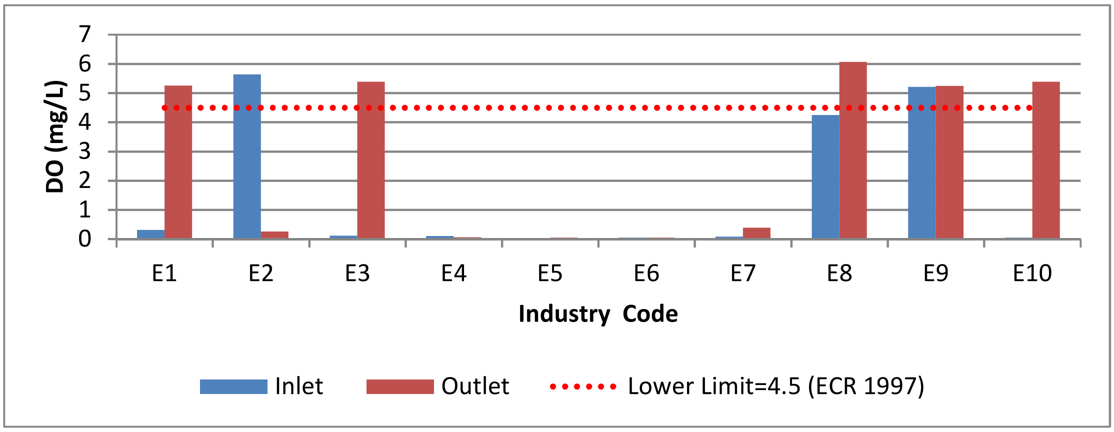

Figure 6.10: Variation of DO Concentration of Selected ETP Industries

Figure 6.11 shows the BOD_5 of influent and effluent of ten ETP (Only) industries. Among these ten industries, eight industries comply with the allowable limit set by ECR,'97 (50 mg/L), and two industries fail to comply. Thus it is apparent that the ETPs of these eight industries are performing well under the present operating conditions.

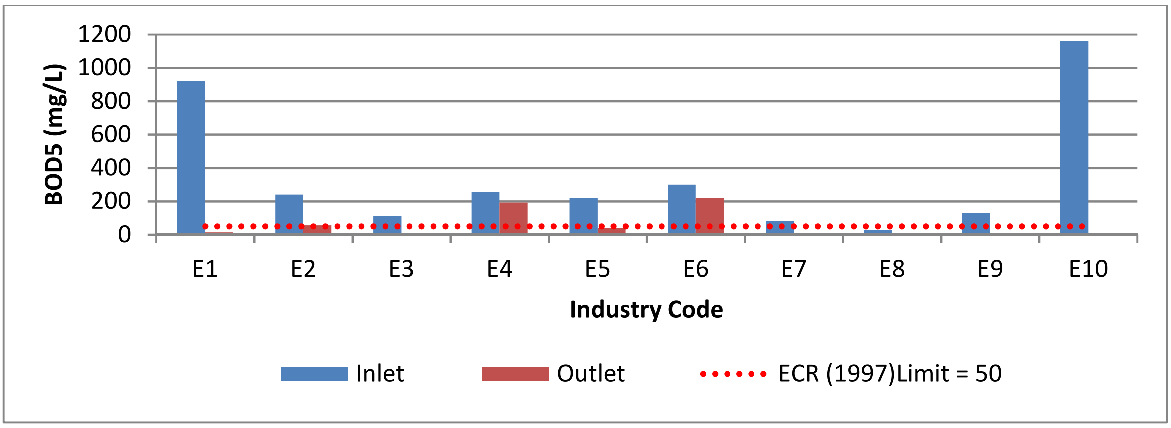

Figure 6.11: Variation of BOD_5 Concentration of Selected ETP Industries

The performance of the industries with ETP in reducing COD is also found to be effective (Figure 6.12). Only two industries fail to comply with the corresponding national standard (200 mg/L) and rest of the industries are well below the ECR,'97 limit. The industries designated with codes E4 and E6 failed to comply with both the corresponding BOD_5 and COD discharge standards of ECR '97. Since these two industries employ only physico-chemical processes, it is difficult for these ETPs to treatwastewater having high BOD_5 and COD loadings resulting from the dyeing and finishing activities.

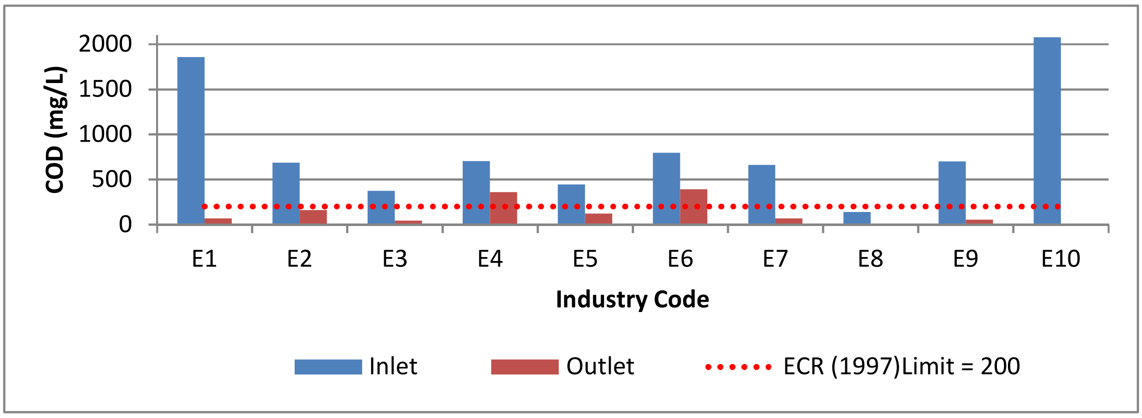

Figure 6.12: Variation of COD Concentration of Selected ETP Industries

The Total Dissolved Solids concentrations (TDS) of industries ETP (Only)are shown in Figure 6.13. Seven industries comply with the allowable value set by ECR, '97 (2100 mg/L) and three industries fail to comply. Although the effluent TDS values are within the allowable limit, TDS of four of these ten industries treated effluents are higher than those of respective influent concentrations. The main reason for non-compliance and higher effluent concentration is that, most of the industries use a number of chemicals usually of large amounts (e.g., PAC, Polymer, Polyelectrolyte, Decoloring agent, Lime, etc.) in the treatment process which are capable of reducing the organic load but generally increase the dissolved solids content.

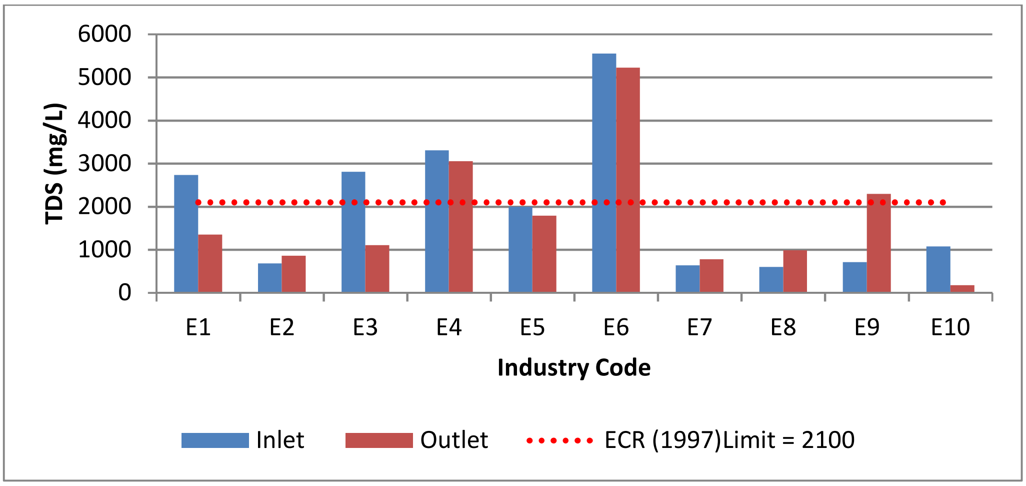

Figure 6.13: TDS Concentration Variation of Selected ETP Industries

The TSS concentration of effluents of all the ten industries are within the limit of ECR, 97 (Figure 6.14).

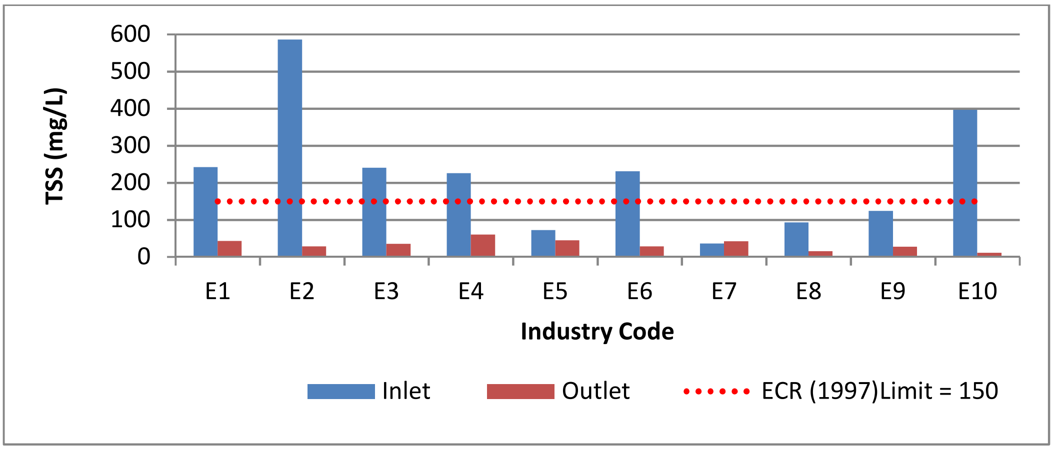

Figure 6.14: TSS Concentration Variation of Selected ETP Industries

Although the chloride concentrations of treated effluent are within the allowable limit of ECR, '97 (600 mg/L) for all the ten industries, eight of these industries show higher chloride concentration in the treated effluent than those of the influents (Figure 6.15). The reason behind this is the use of chloride based chemicals in treatment process.

Although ECR, 97 has no limit for Color and industries don't have to comply with the Color standard, the research team thinks that color is a significant indicator representing industrial pollution. Figure 6.16 shows the influent and effluent color concentration of ten ETP industries.

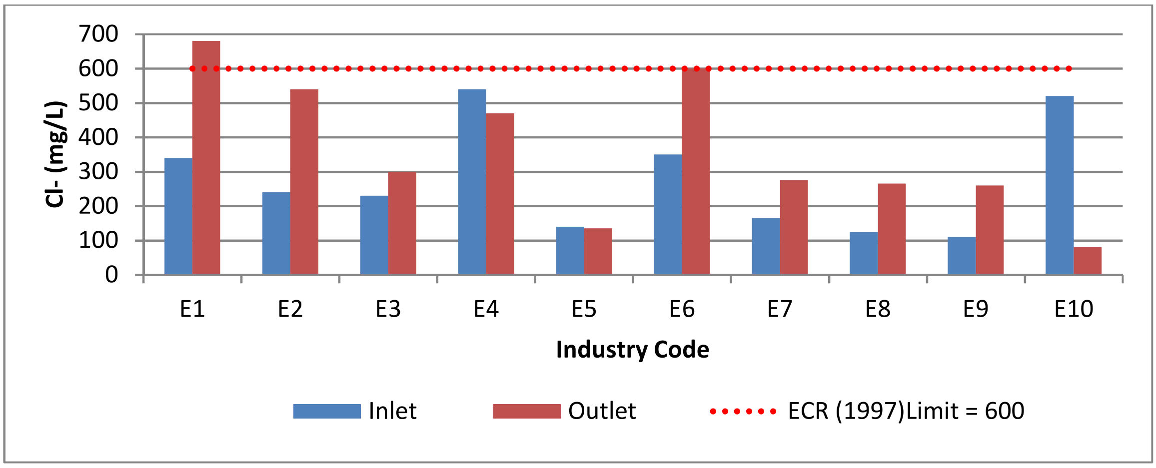

Figure 6.15: Variation of Cl^- Concentration among ETP Industries

It has been found from the Figure 6.16 that industry E-10 is very effective in removing the color (10 Pt-Co unit at the outlet sample) of its wastewater even though its influent color concentration is more than 8000 Pt-Co Units. E-10 employs UASB technology in treating its wastewater and it has been found from the study that this process is also capable of removing other parameters effectively which agrees with the literature.

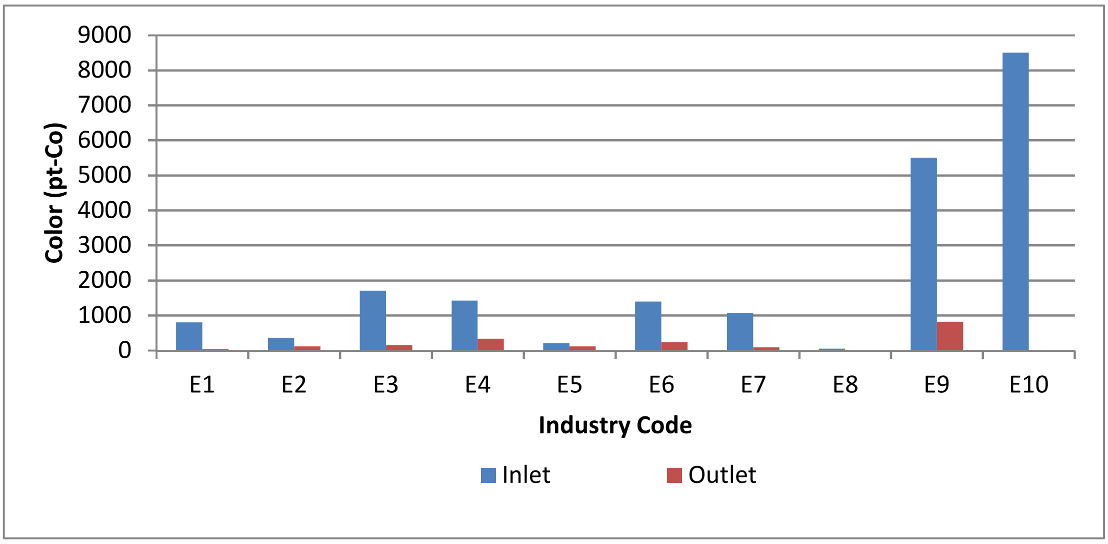

Figure 6.16: Color Variation of Selected ETP Industries

In addition to the comparative analysis of the performance of ETPs for each water quality parameters, variation of concentrations of influent and effluent quality of all ten of these ETPs have been provided in Table 6.3 and Table 6.4.From Table 6.3, it has been observed that the minimum and maximum value of all parameters vary within a wide range, because of wide variation of production capacity of the industries.Like ZLD-ETP industries, the ETP industries' influent is also severely polluted with high organic load and solids content and very low dissolved oxygen.

Table 6.3:Influent characteristics of ten ETP industries

Water Quality Parameters	Concentration at Various Industries										Range (minimum – maximum)	Standard Limit from ECR'97 (Inland Surface Water)	Standard Limit from ECR'97 (Public sewerage system)	Standard Limit from ECR'97 (Irrigated Land)
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10				
pH	11.51	7.03	9.5	9.15	7.77	7.72	7.68	5.63	6.85	11.52	5.63 – 11.52	6.0-9.0	6.0-9.0	6.0-9.0
Color (Pt-Co)	800	360	1700	1420	202	1396	1070	53	5500	8500	53 - 8500	-	-	-
Turbidity (NTU)	303	371	88.2	219	74.3	101	98.6	51	56	744	51 - 744	-	-	-
DO (mg/L)	0.31	5.64	0.11	0.1	0	0.05	0.08	4.25	5.21	0.05	0 – 5.64	4.5-8.0	4.5-8.0	4.5-8.0
BOD_5(mg/L)	920	240	112	256	220	300	80	28	128	1160	28 - 1160	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)
COD (mg/L)	1856	687	372	704	443	794	660	137	698	2078	137 - 2078	≤ 200	≤ 400	≤ 400
EC (μs/cm)	3760	755	3700	4320	2710	7120	755	863	6320	7370	755 - 7370	≤ 1200	≤ 1200	≤ 1200
Cl^- (mg/L)	340	240	230	540	140	350	165	125	110	520	110 - 540	≤ 600	≤ 600	≤ 600
NH_3-N (mg/L)	0.468	1.462	1.994	2.09	0.539	2.025	2.77	1.23	11.5	14.46	0.468 – 14.46	≤ 5	≤ 5	≤ 15
PO_4^{3-}(mg/L)	0.908	0.162	1.09	0.275	1.042	0.392	0.02	0.038	0.37	2.35	0.02 – 2.35	-	-	-
TDS (mg/L)	2736	678	2804	3302	2000	5550	634	601	708	1078	601 - 5550	≤ 2100	≤ 2100	≤ 2100
TSS (mg/L)	242	586	240	226	72	231	36	93	124	396	36 - 586	≤ 150	≤ 500	≤ 200

Table 6.4: Treated Effluent characteristics of ten ETP industries

Water Quality Parameters	Concentration at Various Industries										Range (minimum – maximum)	Standard Limit from ECR'97 (Inland Surface Water)	Standard Limit from ECR'97 (Public sewerage system)	Standard Limit from ECR'97 (Irrigated Land)
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10				
pH	7.32	6.99	7.72	7.12	7.4	7.43	7.3	7.64	7.47	7.48	6.99 – 7.72	6.0-9.0	6.0-9.0	6.0-9.0
Color (Pt-Co)	32	110	148	335	113	231	85	13	820	10	10 - 820	-	-	-
Turbidity (NTU)	8.62	14.3	8.62	57.4	33.2	25.2	4.07	1.29	23.9	1.2	1.2 – 57.4	-	-	-
DO (mg/L)	5.25	0.25	5.39	0.06	0.05	0.05	0.38	6.07	5.24	5.39	0.05 – 6.07	4.5-8.0	4.5-8.0	4.5-8.0
BOD_5(mg/L)	12.8	56	8	192	40	220	10	1.2	7	0.4	0.4 - 220	≤ 50 (at 20°C)	≤ 250 (at 20°C)	≤ 1000 (at 20°C)
COD (mg/L)	68	159	44	359	119	389	67	7	53	5	5 - 389	≤ 200	≤ 400	≤ 400
EC (µs/cm)	2160	1235	1560	4090	2660	7000	1020	1533	3280	264	264 - 7000	≤ 1200	≤ 1200	≤ 1200
Cl^- (mg/L)	680	540	300	470	135	600	275	265	260	80	80 - 680	≤ 600	≤ 600	≤ 600
NH_3-N (mg/L)	0.469	1.103	1.17	0.457	0.652	2.9	1.275	0.567	1.825	0.224	0.224 – 2.9	≤ 5	≤ 5	≤ 15
PO_4^{3-}(mg/L)	0.505	0.073	0.132	0.082	0.242	0.256	0.05	0.2	2.32	0.445	0.05 – 2.32	-	-	-
TDS (mg/L)	1354	858	1107	3051	1790	5224	775	989	2298	173	173 - 5224	≤ 2100	≤ 2100	≤ 2100
TSS (mg/L)	43	28	35	60	45	28	42	15	27	11	11 - 60	≤ 150	≤ 500	≤ 200

The performance of studied ETP industries in treating the wastewater can be termed as good considering the removal efficiency of BOD, COD and TSS (Table 6.4).Whereas like ZLD-ETP industries, these industries are not doing well in removing TDS and achieving minimum DO content.

6.4 ASSESSMENT OF POLLUTION LOAD

Performance of an ETP depends not only on the physico-chemical and biological processes but also largely on the pollutant loadings it has to endure. Usually, an ETP is designed for a specific average and a peak flow and/or loading. Unfortunately, sustained high loading endured by an ETP reduces its performance significantly. The loading rates of different pollutants at ETPs of the ZLD-ETP and ETP (Only) industries are given in Tables 6.5 and 6.6 respectively.

Information collected from the ZLD-ETP industries show that Z-7 industry receives about 0.92 tons of pollutants exerting COD per day. Although it treats 90% of this load, it discharges almost 2 tons of COD to the receiving environment every day. This factory discharges about 13 tons of NH_3-N, 25 tons of TDS, 0.25 tons of TSS, and 0.68 of chloride in the receiving environment per day. In general, this industry fails to perform adequately to achieve the objectives, but it performs very well in removing organic loading in the form of BOD_5, where it receives 5.25 tons and discharges only 0.13 tons in the receiving environment every day.

Table 6.5: Influent and Effluent Loadings on Ten ZLD-ETP industries

Industry Code		Pollution Loading (kg/day)					
		NH_3-N	TDS	TSS	BOD_5	COD	Cl^-
Z-1	Inlet	2.261	3384	156	576	1298	432
	Outlet	0.811	3701	122	24	168	432
Z-2	Inlet	0.64	428	60	74	146	250
	Outlet	1.082	1030	33	6	27	326
Z-3	Inlet	1.768	2722	74	83	262	120
	Outlet	0.44	947	14	6	54	364
Z-4	Inlet	28.512	51408	614	768	3917	35520
	Outlet	5.04	12586	96	115	1358	1944
Z-5	Inlet	1.276	245	96	173	864	32
	Outlet	0.36	202	17	34	133	88
Z-6	Inlet	3.95	6098	175	619	1667	677
	Outlet	10.098	10471	102	86	264	974
Z-7	Inlet	87.225	28170	3210	5250	9240	2850

	Outlet	12.84	25230	255	135	915	675
Z-8	Inlet	21.359	5785	522	571	2289	1183
	Outlet	5.284	9339	184	20	233	1326
Z-9	Inlet	10.98	8965	504	1210	2488	216
	Outlet	0.696	5957	88	47	137	569
Z-10	Inlet	0.361	55	21	16	51	26
	Outlet	0.074	30	1	0.1	1	32
Minimum	Inlet	0.36	55	21	16	51	26
	Outlet	0.07	30	1	0.1	1	2
Maximum	Inlet	87.23	51408	3210	5250	9240	35520
	Outlet	12.84	25230	255	135	1358	1944
Average	Inlet	15.83	10726	543	934	2222	4131
	Outlet	3.67	6949	91	47.3	329	673

Information collected from the ETP industries show that E-1 industry receives the highest amount of pollutants exerting COD per day (about 8.9 tons/day). However, it removes 96% of COD load and discharges about 4% to the receiving environment every day. Performance of E-1 industry in treating BOD_5 loadings is significant removing 98.5% of received load. On the other hand, E-10 industry receiving about 5 tons of pollutants exerting COD per day removes 99.75% of the same. This factory also receives significantly high NH_3-Nloading (34 kg/day), successfully removing 98% of the same.

Table 6.6: Influent and Effluent Loadings on Ten ETP industries

Industry Code		**Pollution Loading (kg/day)**					
		NH_3-N	**TDS**	**TSS**	**BOD_5**	**COD**	**Cl^-**
E-1	Inlet	2.246	13133	1162	4416	8909	1632
	Outlet	2.251	6499	206	61	326	3264
E-2	Inlet	2.105	976	844	346	989	346
	Outlet	1.588	1236	40	81	229	778
E-3	Inlet	1.914	2692	230	108	357	221
	Outlet	1.123	1063	34	8	42	288
E-4	Inlet	2.508	3962	271	307	845	648
	Outlet	0.548	3661	72	230	431	564
E-5	Inlet	0.453	1680	60	185	372	118
	Outlet	0.548	1504	38	34	100	113
E-6	Inlet	1.458	3996	166	216	572	252
	Outlet	2.088	3761	20	158	280	432

E-7	Inlet	0.042	10	1	1.2	10	2
	Outlet	0.019	12	1	0.2	1	4
E-8	Inlet	0.006	3	0	0.1	1	1
	Outlet	0.003	5	0	0	0	1
E-9	Inlet	13.8	850	149	154	838	132
	Outlet	2.19	2758	32	8	64	312
E-10	Inlet	34.704	2587	950	2784	4987	1248
	Outlet	0.538	415	26	1	12	192
Minimum	Inlet	0.01	3	0.47	0.14	0.69	0.63
	Outlet	0.00	5	0.08	0.01	0.04	1.33
Maximum	Inlet	34.70	13133	1162	4416	8909	1632
	Outlet	2.25	6499	206	230	431	3264
Average	Inlet	5.92	2989	383	852	1788	460
	Outlet	1.09	2091	47	58	149	595

6.5 ANALYSIS OF BASELINE DATA OF SELECTED INDUSTRIES

The industries selected in the present study vary in size (area), investment cost, production capacity, type and also the wastewater treatment technology. Table 6.7 shows the information collected on individual industry and Table 6.8 shows a summary of the studied industries regarding their production capacity, water use, ETP capacity and adopted technologies to treat the wastewater.

Table 6.7: Information on Selected Industries

Industry ID	Production Capacity	Industry Type	Water Consumption	ETP capacity	ETP Investment cost (BDT)	Treatment Technology
Z-1	20 ton/day	Composite (Knitting, Dyeing, finishing, Yarn dyeing, Zipper Dyeing and RMG)	3000 m^3/day	2400 m^3/day	10 Crs	Physico-Chemical followed by biological
Z-2	6 ton/day	Composite (Dyeing and RMG)	800 m^3/day	640 m^3/day	90 Lacks	Physico-Chemical followed by biological
Z-3	8-9 ton/day	Dyeing	600 m^3/day	800 m^3/day	2 Crs	Physico-Chemical followed by biological

Industry ID	Production Capacity	Industry Type	Water Consumption	ETP capacity	ETP Investment cost (BDT)	Treatment Technology
Z-4	40 ton/day	Composite (Knitting, Dyeing and Finishing)	6044 m^3/day	4800 m^3/day	4 Crs	Physico-Chemical followed by biological
Z-5	120000 Yards/day	Dyeing& Finishing	300 m^3/day	240 m^3/day	70-80 Lacks	Physico-Chemical followed by biological
Z-6	22 ton/day	Composite (Dyeing, Finishing and RMG)	3000 m^3/day	3300 m^3/day	6 Crs	SBR+Physico-Chemical
Z-7	6, 00,000 meter/day	Dyeing and Printing	Data Not Found	7500 m^3/day	170 Crs	Biological
Z-8	100000 Metric ton/day	Composite (Knitting, Dyeing, Washing, Finishing)	4870 m^3/day	4080 m^3/day	6 Crs	Biological Process
Z-9	12 ton/day	Composite (Knitting, Dyeing and RMG)	2900 m^3/day	1440 m^3/day	3 Crs	Physico-chemical followed by Biological
Z-10	20.000 pieces /day	Washing and RMG	370 m^3/day	280 m^3/day	Data Not Found	Physico-Chemical
E-1	1,40,000 Yards/day	Dyeing, Washing & Finishing	4800 m^3/day	4800 m^3/day	10 Crs	Physico-chemical followed by biological
E-2	20,000 pieces/day	RMG Washing	1890 m3/day	1440 m^3/day	2 Crs	Physico-Chemical
E-3	8 ton/day	Composite (Knitting, Dyeing, Washing, Finishing)	768 m^3/day	960 m^3/day	3 Crs	Physico-chemical followed by Biological
E-4	10-11 ton/day	Dyeing, Washing	1200 m^3/day	1200 m^3/day	2.5 Crs	Physico-Chemical
E-5	4.5 ton/day	Dyeing	450-500 m^3/day	840 m^3/day	1.2 Crs	Physico-Chemical
E-6	8 ton/day	Knitting, Dyeing, Finishing	806 m^3/day	720 m^3/day	Data Not Found	Physico-Chemical
E-7	1 ton/day	Dyeing	5 m^3/day	15 m^3/day	40 Lacks	Physico-Chemical
E-8	0.1-0.2 ton	Washing	4-5 m^3/day	5 m^3/day	25-30 Lacks	Electro-

Industry ID	Production Capacity	Industry Type	Water Consumption	ETP capacity	ETP Investment cost (BDT)	Treatment Technology
	/month					Chemical
E-9	10 ton/day	Knitting, Dyeing, Finishing	960 m^3/day	1200 m^3/day	2.5 Crs	Physico-chemical followed by biological
E-10	1,50,000 Yards /day	Dyeing	2500 m^3/day	2400 m^3/day	34 Crs	Anaerobic Biological (UASB)

Table 6.8: Types, Capacities and Treatment Technologies of the Studied Industries

Item	Range
Production Capacity	4.5 Ton/day – 100000 MT/day
Industry Type	Dyeing,Washing,Printing, Finishing Washing only Dyeing only Dyeing and Washing Knitting, Dyeing and RMG Knitting, Dyeing, Washing, Finishing Dyeing and RMG Dyeing and Printing Knitting, Dyeing and Finishing Dyeing, Washing & Finishing RMGWashing
ETP capacity	5 m^3/day – 7500 m^3/day
Investment cost for ETP	10 lacs – 34 cores (BDT)
Treatment Technology	Physico-chemical only Biological (ASP) only Physico-chemical + Biological (ASP) Anaerobic Biological (UASB) Electro-chemical

Table 6.8 shows that the studied industries vary widely in production capacities, ETP capacities and investment costs for the ETPs. It is worth mentioning that area allocated for ETP also varies greatly from industry to industry. Some industries use huge area for ETP units, especially for biological (ASP) treatment process. The industries which are located within BSCIC area generally have space constraint. It is difficult to accommodate biological treatment units in the available space and are fully dependent on chemical process, which increases the treated effluent TDS as well as volume of sludge.

6.6 ASSESSMENT OF ZD STATUS OF ZLD-ETP INDUSTRIES

The DoE approved ZD plans under 3R policy were collected from DoE zonal offices. Ten industries were selected for the study after comprehensive review of basic data (Section 3.2, Chapter 3). During the field visit of those industries, an attempt was made to observe the 3R measures adopted/implemented in the respective industry to achieve zero discharge. A comparison was made between the proposed ZD measures and progress/achievement of the ZD plans till June, 2017. Table 6.9 shows a summary of this comparison.

Table 6.9: Field Observation of Progress/Achievement of ZD/3R plan and the Proposed Measures

Industry Code	ZD/3R plan Approval Date	Proposed ZD/3R units	Implementation till 2017
Z1	Aug-14	1st year: primary treatment unit for 36% reuse (Scouring, bleaching, washing) 2nd year: extra clarifier, sand filter, and AC filter for 25% reuse (Gardening, washroom, fire fighting) 3rd year: sand filter, AC filter for medium and fine filtration for 30% reuse (washing unit & household purpose) 4th year: RO unit for 8% reuse (main dyeing process & final washing) 5th year: Evaporation unit in RO system & 1% water is evaporated in air (salt recovery)	☑ Primary treatment unit ☒ Extra clarifier ☒ Sand filter ☒ Activated carbon filter ☒ RO unit ☒ Evaporation unit Provision of 180.5 m^3 storage tank of ETP treated recycle water for fire fighting
Z2	Oct-14	1st Phase- 20% (1st year) : 176 m^3/day water reuse in Toilet flashing, chemical dosing tank, car & floor washing, fire fighting, road washing and others Treated water (reservoir cum sedimentation tank)→ MGF→ ACF →Reuse 2st Phase- 80% (3st year) : 704 m^3/day water reuse in Dyeing unit and bathrooms. Sedimentation tank→ Flocculation→ Lamella clarifier→ MGF → ACF→ Micron filter →Softener → RO unit →Reuse	☑ Multi-grade filter ☒ Activated carbon filter ☒ Reservoir cum sedimentation ☑ Flocculation tank ☒ Lamella clarifier ☒ Softener ☒ Micro filter ☒ Ro unit 10-15 % water reuse in gardening & car wash
Z3	Jan-16	1st and 2nd year (1st stage): reuse of effluent treated water 3rd year (2nd stage): RO unit & incinerator plant	☒ RO unit ☒ Incinerator unit No reuse
Z4	Jan-16	1st year: primary treatment unit for 36% reuse (Scouring, bleaching, washing) 2nd year: extra clarifier, sand filter, and AC filter for 25% reuse (Gardening, washroom, fire fighting) 3rd year: sand filter, AC filter for medium and fine filtration for 30% reuse (washing unit	☑ Primary treatment unit ☑ Extra clarifier ☒ Sand filter ☒ Activated carbon filter ☒ RO unit

Industry Code	ZD/3R plan Approval Date	Proposed ZD/3R units	Implementation till 2017
		& household purpose) 4th year: RO unit for 8% reuse (main dyeing process & final washing) 5th year: Evaporation unit in RO system & 1% water is evaporated in air (salt recovery)	☒ Evaporation unit 5 m^3 reuse for gardening
Z5	Jan-15	1st year: primary treatment unit installation for 36% reuse (Scouring, bleaching, washing) Sedimentation tank→ MG filter→ AC filter→ Softener → Micron filter→ Reuse 2nd year: Extra clarifier , Sand filter, Carbon filter for 55% water reuse in Reuse in Dyeing & washing unit and gardening, washroom, fire fighting Sedimentation tank→ Flocculation→ Lamella clarifier→ MGF → ACF→ Micron filter →Reuse 3rd year: medium and fine filtration in outlet and RO unit for 8% water reuse in dyeing unit and rest 1% water in Evaporation unit to blow in air.	☑ Primary treatment unit ☑ Sedimentation tank ☒ Multi-grade filter ☒ Activated carbon filter ☒ Softener ☒ Micron filter ☒ Extra clarifier ☒ Sand filter ☑ Flocculation tank ☒ Lamella clarifier ☒ Evaporation unit No reuse
Z6	April-14	1st Phase- 20% (1st year) : 360 m^3/day water reuse in Toilet flashing, chemical dosing tank, car & floor washing, fire fighting, road washing and others Treated water (reservoir cum sedimentation tank)→ MGF→ ACF →Reuse 2st Phase- 80% (3st year) : 1440 m^3/day water reuse in Dyeing unit and bathrooms. Sedimentation tank→ Flocculation→ Lamella clarifier→ MGF → ACF→ Micron filter →Softener → RO unit →Reuse	☑ Primary treatment unit ☑ Sedimentation tank ☑ Multi-grade filter ☑ AC filter ☑ Flocculation tank ☒ Lamella clarifier ☒ Micron filter ☒ Softener ☒ RO unit Exhaust Gas Boiler (EGB), Boiler with default Economizer, Rain water harvesting, Heat recovery in finishing, Hot water Chiller, Servo motor M/C in sewing machine, Heat Trap in Ironing machine, LED light, Soft

Industry Code	ZD/3R plan Approval Date	Proposed ZD/3R units	Implementation till 2017
			start-up washing m/c
Z7	Apr-15	1st year: Hot Water Recovery, Automation System, Energy & Gas Savings, Wastewater Line Segregation and installation of Plumbing system, Dyeing cooling water recycle, Wastewater Recycle First Phase, Caustic Recovery Plant, Magneto Hydro Dynamics Installation, Water Flow meter Installation 2nd year: Rain Water Harvesting, WTP new reserve tank for blackwash water storage, Bio Gas Plant, Sludge Disposal & Management 3rd year: Salt recovery Plant, Wastewater Recycle Second Phase, Sewage Treatment Plant	☑ Automation System ☑ Water Flow meter Installation ☑ Energy saving ☑ Plumbing system ☒ Waste water recycle 1st phase ☒ Caustic recovery ☒ Magneto Hydro Dynamics ☒ Rain water harvesting ☒ New reserve tank for backwash ☒ Biogas plant ☒ Salt recovery plant ☒ STP ☒ Waste water recovery 2nd phase No reuse
Z8	Jan 17	1st year: Water consumption reduction (60 gallon/kg), Minimization of water loss, Recycling of dyeing water 2nd year: Rain water harvesting, Salt recovery 3rd year: ETP expansion, Flow segregation, Ultra-filtration	☑ Low Liquor ratio machine for water consumption reduction ☑ Minimization of water loss ☒ Recycling of dyeing water ☒ Rain water harvesting ☒ Salt recovery ☒ ETP extension ☒ Flow segregation ☒ Ultra-filtration No reuse
Z9	May-14	1st year: Hot Water Recovery 2nd year: Rain water harvesting	☑ Hot water recovery from boiler ☑ Condense recovery ☑ Cooling water reuse ☒ Rain water harvesting

Industry Code	ZD/3R plan Approval Date	Proposed ZD/3R units	Implementation till 2017
		3rd year: Energy Savings, Wastewater line segregation and installation sanitary work, WTP new reserve tank for backwash water storage, Magneto hydro dynamic Installation 4th year: Waste water recycling 1st phase 5th year: Salt recovery plant installation, Waste water recycling 2nd phase (RO), STP installation	☑ Low liquor ratio in dyeing machine ☑ Servo motor for all sewing machine ☑ EVC (Electronic Volume Control meter) ☑ LED light for energy saving ☑ Boiler within built Economizer ☒ RO unit ☒ Salt recovery plant ☒ STP
Z10		Data Not Available	☑ Primary treatment unit ☑ Flocculation tank ☑ RO unit ☑Treated and RO outlet water tank of capacity 500 m^3 for reuse in washing M/C as per process requirement ☑ Flash water tank of capacity 125m^3 for toilet flashing. ☑ Final treated water tank of dimension 0.98m x 0.75m x 0.88m This industry reuses 35% of RO treated water in the process and recycles 43% of ETP treated water in gardening, toilet flushing etc. Therefore, overall reuse and recycle achievement is 63%.

From Table 6.8, it is evident that although the ten industries were selected as ZLD-ETP industries after reviewing their approved 3R plans, in reality, except for one industry (Z10), none of the industries has ZLD units (such as RO, Evaporation unit, Salt Recovery Plant, Micro Filter, etc.). Industry Z-10 has installed RO unit with ETP and it is the only industry that is reusing the final treated water in its process. Therefore, the other nine industries should not be treated as ZLD-ETP industries; they are ETP industries in reality.

Although most of the industries (90%) have not implemented the units/ components mentioned in their 3R plans yet, many industries have adopted various measures to reduce the discharge and emission and are recovering some heat energy and recycling some amount of ETP treated water in different purposes. The most common features are recycling a certain percentage (varies from 5% to 30%) of treated water for gardening, fire-fighting and toilet flushing. Industry Z-6 has adopted many measures such as heat recovery in finishing, hot water recovery from boiler and condensate recovery. It uses Low Liquor Machine in dyeing which consumes less water. It has installed boiler with built equalizer for less gas use. It is using cooling water in dyeing unit. There is newly installed Rain Water Harvesters (RWH) to store rain water for use as process water. Some of their energy conservation measures include LED lights, sewing machines requiring less energy, heat trap in ironing machine, soft-start washing machines, etc. According to them, a small portion of treated water is used in chemical mixing and use of low volume toilet flush and water tap also help save water. It appears that this industry is very active in reduce, reuse and recovery processes. Industry Z-9 also adopted similar types of measures in reduce, reuse and recovery (Table 6.9). The total reuse and recycle achievement of Z-10 is 63% because of employing RO with ETP. In addition to that, industry Z-10 uses water and energy saving washing machines in washing unit and water saving sanitary fixtures. It also recovers and reuses condensate. The performance of Industry Z-3 and Z-5 is very poor in achieving 3R goals. Industry Z-8 has received approval in January, 2017 and it has two and a half year remaining to implement the proposed plan.

During the survey, it was observed that the industries without ZD plans are also practicing reduce, reuse/recycle and recovery measures in running their industries. Table 6.10 shows some 3R measures adopted in industries with only ETPs.

Table 6.10: 3R measures adopted in industries with ETPs only

Industry ID	3R Measures
E-1	• Systematic vegetation to increase water retention and recharge of groundwater, • plantation of red oak tree which releases highest O_2 • white road surface to reduce radiation, • cogeneration • Use of hot steam chiller. • Treated water recycles in flushing, gardening, road cleaning, aquaculture etc.

Industry ID	3R Measures
	• Provision of stone pits for vertical draining, resulting in increased aquifer recharge. • Composting plant using organic waste to make fertilizer. • Liquid indigo is used instead of powder indigo to reduce toxicity and load on ETP. • Around 30 m^3/hr water is saved in finishing unit and reused in WTP • Recovery of condense from boiler and reused. • LED lighting • Total reuse and recycle is around 40% including 18% from ETP water • Paper less policy to reduce the waste and thus conserving the resource. • ETP sludge is recycled in brick making
E-2	• Hot water produced in boiler is recovered. This system was introduced in January 2016
E-3	• Hot water produced in boiler is recovered.
E-4	• No mentionable 3R activities in practice
E-5	• Reuse of dyeing water in boiler. • Use of Low liquor ratio machine reduces amount of water consumption.
E-6	• Hot water produced in boiler is recovered and this system was introduced since 1993.
E-7	• Rain water harvesting RCC reservoir tank of 10,000L capacity was installed in October 2016 which reduces water consumption.
E-8	• Solar panel of capacity 1200 Watt was introduced which reduces energy consumption.
E-9	• No mentionable 3R activities currently.
E-10	• No mentionable 3R activities currently.

6.7 SLUDGE MANAGEMENT

Of all the industries surveyed, a few industries have filter press and sludge drying bed for dewatering and reducing the volume of generated sludge at the ETP. Most of the industries dry the sludge in open air naturally and then store it for days and finally dispose of the sludge in landfills. It has been found from the study that two industries dispose of their sludge with municipal solid wastes. One industry has conducted a research on sludge to investigate if there are any hazardous elements in the sludge and are currently dumping in agricultural filed. Another industry is using their sludge in brick making industry. Amount of sludge generated at ETP is significant occupying large area. The amount of sludge generated in UASB is considerably less than ASP and chemical treatment processes and sludge generated in ASP is less than the chemical process. Therefore, the volume of sludge generation also depends on the type of wastewater treatment technology adopted by the industries. Sludge disposal is still a problem for the textile industries. The concept of ZLD is converting one problem into another --- decreasing the volume of liquid waste but increasing the amount of solid wastes. So, the paradigm of problem shifts from one form to another.

6.8 COST ANALYSIS

During the field visit, questionnaire survey was conducted (Annex A) to collect the information on cost, water use etc. from the industry. Based on the collected information, Table 6.11 presents the operational cost and capital investment in ETP.

Table 6.11: Capital Investment and Operational Cost of Selected ETPs

Industry Name	ETP Operational Cost (BDT/m^3)	ETP Capital Cost (BDT)
Z-1	12-14	10 Crs
Z-2	8	90 Lacks
Z-3	2	2 Crs
Z-4	10	4 Crs
Z-5	20	70-80 Lacks
Z-6	17	6 Crs
Z-7	Data not available	170 Crs
Z-8	12.5	6 Crs
Z-9	24	3 Crs
Z-10	48	Data not available
E-1	23-25	10 Crs
E-2	12-14	2 Crs
E-3	10	3 Crs
E-4	22	2.5 Crs
E-5	37	1.2 Crs
E-6	38	Data not available
E-7	6	40 Lacks
E-8	10	25-30 Lacks
E-9	5	2.5 Crs
E-10	75	34 Crs

The capital cost of ETP includes the cost of land, equipment, infrastructure construction etc. and the operation cost of ETP includes cost of chemicals, energy bill, salary of ETP staff, operation and maintenance etc. Table 6.11 shows that among the twenty industries, seven industries operational cost of treatment for per unit m^3 of wastewater is within Tk.2.00 – 10.00, five industries is within the range of Tk.11.00 – 20.00, five industries is within Tk.21.00 – 40.00 and the rest three industries' cost is higher than Tk. 40.00. It is observed from Table 6.11, that the investment cost of ETP of all twenty industries varies in a wide range depending on the technology, space and industry type but the variation in operational cost of most of the industries is not much wide (Tk. 5.0–38.0 /m^3 of water), except two industries, Z-3 and E-10. Operational cost of Z-3 is 2.0 Tk./m^3, which is very low and E-10 is 75.0 Tk./m^3 which is very high compared to those of other industries. Industry E-10 has implemented UASB technology and biofiltration in treating its wastewater in a huge area. Therefore, its investment cost is very high compared to the other industries but the reason for its high operational cost cannot be explained since in their UASB technology, it is not using any chemicals, sludge recycling and mechanical aeration. There might be some mistakes in providing the data for Z-3 industryw.r.t. operational cost.

6.9 TECHNOLOGICAL ASSESSMENT

Different types of technologies were observed in textile industry ETPs. Common technologies include physico-chemical (aeration, coagulation-flocculation, clarification and filtration) and activated sludge process (biological). Of the surveyed industries, two industries employSBR (Sequencing Batch Reactor) system which is aerobic biological process and one industry employsanaerobic biological process (UASB). Industry E-9 has adopted Dissolved Air Flotation (DAF) method in its physico-chemical ETP system.

In industry Z-6, it is found that ithas two flocculation tanks (one before SBR and another after SBR,) two ozonization tanks (one before SBR and one after SBR), two sets of inclined plate settler (one before SBR and one after SBR), Activate Carbon Filter and Multi-grade Filter in the ETP. To study the effectiveness of these additionaltreatment units in this ETP, one extra sample was collected at the outlet of SBR in excess ofinfluent and final effluent samples and was analyzed at BUET Laboratory.The test results are shown in Table 6.12.

Table 6.12: Test Results of Additional Sample at the SBR unit of Z-6

Parameters	Inlet	Before Recycle (after SBR)	Outlet (Final disposal)	Removal Efficiency (%)	
				After SBR	At the outlet
pH	10.54	7.75	7.6	--	---
Color Pt-Co	484	287	284	41%	41%
Turbidity (NTU)	66.6	11.9	11	82%	83%
DO (mg/L)	5.14	0.33	0.15	- 94%	- 97%
BOD_5 (mg/L)	187.5	24	26	87%	86%
COD (mg/L)	505	66	80	87%	84%
EC (μS/cm)	2660	4540	4550	-71%	-71%
Cl^- (mg/L)	205	290	295	-41%	-44%
NH_3-N (mg/L)	1.197	2.19	3.06	-83%	-156%
PO_4^{3-} (mg/L)	0.299	0.738	0.81	-147%	-171%

Parameters	Inlet	Before Recycle (after SBR)	Outlet (Final disposal)	Removal Efficiency (%)	
				After SBR	At the outlet
TDS (mg/L)	1848	3164	3173	-71%	-72%
TSS (mg/L)	53	28	31	47%	42%

From Table 6.12, it has been found that the additional units in the ETPs are not so effective in reducing the contaminants, instead the removal efficiency decreased for almost all parameters.

Performance of the UASB type ETP (Industry E-10) was found to be very promising(Table 6.13), specially the color removal (efficiency 100%)and TDS (89%) compared to other industries.

Table 6.13: Test Results of UASB system at E-10

Parameters	Inlet	Before UASB	After UASB	Outlet	Removal Efficiency of Neutralization Tank (%)	Removal Efficiency of UASB (%)	Removal Efficiency of Biofilter (%)	Overall Removal Efficiency (%)
pH	11.52	6.90	6.99	7.48	40%	---	---	---
Color Pt-Co	8500	1300	620	10	85%	52%	98%	100%
Turbidity (NTU)	744	60.9	24	1.2	92%	61%	95%	100%
DO (mg/L)	0.05	0.05	0.05	5.39	0%	0%	10680%	10680%
BOD_5 mg/L	1160	550	230	0.40	53%	58%	100%	100%
COD (mg/L)	2078	1234	498	5	41%	60%	99%	100%
EC (µS/cm)	7370	2800	2690	264	62%	4%	90%	96%
Cl^- mg/L	520	540	500	80	-4%	7%	84%	85%
NH_3-N mg/L	14.46	19.60	33.125	0.224	-36%	-69%	99%	98%
PO_4^{3-} mg/L	2.35	15.65	40	0.445	-566%	-156%	99%	81%
TDS mg/L	1078	1734	1532	173	-61%	12%	89%	84%

Parameters	Inlet	Before UASB	After UASB	Outlet	Removal Efficiency of Neutralization Tank (%)	Removal Efficiency of UASB (%)	Removal Efficiency of Biofilter (%)	Overall Removal Efficiency (%)
TSS mg/L	396	90	49	11	77%	46%	78%	97%

It has been found from the study that the performance of UASB and Biofilter is very good,especially in treating BOD_5, COD and color (almost 100%) removal. Efficiency of Biofilter is excellent in removing TDS and the overall removal of all parameters is very good.

The only industry which has RO system (Z-10) as a tertiary treatment.Samples were also collected before and after RO unit to assess the performance of RO. Table 6.14 shows the performance of RO system.

Table 6.14: Test Results of RO system installed at Z 10

Parameters	Inlet	Before RO (after Ion-exchange, coagulation-flocculation)	Outlet	Removal efficiency of ETP (%)	Removal efficiency of RO (%)	Overall Removal efficiency (%)
pH	7.88	6.64	6.52	---	---	---
Color Pt-Co	78	45	10	42%	78%	87%
Turbidity (NTU)	85.1	15.7	0.72	82%	95%	99%
DO (mg/L)	5.59	3.09	3.67	-45%	19%	34%
BOD_5 mg/L	100	11.2	0.4	89%	96%	100%
COD (mg/L)	320	30	5	91%	83%	98%
EC (μS/cm)	540	1369	367	-154%	73%	32%
Cl^- mg/L	165	315	187	-91%	37%	-21%
NH_3-N mg/L	2.258	1.564	0.465	31%	70%	79%
PO_4^{3-} mg/L	0.058	0.162	0.055	-179%	66%	5%
TDS mg/L	341	855	200	-151%	78%	45%
TSS mg/L	129	27	7	79%	74%	95%

Performance of conventional ETP units (coagulation-flocculation and ion-exchange) in this industry is not good regarding color and TDS removal. Instead of reducing TDS, it has increased TDS and the reason might be the use of PAC and Polymer in coagulation-flocculation unit. It is known that RO is very effective in removing TDS and the test results also support that. However, the industry is a washing industry and its influent quality is not aspoor as the dyeing industries. Again, the industry has introduced its RO in August,2016 and as per their records it has not faced the problem of replacing the membrane yet.

Chapter 7

Discussion

7.1 INTRODUCTION

The present action research was undertaken with an objective to investigate the status of textile industries in Bangladesh regarding their performance in effluent treatment and their progress in achieving zero discharge under 3R plan. Keeping this objective in view, the research was designed and conducted accordingly and the survey results and analysis were presented in Chapter 5 and Chapter 6. This chapter presents a detail discussion on the survey findings and results which may help to attain the goals and reach a conclusion. The discussion is focused in the light of the objectives and outcomes of this research.

7.2 DISCUSSION ON PROPOSED TECHNOLOGICAL SCHEMES IN 3R PLAN

The first objective of this research was to analyzeapproved 3R plans of different textile industries to assess the technological schemes to achieve ZLD. It is worthy to note that the main focus of this research is on Zero Liquid Discharge (ZLD), although the industries submitted their 3R plans in light of Zero Discharge (ZD). Introducing ZLD system (RO, Evaporation unit, Crystallizer, etc. as Tertiary treatment system) with ETP usually is one of the main components of achieving zero discharge. Therefore, the emphasis was given in the present study to assess the technological scheme proposed by the industries. From the review of the plans, it was observed that common technological schemes proposed by the industries are inclusion of Pressure Sand filter, Activated Carbon filter, Multi-grade Filter, Micro filter, Ultrafilter etc. (Table 6.9). All these units are meant to improve the treated water quality and increase the water reuse. The industries have proposed to reuse this water in gardening, floor washing, toilet flushing, firefighting purposes. All ten selected industries have proposed RO unit as ZLD component in their treatment system to increase the water recycle percentage and to use this water in main production process. Many industries have proposed evaporation unit with RO system to recover the salt.

In the 3R plan, industries have suggested some other measures to reduce, recover and conserve such as RWH, Energy Saving by LED lighting and sewing machine, heat recovery through economizer, Bio-gas plant, incinerator, medical waste disposal process, etc.

While reviewing the plan, it was observed that DoE has no generalized uniform format of ZD/3R plan. The format of the plan submitted by one industry was reviewed and modified by DoE and then was recommended to the other industries to follow that format. It is understood that making a uniform format is difficult as every industry is different from other industries in terms of type, capacity, processes, treatment technologies etc. and updating is a continuous process.

7.3 DISCUSSION ON PROGRESS OF ZLD

The DoE started giving approval of ZD/3R plan in 2014. The industries have to implement the plan phase by phasein 3 years'timeline. The present study was undertaken with a view to find out how the industries have progressedwith the implementation of their proposed plan to achieve Zero Liquid Discharge. One of the objectives was to assess the consistency of the proposed 3R plan with the actual scenario. It has been found during this research that although the industries have proposed implementing ZLD units in their industry, very little progress have been achieved so far. Of the ten selected industries as ZLD-ETPs, only one industry was found to have RO system, the other nine industries have yet to start implementing.Some industry time line has already expired and others are approaching the end. There are many reasons behind this poor level of progress. It was learnt from the industries that despite all the good intention they are unable to implement the proposed plans because of many constraints. Some industries have huge space limitations, especially those located in BSCIC Industrial area. Some industries have financial constraint, whereas, other industries are struggling with the running of ETP smoothly. A few are investing in expanding their production capacity, giving less priority on ZLD implementation. The research team held dialogues with the ETP personnel and learnt that the industries have many queries and confusions regarding the ZLD system. According to them, the ZLD technologies are highly sophisticated, advanced systemrequiring skilled andexperienced staff to run. There is a serious dearth of skilled personnel. Capacity building through training and hands-on teaching in this sector should be given priority. The effectiveness and sustainability of ZLD units mostly depend on the efficient performance of ETP.Otherwiseany advanced system such the RO system will need frequent membrane replacement. Unfortunately, performance of the ETPs of many industries is not even good enough to comply with the national standard, let alone achieving100% zero liquid discharge. Another reason for not achieving much progress in ZLD is that many industries have submitted the plans to get the clearance from DoE, but they do not know how to proceed with the implementation process or are not yet ready to implement those plans.

Although most of the industries visited (90%) by the research team have not implemented the units / components mentioned in their 3R plans yet, many have adopted various measures to reduce the liquid discharge and emission. Some industries are recovering some heat energy and recycling some amount of ETP treated water for different purposes. The most common features are recycling a certain percentage (varies from 5% to 30%) of treated water for gardening, fire fighting and toilet flushing. Industry Z-6 has adopted many measures such as heat recovery in finishing, hot water recovery from boiler and condensate recovery. They use Low Liquor Machine in dyeing which consumes less water, boiler with in-built equalizer for less gas use. They are using cooling water in dyeing unit and stored rain water (through RWH system) contributes to the process water. Some of their energy conservation measures include the use of LED light, sewing machines which requires less energy, heat trap in ironing machine, soft-start washing machine, etc. According to them, a small portion of treated water is used in chemical mixing. Also, use of low volume toilet flush and water tap adds to their water saving scheme. Thus, it is evident that this industryis very active in reduce, reuse and recovery. Industry Z-9 also adopts similar type of measures in reduce, reuse and recovery (Table 6.9). In addition to RO system, industry Z-10 uses water and energy saving washing machines in Washing unit and water saving sanitary fixtures in the toilets. It also recovers condensate and reuses it. The total reuse and recycle of treated water of Z-10 is 63% because of introducing RO (ZLD unit) with ETP. The performance of Industry Z-3 and Z-5 is very poor in achieving 3R goals. Industry Z-8 has received approval in January 2017 and it has one and a half year time to implement the proposed plan. Some industries have already started using water saving machine/equipment in their processes to reduce the water consumption at the source. Some industries are using those chemicals which are less toxic and make less sludge. Therefore, these types of measures are certainly in line with 3R plans.

From this study, it was found that not only the industries which have received approval from DoE but also the industries which are yet to submit plans have adopted many 3R measures. One of the industries (E-1), which has not submitted 3R plan, is presently recycling around 40% of its treated water that is being used for many purposes. Other ETP industries are practicing some forms of reduce and recycling measures (Table 6.10, Chapter 6).

Therefore, it can be said that if the ETP runs effectively, producing improved quality of treated water, then a considerable amount of water can be recycled if the industry is willing.

Regarding the time frame mentioned in the proposed plan to achieve 3R goals, it is found that almost none of the industries comply with the time line mentioned in introducing ZLD units. There may be several reasons behind this: the industries are bit confused about how to proceed with this, some industries have future plans in expanding their business and this may require the extension/up gradation of their ETP which may take time, official complexities, financial constraints etc. If there is any mechanism so that the industry could inform DoE explaining the reason of not complying with 3R goals in proposed time frame, then DoE may help them in resolving their issues.

7.4 DISCUSSION ON PERFORMANCE OF ZLD AND ETPs

Of the twenty industries selected for this study nineteen industries are running with ETP only and one industry has ETP with ZLD (in the form of RO system). Therefore, comparison of performance between these two unequal groups would be improper.Moreover, the industry with RO system has only the Washing Plantwhereas others are of various types. Therefore, it would be appropriate to consider all the industries as one group while evaluating their performance in treating the industrial effluent.

The baseline scenario of the influent to the ETP and treated effluent of the ETP of the studied industries (20) are presented in Table 7.1 and Table 7.2.

Table 7.1: Wastewater Characteristics of Studied Textile Industries at Inlet

Industries	Wastewater Quality Parameters											
	pH	Color (Pt-Co)	Turbidity (NTU)	DO (mg/L)	BOD_5 (mg/L)	COD (mg/L)	EC (µs/cm)	Cl^- (mg/L)	NH_3-N (mg/L)	PO_4^{3-} (mg/L)	TDS (mg/L)	TSS (mg/L)
Z1	7.51	256	55.3	0.31	240	541	1772	180	0.942	1.38	1410	65
Z2	7.4	186	94.7	0.16	116	228	1240	390	1	0.325	669	94
Z3	9.83	1150	27.1	0.09	104	328	4520	150	2.21	0.95	3402	93
Z4	8.98	4000	49.7	2.73	160	816	13700	7400	5.94	0.147	10710	128
Z5	10.07	2340	361	0.19	720	3600	1264	135	5.32	0.298	1021	402
Z6	10.54	484	66.6	5.14	187.5	505	2660	205	1.19	0.299	1848	53
Z7	11.56	4500	249	0.81	700	1232	4410	380	11.63	4.74	3756	428
Z8	10.09	2650	746	1.0	140	561	2140	290	5.24	1.5	1418	128
Z9	9.74	3780	59.9	0.08	840	1728	7870	150	7.63	4.82	6226	350
Z10	7.88	78	85.1	5.59	100	320	540	165	2.26	0.058	341	129
E1	11.51	800	303	0.31	920	1856	3760	340	0.468	0.91	2736	242
E2	7.03	36600	371	5.64	240	687	755	240	1.46	0.16	678	586
E3	9.5	1700	88.2	0.11	112	372	3700	230	1.99	1.09	2804	240
E4	9.15	1420	219	0.1	256	704	4320	540	2.09	0.275	3302	226
E5	7.77	202	74.3	0	220	443	2710	140	0.54	1.04	2000	72
E6	7.72	1396	101	0.05	300	794	7120	350	2.03	0.392	5550	231
E7	7.68	1070	98.6	0.08	80	660	755	165	2.77	0.02	634	36
E8	5.63	53	51	4.25	28	137	863	125	1.23	0.038	601	93
E9	6.85	5500	56	5.21	128	698	6320	110	11.5	0.37	708	124
E10	11.52	8500	744	0.05	1160	2078	7370	520	14.46	2.35	1078	396
Range (min. – max.)	5.63 - 11.56	53 - 8500	27.1 - 746	0 - 5.64	28-1160	137-3600	540-13700	110-7400	0.468-14.46	0.02-4.82	341-10710	36-586
ECR, 1997 (Discharge into surface water)	6.0-9.0	-	-	4.5-8.0	≤ 50 at 20^0C	≤ 200	≤ 1200	≤ 600	≤ 5	-	≤ 2100	≤ 150

Table 7.1 shows that the concentration of all the parameters of the selected industries are very high. It is evident that the wastewater of textile industries is heavily polluted with high organic loading, less dissolved oxygen, and high dissolved solids which should not be discharged directly into the environment without treatment.

The data shown in Table 7.2 indicates that the concentrations of the parameters of most of the industries are within the allowable limit set by ECR, 97, except for DO and TDS. Therefore, the treatment of textile industry effluent scenario is not so dismal. Considering individual industries compliance status, it has been found that, 8 industries fail to comply with TDS,13 industries fail to comply with DO, 3 industries fail to comply with BOD_5 and 4 industries fail to comply with COD Standard (ECR, 97) (Figures 6.2, 6.3, 6.4, 6.5, 6.10, 6.11, 6.12 and 6.13).Therefore, it can be said that ETP of the studied industries is effective in reducing BOD_5 and COD but not so effective in reducing TDS and complying DO content. The color removal efficiency of ETP is also not noticeable, although there is no standard for Color. Of all the industries studied, the color removal of industry E-10 is very good (100%). The technology adopted for treating its wastewater is UASB. From literature, it is known that UASB technology is effective in removing colorand the present study finding supports that.

Table 7.2: Treated Effluent Characteristics of Textile Industries at Outlet

Industries	Treated Effluent Parameters											
	pH	Color (Pt-Co)	Turbidity (NTU)	DO (mg/L)	BOD_5 (mg/L)	COD (mg/L)	EC (µs/cm)	Cl^- (mg/L)	NH_3-N (mg/L)	PO_4^{3-} (mg/L)	TDS (mg/L)	TSS (mg/L)
Z1	8.13	125	14.9	1.87	10	70	2280	180	0.338	0.08	1542	8.13
Z2	8.09	87	9.04	4.08	9.6	42	2460	510	1.69	0.492	1610	8.09
Z3	8.24	55	11.2	5.08	8	67	1841	455	0.55	0.105	1184	8.24
Z4	7.71	920	8.23	3.79	24	283	3590	405	1.05	2.435	2622	7.71
Z5	7.81	400	60.2	0.26	140	553	1148	365	1.5	0.095	840	7.81
Z6	7.6	284	11	0.15	26	80	4550	295	3.06	0.81	3173	7.6
Z7	7.32	1020	4.36	0.32	18	122	4360	90	1.712	3.2	3364	7.32
Z8	7.49	1150	5.58	4.23	5	57	3330	325	1.295	2.5	2289	7.49
Z9	6.9	310	25.5	5.39	32.5	95	5650	395	0.483	13.21	4137	6.9
Z10	6.52	10	0.72	3.67	0.4	5	367	200	0.465	0.055	187	6.52
E1	7.32	32	8.62	5.25	12.8	68	2160	680	0.469	0.505	1354	43
E2	6.99	110	14.3	0.25	56	159	1235	540	1.103	0.073	858	28
E3	7.72	148	8.62	5.39	8	44	1560	300	1.17	0.132	1107	35
E4	7.12	335	57.4	0.06	192	359	4090	470	0.457	0.082	3051	60
E5	7.4	113	33.2	0.05	40	119	2660	135	0.652	0.242	1790	45
E6	7.43	231	25.2	0.05	220	389	7000	600	2.9	0.256	5224	28
E7	7.3	85	4.07	0.38	10	67	1020	275	1.275	0.05	775	42
E8	7.64	13	1.29	6.07	1.2	7	1533	265	0.567	0.2	989	15
E9	7.47	820	23.9	5.24	7	53	3280	260	1.825	2.32	2298	27
E10	7.48	10	1.2	5.39	0.4	5	264	80	0.224	0.445	173	11
Range (min. – max.)	6.52-8.24	10-1150	0.72-60.2	0.05-6.07	0.4-220	5-553	264-7000	80-680	0.224-3.06	0.05-13.21	173-5224	7-72
ECR, 1997 (Discharge into surface water)	6.0-9.0	-	-	4.5-8.0	≤ 50 at 20^0C	≤ 200	≤ 1200	≤ 600	≤ 5	-	≤ 2100	≤ 150

7.5 DISCUSSION ON TECHNOLOGIES

Various technologies have been found in twenty studied industries such as chemical process (coagulation-flocculation), Activated sludge process and Up-flow anaerobic sludge blanket process (UASB). Most common are coagulation and ASP. Few industries were found to use return sludge in their biological treatment process (ASP). Most of the industries have only clarifier/settling tank with long detention time along with chemical treatment (coagulation-flocculation) units which facilitates in decomposing organic load and thus removed by biological process. Due to the wide variation of technologies, it will very difficult and unrealistic to recommend from this study that one technology is better compared to other or generalizedit for treating the wastewater effectively. The reason is that every industry is different in terms of its type, production capacity, wastewater flow rate, raw materials and chemicals use in the process etc. However, some observations were made from the findings of this study and based on these observations, comments can be made which may guide in selecting the right technology. It has found that in some industries, many units are included and the test results show that inclusion of these units are not reducing the contaminants, rather contributing to the pollution load (Section 6.9, Table 6.12). These units seem unnecessary in ETPs and increase the investment cost and operational cost to ETP. However more tests should be done for establishing this fact. Again, it is evident from test results of many industries, that although the use of PAC, Poly-electrolyte, Polymer, and decoloring agent remove COD and color, it increases TDS, exceeding the allowable limit. This high TDS can only be removed by using RO system to achieve ZLD and the effectiveness of RO also depends on the quality of treated effluent, otherwise the membrane will haveto be replaced frequently increasing the operational cost.

It is worthy to mention here that many ETPs are performing well and practicing 3R measures (reduce, recycle, recovery) (up to 40%) in their industries. Therefore, if the industry can run their ETP effectively, they can recycle a considerable amount of water without increasing the cost. The ZLD concept is to convert the liquid into solid phase. Unfortunately, this only transfers the problem from liquid phase to solid phase.

7.6 ASSESSMENT OF ZLD AND ETPs IN TERMS OF COST

The study team found it very difficult to get the information on cost involved in ETPs (both capital cost and operationalcost) from the industries. Most of the industries could not provide these data since they do not have this in record. Whatever data collected from some of the industries seem to be unrealistic and unreliable. However, an attempt was made to determine the operational cost of ETPs (Section 6.8, Chapter 6). It is observed from the Table 6.10, that the investment cost of ETP of all twenty industries varies in a wide range depending on the technology, space and facility but the variation in operational cost of most of the industries is not much different (5.0 – 38.0 Taka/m^3 of water), except for twoindustries, Z-3 and E-10. Industry E-10 has implemented UASB technology and biofiltration in treating its wastewater in a huge area. Therefore, its investment cost is very high compared to the other industries but the reason for its high operational cost is not known since, it is not using any chemicals, sludge recycling and mechanical aeration in UASB technology. There might be some mistakes in providing the data of operational costfrom other industry.

It has been found from the study that the land area and treatment technology (includes equipment) dominates capital cost. In addition, lack of skilled manpower in handling of ETP is a major factor influencing operational and maintenance cost. And as industry tends to use more advanced and sophisticated technologies like RO, MEE, Crystallizersetc, the need of skilled man power in this area will be increasing.

To achieve ZLD, the industry is in need of financial support and technological support from the Government and capacity building should be given priority in this sector.

7.7 DISCUSSION ON HANDLING MECHANISM OF REJECT/CONCENRATE OF ZLD SYSTEM

One of the objectives of this research was to identify the handling mechanism of reject/concentrate of wastewater from ZLD units. Since only one industry in the present study has ZLD (RO) system and they have installed this unit in last year August. Therefore, they have not faced any problem with the disposal of reject/concentrate yet. Again, if there are more industries with RO system in operation, it is quite possible that those are also recent. However, the disposal of this reject will be a concern if more industries are going to install this to obtain the treated water quality as potable water and 100% reuse them in process water.

Regarding the sludge management of ETPs, it has been observed that, few industries have filter press, sludge digester and sludge drying bed for dewatering and decreasing the volume of generated sludge at the ETP. Most of the industries dry the sludge in open air naturally and then store it for days and finally dispose of the sludge in landfills. It has been found from the study that two industries dispose of their sludge with municipal solid wastes. One industry has conducted a research on sludge to investigate the presence ofhazardous elements; subsequently is using in agricultural filed. Another industry is using their sludge in brick manufacturing. Amount of sludge generated at ETP is significant occupying large space. The amount of sludge generated in UASB is considerably less than ASP and chemical treatment processes. On the other hand, sludge generated in ASP is less than that in chemical process. Therefore, it is evident that volume of sludge generation also depends on the type of adopted treatment technology. Sludge disposal is still a major problem for the textile industries. The introduction of ZLD units in treatment processes will generate more sludge and disposal of this sludge will be anotherconcern for the industries.

7.8 DISCUSSION ON OPERATION AND MAINENANCE OF ETP

During this study, discussions were held with industries regarding the operation and maintenance related problems in running ETPs. A few of these problems mentioned by the industrypersonnel are listed below:

- High operational cost;
- Insufficient lab facility and shortage of skilled manpower;
- Consumes huge amount of chemicals in physico-chemical process;
- High volume of sludge generation in physico-chemical process;
- Limited sludge disposal options;
- Lack of landfilling sites for sludge disposal;
- Reduction of TDS in treated effluent is extremely difficult and involves tertiary treatment increasing the cost of operation.

7.9 EVALUATION OF REDUCTION IN GROUNDWATER EXTRACTION

Another objective of this research was to evaluate the overall drop of groundwater extraction in respective industries due to implementation of 3R plan. The research team found it very difficult to estimate the reduction in water use. The primary problem is that many industries don't have the data on how much water they use especially in their industrial process. They do not have any water meter installed. In thoseindustries where part of treated water is recycled/reused, there is no record or meter, measuring the recycled/reused amount. Another significant reason is that the industriesare expanding on a regular basis, resulting in more water consumption. Therefore, even if these industries recycle a part of treated effluent, the total demand remains much more than the reused/recycled amount. Thus, the burden on groundwater extraction is increasing instead of decreasing. Therefore, the study team strongly suggests that metering system is introduced in the water supply line at the inlet and the final outlet. Monitoring of the flow data will help to determine the amount of water used, reusedand recycled and thus, will enable one to estimate the level of reduction of groundwater extraction.

Chapter 8

Conclusions

8.1 CONCLUSIONS

The major conclusions drawn from this research are as follows:

- The study findings show that the overall scenario of wastewater treatment of textile industries in Bangladesh is fairly good. The randomly selected all the twenty industries have ETPs and the concentration of all tested parameters of most of the industries' treated effluent are within the allowable limit of ECR,97 except DO and TDS.
- Of the twenty industries treated effluent concentration, seven industries comply with the minimum DO requirements and thirteen industries fail to comply; considering BOD_5 concentration, seventeen industries comply and three industries fail; sixteen industries meet the allowable limit of COD and four industries fail to meet; regarding TDS, twelve industries comply with the ECR, 97 standards and eight industries fail to comply.
- Nine out of ten selected industries that have approved zero discharge plans, have not implemented ZLD units yet as proposed.
- Although most of the industries do not have ZLD units with their ETPs according to their proposed plan, six industries out of ten such industries, are practicing many 3R measures (reduce, reuse, recovery) at their facility. The common measures are use of water and energy saving machines in the process, use of less toxic chemicals, boiler with built-in economizer, reuse of water in gardening, toilet flushing, fire fighting, condense recovery, heat recovery in finishing, LED lighting, RWH, water saving sanitary fixtures etc. (Table 6.9).
- The industries without zero discharge plans also have 3R measures in place. Seven industries out of ten are practicing measures such as hot water recovery from boiler, reuse of boiler water in dyeing, use of solar panel, RWH, LED lighting, Low liquor ratio machine etc. (Table 6.10).
- For the lone ZLD-ETP (RO system with ETP) industry in this research, the total reuse and recycling of treated water is found around 63%.
- The amount of recycled water is found in the range of 5% to 40% considering the industries (nineteen) with conventional (physico-chemical and biological processes) ETP only. The percentage of this reuse is achieved only by applying different measures. It is observed in this study that the industry's good intention is the main driving force of attaining zero discharge.
- The operational cost of ETP varies in the range of Tk. 5.0- 38.0 per m^3 of wastewater treated. No correlation is found between the operational cost of ETP and the production capacity and the technology/processes being used in the treatment process.

- The study observed that attitude of the industry is a major factor in reducing the pollution created by the industry. If the industry feels the responsibility of protecting the environment along with its economic contribution, and act accordingly, only then they will be successful in achieving zero discharge.

8.2 RECOMMENDATIONS

Based on the research findings and discussion, following recommendations are made.

- DoE should introduce use of flow meter at the inlet and outlet of every industry. Only by doing this, the amount of reused/recycled treated water can be determined and monitored.
- As ZLD technology is very expensive, there should be some incentive from government in form of subsidy or soft loan for the industry to implement the technology and reduce the pollution.
- If the ETP treated wastewater of the industries can be collected and then treated in a centralized ZLD system, the cost will be less and industries will be able to secure their business as well as the environment
- Before implementing ZLD technology, every industry should ensure that their ETP is performing effectively, otherwise ZLD will not work properly.
- The industries which are in shortage of land (specially in BSCIC area) for accommodating biological and ZLD units, alternative arrangements should be made from the government to treat their wastewater i.e. arrangement for CETP.
- The success of achieving zero discharge also depends on source reduction. Use of less toxic chemicals and advanced machineries in the process reduce the water consumption. Financial support should be given to the industry to promote this, specially for small scale industries.
- There is a dearth of skilled man power in handling, operating and maintaining the advanced technology and sophisticated machines in ETP and ZLD units. Capacity building in this area is strongly recommended.
- There should be some mechanisms/arrangement between DoE and industry so that the industry could inform DoE explaining the reason of not complying with 3R goals in proposed time frame, then DoE may help them in resolving their issues.

The research team believes that if the abovementioned recommendations can be implemented, both the industry and DoE will be benefited and pollution created by textile industries can be managed sustainably and the pollution scenario of the country will improve significantly.

8.3 CONSTRAINTS AND LIMITATIONS

The research team has faced many constraints and challenges while conducting the work. These are as follows:

- The samples were collected from the industry only once. It would be more representative if more samples could be collected from the same industry since industrial wastewater composition varies widely with time.
- Most of the industries could not provide reliable data on ETP cost, water consumption, amount of recycle water etc., therefore the cost-benefit analysis regarding technology; water reuse could not be performed.
- If these industries were of the same type and have same ETP processes, then suggestion could be made on specific amount of water reuse potential for a given technology. However, the studied industries are of various types (dyeing, washing, composite etc.) and sizes (capacity), and therefore suggestion made like this would not be realistic and logical.
- Unfortunately, the research team found only one industry among the 10 selected industries (as ZLD-ETP) which has RO system, although the 10 industries supposed to have RO system according to their approved plan. Therefore, the team has not found enough data and information of ZLD units and consequently the conclusions are mainly made based on ETP system, not ZLD-ETP system.

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ANNEX A

Questionnaire Survey

ANNEX B

List of Participants

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Performance Evaluation of Zero Liquid Discharge-Effluent Treatment Plants (ZLD-ETPs) in Textile Industries of Bangladesh

A. Questionnaire Information

Name of Industry: Location: GPS Location:	Date: Industry No.: Water Treatment Plant: ETP/ZLD-ETP
Name of Respondent: Designation: Contact info:	

B. Industry General Info

1. Type of Industry	☐ Knitting ☐ Dyeing ☐ Washing ☐ Finishing ☐ Composite ☐ Others
2. Production Capacity	

3. Number of Employee	
4. Water Consumption(in Total)	
5. Source of Water	☐ Ground Water ☐ Surface Water ☐ Supply Water ☐ Others
6. Consumption of Water in Different Units	
7. Units Generating Waste Water	
8. Measures to reduce water consumption	
9. Amount of energy consumption	
10. Sources of Energy	

C. ETP Information	
1. Capacity of ETP	
2. ETP Technology	☐ Physico-Chemical Process ☐ Biological Process ☐ Biological followed by Physico-Chemical Process ☐ Physico-Chemical followed by Biological Process
3. Units in ETP	
4. Which Units feed waste water in ETP?	

5. Reuse of ETP treated water and amount			
6. Disposal of ETP treated water and amount			
7. Parameters of Water	**Parameters**	**Before Treatment**	**After Treatment**
	BOD **COD** **TOC** **TDS** **TSS** **Hardness** **pH** **Color**		

8. Energy Consumption in ETP	
9. Costs in ETP	Installation
	Operational
10. Units to be added in future	
11. Concerns or Issues in ETP	
12. Sludge Management (Amount+ Disposal)	

D. ZLD/ Advanced Technology	
1. Do you use any units of ZLD or other advanced technology after ETP?	☐ Yes ☐ No
2. If Yes, Name of Units	
3. Date of Approval and Establishment	Approval- Establishment-
4. Capacity of ZLD units?	
5. Energy consumption in ZLD units	

<table>
<tr><td rowspan="2">6. Parameters of Water</td><td>Parameters</td><td>Before Treatment</td><td>After Treatment</td></tr>
<tr><td>BOD
COD
TOC
TDS
TSS
Hardness
pH
Color</td><td></td><td></td></tr>
<tr><td colspan="2" rowspan="2">7. Cost in ZLD</td><td colspan="2">Installation</td></tr>
<tr><td colspan="2">Operational</td></tr>
<tr><td colspan="2">8. Concerns or Issues in ZLD</td><td colspan="2"></td></tr>
</table>

9. Units to be added in future	
10. Sludge management (amount+ disposal)	

E. 3R Implementation Information:

SL. No.	Technology	Cost	Function	Time of Installation	Remarks

Meeting with Textile Industries on 'Zero Liquid Discharge-Effluent Treatment Plants' ZLD-ETPs

Date: 11 April 2017, Time: 10.30AM

CERM

CENTER FOR ENVIRONMENTAL & RESOURCE MANAGEMENT

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Meeting with Textile Industries on 'Zero Liquid Discharge-Effluent Treatment Plants' ZLD-ETPs

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Meeting with Textile Industries on 'Zero Liquid Discharge-Effluent Treatment Plants' ZLD-ETPs

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Meeting with Textile Industries on 'Zero Liquid Discharge-Effluent Treatment Plants' ZLD-ETPs

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