Draft Final

Limited Environmental & Social Impact Assessment
And
Environmental & Social Management Framework

Bangladesh:
Dhaka Environment and Water Project

Volume 2: Annex

Department of Environment

&

Local Government Engineering Department

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Annex- A: Process Improvement Technologies under Consideration

Process improvement technologies under consideration

Process technology to be implemented in the project: Right First Time Dyeing

Research in factories in Bangladesh suggests that errors due to incorrect recipes or not following the recipe could result in around 20% of fabric being re-shaded and around 10% being re-bleached and redyed. The dyeing time-temperature profile is very important and should be based on the dyes used. It should be clearly documented for each recipe developed, and the recipes and procedures carried out in the laboratory should be properly followed on the factory floor.

Good equipment in the laboratory that best represents the machines on the factory floor greatly improves the frequency of "right first time'' dyeing. Additional equipment can be purchased to monitor dyeing efficiency, but in general a good understanding of dye chemistry and good shade matching equipment is likely to be sufficient. On the factory floor, machines that are automated will improve the dyeing process by maintaining the correct time, temperature and pH.

Liquor Ratio: The correct liquor ratio for the recipe must be maintained otherwise incorrect concentrations of dyes and other chemicals will be present in the dye bath and the right shade will not be achieved first time. The water gauges should be clean so that they can be easily read and should be monitored at each step during the entire dyeing process. The liquor ratio will be altered when extra water is added to mix the dyes, the salt and the alkali. This should be factored into the liquor ratio in the recipe, i.e. if a total of 1000 L is needed but 50 L of caustic soda will be added, then the volume of water initially put in the dye bath should be 950 L.

pH Control: The pH must be measured after the alkali (e.g. soda ash) is added to ensure that it is the same as that specified in the recipe. Different dye types require different pHs and the recipe should account for this but in general pH must be within pH 10.5-11.5.

Temperature Control: Different dyes require different temperatures and times for optimal dyeing. The recipes are created to ensure that the best conditions are used for each dye. It is therefore very important that these temperatures are maintained for the correct period of time. Some machines might take a longer period of time to reach the temperature required. These should be monitored and adjusted so that the required time to reach the right temperature is maintained. Records should be kept of any changes.

Cost/Savings: Ensuring that the dye recipe is carefully developed to suit the dye type being used and that the recipe is accurately followed on the factory floor can make significant savings. If this is the case then it is possible to make yet substantial savings by improving the number of "right first time" dyeings. For example, based on actual dyeing costs provided by factories in Bangladesh, if a factory dyes 1,000,000 kg of fabric per year, and has to re-shade 20% and re-dye 10% because it did not get the shade "right first time", the factory is incurring US$ 90,946 per year of unnecessary cost. This loss is made up of the cost of using more chemicals, dyes, energy for operating equipment and labor (see explanation of costs in table below).

The factory can also lose money because time spent for re-dyeing or reshading is time lost from meeting other orders. In extreme cases business can be lost altogether due to customer dissatisfaction with the time taken to produce goods. Small to medium firms could save up to US $90,946 per year by implementing this P2 option.

Explanation of Annual Cost of Re-shading and Re-dyeing

Explanation	Average
Re-shading (%)	20
Re-dyeing (%)	10
Total production per year (kg)	1,000,000
Costs of re-shading per year (Tk) Cost of 20% extra chemicals, dyes, energy and labour	966,000*
Cost of re-dyeing per year (Tk) 10% of total cost of production each year including chemicals, dyes, energy and labour	4,830,000*
Cost per year (Tk)	**5,796,000**
Cost per year (US $)	**90,946**

Process technology to be implemented in the project: Good Housekeeping

Good housekeeping includes a range of activities that can be implemented at no or little cost. Potential housekeeping interventions to be implemented in the project are detailed in the table below.

Sr. No	Clean technology measures	Implementation Potential	Impact	Actions required	Implementation Barriers	Remarks
1.	Minimize leakage from valves	Low	Low	Awareness among Plant operators	Most plants are new and hence leakage of valves may not be a problem.	Over time, with ageing of plants, the implementation potential of this measure will increase.
2.	Avoid spilling of water	Medium	Low	Robust Maintenance plan together with Implementation. Awareness. Management Outlook	Fresh water availability is good together with low cost	
3.	Condensate from steam traps should be reused in boiler	High	Low	Installation of steam traps and steam return line.	Awareness. Organization Culture	
4.	Audit of Resources consumed	High	Medium	Organization Culture to be changed	Organization culture and Outlook of Management	Free availability of water is a hindrance to the implementation of this measure

Sr. No	Clean technology measures	Implementation Potential	Impact	Actions required	Implementation Barriers	Remarks
5.	Optimize number of boiler blow downs and ensure heat recovery before discharge	Low	Low	Periodic blow down to be judiciously carried out as required	Awareness	Thermal energy is available at a low cost in Dhaka. This is a detriment to its judicious use.
6.	Optimize the number of back washes in WTP	Low	Low	Awareness	Low cost of water	Potential to implement this measure is high in Dhaka as currently there is no control over time duration of backwashes.
7.	Adopt production procedures as recommended by equipment supplier	Medium	Medium	Follow the prescribed production procedures.	Technology absorption. Water availability at low cost	The liquor ratio used was higher than that prescribed by equipment supplier in the factories visited. This measure will impact the quality of water over time.
8.	Modify jiggers by making use of sprays and vacuum slots – enhances rinsing efficiency.	Low	Medium	To carry out modification of equipment	Technical know how. Support from machinery manufacturer. Capital cost	This measure is applicable to limited factories which are old and small scale
9.	Fit shut-off nozzles onto manually held hosepipes.	High	Low	Fitting nozzles on the pipes	Capacity	This is a low cost and is easy to implement. The practise is not followed currently in most places.
10.	In Bleaching process – Use of chlorides and hypo-chlorides to be replaced with hydrogen peroxide where process permits.	High	Medium	Substitution as suggested	Awareness	It is easy to implement and cost involved is minimal. This measure impacts the water quality
11.	Eliminate use of detergents in 'washing off' after reactive dyeing.	High	Low	Adopt measure suggested	Awareness	This measure is easy to implement, requires no cost or technical skills and is not dependant on size of the plant
12.	Reuse dirty water for washing printing buckets, to dampen ash from boilers and cleaning and flushing water.	Low	Low	Setting up piping and pumps	Organization culture. Fresh water availability at low cost	

Sr. No	Clean technology measures	Implementation Potential	Impact	Actions required	Implementation Barriers	Remarks
13.	Control and monitoring for chemical and water consumption in continuous processes.	Low	Medium	Setting up monitoring systems	Awareness and Vigilance	This measure requires minimal cost and is easy to adopt.
14.	Controlling machine cleaning with a timer for water consumption.	High	Low	Setting up control systems	Awareness and Vigilances	It is low cost and easy to implement
15.	Collect all unused print pastes for bulking-up, do not allow dumping of print pastes to effluent drain. Dispose print pastes at disposal grounds or send to ETP sludge bed	High	Medium	Efficient waste disposal system	Awareness. Organization Culture	This measure does not involve high cost and is easy to implement. It impacts the water quality.

Annex- B: World Bank Effluent Discharge Requirements

Table Effluent Discharge Requirements: Parameters and Maximum Values, Metals
(mg/l, unless otherwise specified)

Guideline	Ag	Al	As	Cd		Total Cr	Cu	Fe	Hg	Ni	Pb	Sn	Zn	Total metals	Other; comments
Aluminum manufacturing		0.2		0.1	0.1										
Base metal and iron ore mining				0.1	0.5	3.5	0.01	0.5			0.2		2	10	
Breweries															
Cement manufacturing															
Chlor-alkali industry															
Coal mining and production									3.5					10	
Coke manufacturing			0.1	0.1			0.5	3.5	0.01		0.1				
Copper smelting													1	10	
Dairy industry					0.1		0.5								
Dye manufacturing															
Electronics manufacturing			0.1	0.1	0.1		0.5		0.01	0.5	0.1			10	
Electroplating industry	0.5		0.1	0.1	0.1	0.5	0.5		0.01	0.5	0.2		2	10	
Foundries							0.5								
Fruit and vegetable processing														10	
General manufacturing	0.5		0.1	0.1	0.1	0.5		3.5	0.01	0.5	0.1			10	Se: 0.1
Glass manufacturing											0.1				
Industrial estates				0.1	0.1	0.5	0.5			0.5	0.1		2		
Iron and steel manufacturing				0.1		0.5			0.01		0.2			10	
Lead and zinc smelting			0.1	0.1			0.5	3.5	0.01		0.1		2	10	
Meat processing and rendering				0.1	0.1	0.5	0.5			0.5	0.1				
Mini steel mills														See com-	
Mixed fertilizer plants				0.1										ments	
Nickel smelting and refining								3.5		0.5					
Nitrogenous fertilizer plants															
Oil and gas development (onshore)															Total toxic metals (antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, vanadium, zinc): 5
Pesticides formulation Pesticides			0.1		0.1		0.5		0.01						
manufacturing Petrochemicals			0.1		0.1		0.5		0.01						
manufacturing				0.1	0.1		0.5								

(Table continues on the following page.)

Table *(continued)*

Guideline	*Ag*	*Al*	*As*	*Cd*	*Cr*[e]	*Total Cr*	*Cu*	*Fe*	*Hg*	*Ni*	*Pb*	*Sn*	*Zn*	*Total metals*	*Other; comments*
Petroleum refining					0.1	0.5									
Pharmaceutical manufacturing			0.1	0.1	0.1		0.1	0.1						0.01	
Phosphate fertilizer plants				0.1											
Printing industry	0.5			0.1	0.1	0.5	0.5								
Pulp and paper mills															
Sugar manufacturing					0.1	0.5									
Tanning and leather finishing															
Textiles industry						0.5	0.5								
Thermal power						0.5	0.5								
Vegetable oil processing															
Wood preserving industry			0.1		0.1	0.5	0.5								

Table ■ Wastewater Characteristics in theTextiies Industry

Process and unit (U)	Waste volume (mP/U)	BOD (kg/U)	TSS (kg/U)	Other pollutants (kg/U)	
Wool processing (metric ton of woolf					
Average unscoured stock"	544	314	196	Oil	191
Average scoured stock	537	87	43	Cr	1.33
Process-specific				Phenol	0.17
Scouring	17	227	153	Cr	1.33
Dyeing	25	27		Phenol	0.17
Washing	362	63			
Carbonizing	138	2	44	Oil	191
Bleaching	12.5	1.4		Cr	1.33
				Phenol	0.17
Cotton processing (metric ton of cotton)					
Average compounded"[1]	265	115	70		
Process-specific					
Yarn sizing	4.2	2.8			
Desizing	22	58	30		
Kiering	100	53	22		
Bleaching	100	8	5		
Mercerizing	35	8	2.5		
Dyeing	50	60	25		
Printing	14	54	12		
Other fibers (metric ton of product)					
Rayon processing	42	30	55		
Acetate processing	75	45	40		
Nylon processing	125	45	30		
Acrylic processing	210	125	87		
Polyester processing	100	185	95		

a. The pH varies widely, from 1.9 to 10.4.
b. The average compounded load factors listed are based on the assumption that only 20% of the product is mercerized (only nonwoolen components are mercerized) and 10% is bleached.
c.The average compounded load factors listed are based on the assumption that only 35% of the product is mercerized, 50% of the product is dyed, and 14% of the product is printed. *Source:* Economopoulos 1993.

Table Effluents from the Textiles Industry

(milligrams per liter, except for pH, temperature, and bacteria)

Parameter	*Maximum value*
pH	6-9
BOD	50
COD	250
AOX	8
TSS	50
Oil and grease	10
Pesticides (each)	0.05
Chromium (total)	0.5
Cobalt	0.5
Copper	0.5
Nickel	0.5
Zinc	2
Phenol	0.5
Sulfide	1
Temperature increase	<3°C[a]
Coliform bacteria	400 MPN/100 ml

Note: Effluent requirements are not direct discharge to surface waters. Mercury should not be used in the process. The liquid effluent should not be colored. MPN, most probable number. A. The effluent should result in a temperature increase of no more than 3^{o} C at the edge of the zone where initial mixing and dilution take place. Where the zone is not defined, use 100 meters from the point of discharge.

Annex- C: Brief Description of 9 Clusters

Brief Description of Industrial Clusters

Tongi (Cluster 1)

Tongi municipal area covers the most part of this cluster. Tongi BSCIC area, Tongi Industrial area, Cherag Ali, Ershad Nagar, Vhadam, Gazipura, Sataish and Nimtoli area situated in this cluster. Tongi khal is the southern boundary, Ardo bazar (Pagar) khal is the eastern boundary and the Turag is the western boundary of this cluster. The area of this cluster is 22.3 km^2. Industrial effluent discharges mainly into the Tongi khal. Five major industrial effluent outlets were identified during field investigations and subsequently selected for water quality sampling and flow measurements.

Hazaribag (Cluster 2)

Hazaribag is located at the south-west of Dhaka city. It is known as the cluster for tannery. The surrounding water bodies are highly polluted by the tannery waste and odor is one of the major challenges for the people living in the surrounded areas. The government decided to relocate the tannery industry from Dhaka and provided a land in Savar. A CETP will be set-up in Savar area. However, the relocation from Hazaribagh to Savar is not yet takne place.

Tejgaon (Cluster 3)

This industrial cluster situated in the middle of Dhaka city. Hatir Jheel (Begunbari khal flows in the southern part of this cluster. The area of this cluster is 2.5 km^2. The industrial effluent from this area discharges into the Hatir Jheel and finally falls into the Balu River through Norai khal. However, three major industrial effluent outlets were identified during field investigations and subsequently selected for water quality sampling and flow measurements.

Tarabo (Cluster 4)

The industries govern along the left bank of the Lakya River from Kanchpur Bridge to Rupganj Ferry Ghat in this cluster. Major industrial areas are Kanchpur, Tarabo, Rupshi and Jatramura. Industrial effluent discharges into the Lakhya River directly through pipes and Kaitka khal. The area of this cluster is 5 km^2. Five major industrial effluent outlets were identified during field investigations and subsequently selected for water quality sampling and flow measurements.

Narayanganj (Cluster 5)

The industries along the right bank of the Lakya River from Demra Ferry Ghat to Narayanganj city including DND area was considered in this cluster. Shyampur industrial area and Fatullah BSCIC industrial area is also situated in this cluster. Industrial effluent discharges into the Buriganga, Dhaleswari and Lakhya Rivers. The area of this cluster is 87.4 km^2. Seven major industrial effluent outlets were identified during field investigations and subsequently selected for water quality sampling and flow measurements.

Savar (Cluster 6)

The industries along both the sides of Dhaka-Aricha highway from Hemayetpur bus stand to Savar Bus stand is situated in this cluster. The major industries are situated at Hemayetpur and Kornopara area. The Bangshi River flows in the western part of this cluster and Karnatoli khal receives discharges from Bangshi and later flows into the Turag River near Aminbazar Bridge. The area of this cluster is 9 km^2. Industrial effluent discharges into the Bangshi River and

Karnatoli khal. Four major industrial effluent outlets were identified during field investigations and subsequently selected for water quality sampling and flow measurements.

Gazipur (Cluster 7)

The industries along both the sides of Dhaka-Mymensingh highway from Board Bazar to Mawna bus stand and the left side of Joydebpur-Tangail highway at Konabari BSCIC and Kashimpur area are situated in this cluster. Major industrial areas are Board Bazar, Rajendrapur, Vhawal, Konabari BSCIC and Kashipur industrial area. Industrial effluent discharges into the Turag River through Konabari BSCIC khal, Kashimpur khal and Labanga khal; into the Balu River through Chilai khal and into the Tongi khal through Ardobazar khal. The area of this cluster is 168 km^2 .Four major industrial effluent outlets were identified during field investigations and subsequently selected for water quality sampling and flow measurements.

Dhaka EPZ (Cluster 8)

DEPZ, DEPZ (extended), Ashulia and Jirabo industrial area are situated in this cluster. Bangshi River flows in the western part of this cluster. The area of this cluster is 36 km^2. The industrial effluent from this area discharges into the Bangshi River through two major khals namely Nolam Kunda and Sokundi. However, seven major industrial effluent outlets were identified during field investigations and subsequently selected for water quality sampling and flow measurements.

Ghorasal (Cluster 9)

The industries along the left bank of the Lakhya River at Palash and Ghorasal area are considered in this cluster. Industrial effluent discharges into the Lakhya River directly. The area of this cluster is 14 km^2. Three major industrial effluent outlets were identified during field investigations and subsequently selected for water quality sampling and flow measurements.

Details of Wastewater Sampling and Discharge Measurements in Major Outfalls of the Industrial Clusters

Sl No	Cluster Name	Date of Sampling and discharge measurement	Sample ID	Location	Position		Discharge (m^3/s)	Temp (^oc)	Remarks
					Easting (m)	Northing (m)			
1	Tongi	21/05/2006	TON-01	Kathaldia	539679	642960	0.018	29	Outlet of Beximco, SKF and Novartis Pharmaceuticals
2		21/05/2006	TON-02	Tongi Industrail Area	539893	642284	0.100	30	Outlet of Sajid Washing and Dyeing
3		21/05/2006	TON-03	Tongi BSCIC Area	542733	641772	0.198	31	Outlet of Tongi BSCIC area
4		21/05/2006	TON-04	Sukundi Rly. Bridge	544591	642771	0.370	30	Outlet of Gazipur and Gazipura area (Ardhobazar /Pagar Khal)
5		01/06/2006	TON-05	Vadam	536662	642746	0.050	34	Outlet of Etafil and Tamishna dyeing
6	Savar	18/05/2006	SAV-01	Karnopara	526357	634365	0.067	29	Karnopara Khal
7		18/05/2006	SAV-02	Hemayetpur	525899	630883	0.056	32	Outfall of Hemayetpur Industrial area
8		18/05/2006	SAV-03	near Karnopara Bridge	526166	633762	0.045	36	Outfall of Karnopara Bridge adjacent industrial area
9		01/06/2006	SAV-04	near Banshi River	525666	634751	0.035	30	Outfall of AKH dyeing and Abedin textiles
10	Narayanganj	29/05/2006	NAR-01	Shympur	544587	618940	0.193	31	Outfall of Shympur Industrial Area
11		29/05/2006	NAR-02	Kashipur	549555	610456	2.110	36	Outfall of Fatullah BSCIC area
12		29/05/2006	NAR-03	DND Canal	552548	620723	5.830	29	DND Drainage canal

(Contd.)

Sl No	Cluster Name	Date of Sampling and discharge measurement	Sample ID	Location	Position		Discharge (m^3/s)	Temp (^oc)	Remarks
					Easting (m)	Northing (m)			
13		30/05/2006	NAR-04	Katchpur	552058	622225	0.150	35	Outfall of Bengal Paper mill
14		30/05/2006	NAR-05	Mipara, Godnail	553091	616136	0.500	30	Outfall Abir dyeing and others dyeing
15		30/05/2006	NAR-06	Jelapara Khal	552854	614484	1.800	32	Outfall off huge numbers of dyeing and textiles
16		30/05/2006	NAR-07	Killarpool Khal	552459	613234	0.650	31	Outfall off huge numbers of dyeing and textiles
17	Ghorasal	31/05/2006	GHO-01	Polash	565096	652906	0.720	42	Outfall of Ghorasal Fertilizer
18		31/05/2006	GHO-02	Ghorasal	562126	645798	0.170	32	Outfall of Capital Paper mill
19		31/05/2006	GHO-03	Rupganj Ferry Ghat	553528	630727	0.150	38	Outfall of Leena Paper mill
20	Tejgaon	21/05/2006	ABR-01	Niketon Khal	542454	628751	1.519	36	Near Arong Bridge
21		21/05/2006	SGM-01	East Sonargoan Road	541207	626680	3.058	38	Near Culvert
22		21/05/2006	MKP-01	Modhukunipara	542137	628110	0.067	38	Local market place
23	Tarabo	23/05/2006	TAR-01	On the bank of Lakha River	551697	622719	0.049	31	Rahman chemical and Sobnom oil mill (rectangular drain)
24		23/05/2006	TAR-02	Kaitka Khal	552197	622376	0.712	35	Connected with Lakha River
25		23/05/2006	TAR-03	On the bank of Lakha River	552768	621809	0.560	33	Sinha Industries

(Contd.)

Sl No	Cluster Name	Date of Sampling and discharge measurement	Sample ID	Location	Position		Discharge (m^3/s)	Temp (^oc)	Remarks
					Easting (m)	Northing (m)			
26		23/05/2006	TAR-04	On the bank of Lakha River	552779	621822	0.589	32	Near Kachpur Bridge
27		29/05/2006	TAR-05	Rupgonj Mor	553899	625307	0.050	31	Fall in borrow pit by 9'' dia pipe
28	DEPZ (Ashulia)	28/05/2006	EPZ-01	Beximco Industrial Park (Near Modhupur)	527083	651647	1.605	29	Beximco Industrial Park (comes from their dying company mainly)
29		28/05/2006	EPZ-02	Beximco Industrial Park (Near Modhupur)	527064	651518	2.333	28	Beximco Industrial Park (comes from their ceramic industry mainly)
30		29/05/2006	EPZ-03	Beximco Synthetic Factory	525802	653874	0.946	31	Comes waste water mainly by pipe
31		29/05/2006	EPZ-04	Samad Group of industries (Near Girabo)	527444	650374	0.318	32	Fall in borrow pit by pipe
32		29/05/2006	EPZ-05	EPZ gate	528195	648140	0.633	31	Comes waste water by drain
33		22/05/2006	NKD-01	Nolam Konda Khal	524326	647782	1.270	33	Carry Canal of EPZ Pollutant Water
34		22/05/2006	SKD-01	Sokundi Khal	524312	647804	0.181	32	Carry Canal of BEXIMCO Pollutant Water
35	Gazipur	30/05/2006	GAZI-01	Konabari Khal at Namapara	533378	653241	0.015	28	Waste water from Konabari Industrial area
36		30/05/2006	GAZI-02	Kashimpur Khal	533233	652530	3.729	31	Comes waste mainly from BSCIC Industrial park
37		15/06/2006	GAZI-03	Rajendrapur Chourasta	541238	665283	0.230	28	Outfall of several dyeing

(Contd.)

Sl No	Cluster Name	Date of Sampling and discharge measurement	Sample ID	Location	Position		Dischrge (m^3/s)	Temp (^oc)	Remarks
					Easting (m)	Northing (m)			
38		15/06/2006	GAZI-04	Dasobanga Bridge, Duguria	536941	665351	0.490	27	Waste water from several dyeing
39	Hazaribagh	23/05/2006	HAZ-01	Hazaribagh	537729	623786	0.250	30	Waste water from tanneries
40		23/05/2006	HAZ-02	Rayerbazar	536906	625700	1.100	29	Waste water from tanneries
41		23/05/2006	HAZ-03	Nawabganj	538594	623204	0.450	30	Small industries waste water

Annex- D: Test Results of Wastewater Samples

Test Results of Wastewater Samples

Sample ID	P^H	NH_3-N	NH_4^+-N	T. Ammonia	NO_3-N	TDS	TSS	PO_4^{3-}	SO_4^{2-}	DO	BOD_5	COD	Cr	Cd	Pb	Cl^-	Discharge
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	mg/l	m^3/s
EQS (mg/l)	***6 - 9***	***-***	***-***	***5***	***10***	***2,100***	***150***	***-***	***-***	***4.5 - 8***	***50***	***200***	***0.5***	***0.05***	***0.1***	***600***	
Savar																	
SAV-01	7.80	0.11	3.24	3.35	0.4	2041	33	1.52	429.0	**1.21**	**245**	**359**	0.136	**0.089**	22.5	11	0.067
SAV-02	6.89	0.01	1.29	1.30	0.3	1123	51	0.81	269.0	**0.70**	**275**	**398**	0.131	**0.090**	7.0	18	0.056
SAV-03	7.05	0.03	4.77	4.80	0.4	941	44	1.22	330.0	**0.37**	**115**	177	0.142	**0.089**	<1	15	0.045
SAV-04	8.10	0.14	1.99	2.13	0.3	671	27	1.78	179.0	**0.50**	48	86	0.152	0.004	5.7	114	0.035
Tejgaon																	
ABR-01	6.92	0.07	15.06	**15.13**	0.3	466	149	18.94	35.3	**1.63**	**145**	**216**	0.225	0.012	22.9	63	1.519
SGM-01	6.58	0.05	22.80	**22.85**	0.3	435	**251**	20.50	37.5	**1.89**	**320**	**457**	0.156	0.003	1.5	96	3.058
MKP-01	6.74	0.01	2.69	2.70	0.4	907	138	12.04	138.0	**5.51**	**240**	**345**	0.159	0.002	5.3	240	0.067
Tongi																	
TON-01	6.47	0.03	19.52	**19.55**	0.6	780	17	11.73	4.2	**0.40**	**550**	**752**	0.154	0.003	7.0	90	0.018
TON-02	6.75	0.02	2.02	2.04	0.4	368	137	12.42	2.7	**3.20**	**200**	**284**	0.156	0.002	<1	25	0.100
TON-03	6.80	0.02	6.50	**6.52**	0.4	919	**190**	10.64	179.0	**0.50**	**400**	**578**	0.176	0.004	14.0	130	0.198

Sample ID	P^H	NH_3-N	NH_4^+-N	T. Ammonia	NO_3-N	TDS	TSS	PO_4^{3-}	SO_4^{2-}	DO	BOD_5	COD	Cr	Cd	Pb	Cl^-	Discharge
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	mg/l	m^3/s
EQS (mg/l)	***6 - 9***	***-***	***-***	***5***	***10***	***2,100***	***150***	***-***	***-***	***4.5 - 8***	***50***	***200***	***0.5***	***0.05***	***0.1***	***600***	
TON-04	7.15	0.07	9.03	**9.10**	2.2	896	35	11.05	208.0	**0.79**	**68**	112	0.168	0.003	<1	170	0.370
TON-05	9.00	0.90	1.65	2.55	0.8	1692	100	0.80	71.0	**0.30**	**240**	**352**	0.200	0.003	<1	**960**	0.050
DEPZ/Ashulia																	
NKD-01	7.46	0.08	4.90	4.98	0.4	1247	142	10.57	322.0	**0.40**	**190**	**282**	0.194	0.003	17.0	153	1.270
SKD-01	7.47	0.10	5.90	**6.00**	0.2	1333	87	13.71	323.0	**0.50**	**130**	**203**	0.154	0.002	<1	155	0.181
EPZ-01	7.62	0.03	1.45	1.48	0.2	210	**190**	1.60	52.5	**0.60**	38	64	0.165	0.002	29.5	35	1.605
EPZ-02	7.20	0.01	1.31	1.32	0.7	98	**266**	0.95	14.6	5.30	**60**	95	0.128	0.004	20.2	18	2.333
EPZ-03	7.68	0.08	3.02	3.10	0.2	458	32	1.90	203.0	**0.20**	36	60	0.135	0.003	31.7	38	0.946
EPZ-04	**9.79**	1.02	0.30	1.32	0.3	**5003**	**295**	1.80	3250.0	**0.20**	**210**	**318**	0.152	0.005	<1	150	0.318
EPZ-05	7.75	0.09	2.86	2.95	0.1	1103	45	1.89	310.0	**0.30**	**240**	**355**	0.191	0.003	<1	225	0.633
Tarabo																	
TAR-01	**3.71**	0.00	10.25	**10.25**	0.2	1520	**1269**	170.30	125.0	**0.20**	**5700**	**7600**	0.174	0.006	17.9	230	0.049
TAR-02	7.33	0.18	15.37	**15.55**	0.3	1071	68	7.27	223.0	**1.04**	**130**	**204**	0.168	0.003	<1	250	0.712
TAR-03	7.04	0.04	7.13	**7.17**	0.3	750	102	6.34	66.0	**0.90**	**180**	**274**	0.159	0.004	<1	68	0.560
TAR-04	**9.05**	3.55	5.75	**9.30**	0.5	**2306**	111	3.77	740.0	**0.80**	**230**	**344**	0.171	0.004	<1	53	0.589

Sample ID	P^H	NH_3-N	NH_4^+-N	T. Ammonia	NO_3-N	TDS	TSS	PO_4^{3-}	SO_4^{2-}	DO	BOD_5	COD	Cr	Cd	Pb	Cl^-	Discharge
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	mg/l	m^3/s
EQS (mg/l)	***6 - 9***	***-***	***-***	***5***	***10***	***2,100***	***150***	***-***	***-***	***4.5 - 8***	***50***	***200***	***0.5***	***0.05***	***0.1***	***600***	
TAR-05	**9.16**	1.76	2.22	3.98	0.5	**2384**	104	2.17	258.0	**0.10**	**320**	**467**	0.152	0.004	<1	**1020**	0.050
Narayanganj																	
NAR-01	7.61	0.34	15.33	**15.67**	0.3	593	143	4.29	57.3	**0.20**	**140**	**218**	0.149	0.003	88.6	96	0.193
NAR-02	8.02	0.44	7.67	**8.11**	0.2	1021	53	5.12	186.0	**0.10**	**65**	108	0.146	0.002	4.5	240	2.110
NAR-03	7.66	0.18	7.36	**7.54**	0.2	533	56	4.77	56.6	**0.20**	50	83	0.135	0.003	18.8	110	5.830
NAR-04	7.51	0.06	3.64	3.70	1.0	857	**1065**	1.23	130.0	**0.30**	**1150**	**1608**	0.154	0.004	26.5	23	0.150
NAR-05	8.42	0.49	3.36	3.85	0.4	447	39	2.92	28.7	**1.10**	42	70	0.135	0.003	<1	132	0.500
NAR-06	8.81	2.61	7.36	**9.97**	0.2	1230	119	2.45	224.0	**0.20**	**120**	197	0.166	0.003	<1	450	1.800
NAR-07	7.74	0.02	0.50	0.52	0.2	672	124	8.32	45.3	**0.10**	**115**	187	0.152	0.004	2.9	98	0.650
Gazipur																	
GAZI-01	7.14	0.04	5.08	**5.12**	0.6	346	90	3.79	41.2	**3.90**	**260**	**388**	0.163	0.003	0.9	41	0.015
GAZI-02	7.63	0.05	2.06	2.11	0.2	809	42	1.59	223.0	**0.20**	**110**	174	0.146	0.005	<1	205	3.729
GAZI-03	8.70	0.25	0.92	1.17	0.3	376	85	0.40	76.9	**1.70**	**55**	98	0.310	0.006	<1	26	0.230
GAZI-04	7.25	0.01	1.45	1.46	1.4	379	62	0.66	105.0	**4.28**	23	43	0.064	0.005	<1	23	0.490
Ghorasal																	

Sample ID	P^H	NH_3- N	NH_4^+- N	T. Ammonia	NO_3- N	TDS	TSS	PO_4^{3-}	SO_4^{2-}	DO	BOD_5	COD	Cr	Cd	Pb	Cl^-	Discharge
		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	mg/l	m^3/s
EQS (mg/l)	***6 - 9***	***-***	***-***	***5***	***10***	***2,100***	***150***	***-***	***-***	***4.5 - 8***	***50***	***200***	***0.5***	***0.05***	***0.1***	***600***	
GHO-01	**9.63**	138.44	59.06	**197.50**	**14.9**	288	6	1.38	110.0	**3.00**	25	50	0.154	0.003	13.8	190	0.720
GHO-02	7.46	0.02	1.43	1.45	0.3	723	**749**	0.92	191.0	**0.10**	**500**	**742**	0.160	0.004	15.5	100	0.170
GHO-03	7.82	0.03	0.89	0.92	0.6	133	**267**	0.28	40.0	**3.60**	**150**	**234**	0.143	0.003	3.0	15	0.150
Hazaribagh																	
HAZ-01	7.15	0.24	30.31	**30.55**	0.4	535	74	11.02	29.0	**1.37**	**100**	173	0.179	0.003	38.1	120	0.250
HAZ-02	6.93	0.32	68.60	**68.92**	0.4	**2230**	**717**	19.30	588.0	**0.05**	**950**	**1314**	**30.670**	0.005	16.1	**1020**	1.100
HAZ-03	6.67	0.06	24.71	**24.77**	0.5	532	**294**	11.39	36.0	**0.85**	**370**	**598**	0.430	0.004	23.1	116	0.450

Annex- E: BOD Loadings of Industrial and Domestic Effluent

Outfall-wise BOD Loadings and Separation of those into Industrial and Domestic Sources

Cluster	Outfalls	Q outfall (m3/s) [measured]	BOD at outfall (mg/l) [measured]	Duration of domestic discharge [estimated]	Q dom. at outfall [calculated]	Q ind. at outfall [calculated]	Outfall Load (kg/day) [calculated]	Effluent Load from Ind. (kg/day) [calculated]	Effluent Load from Dom. (kg/day) [calculated]	Total flow from outfall (m3/day) [calculated]	Industry		Domestic	
											Industrial BOD Concentration (mg/l) [calculated]	Industrial Effluent (m3/day) [calculated]	Domestic BOD Concentration (mg/l) [estimated]	Domestic Effluent (m3/day) [estimated]
Tongi	TON-01	0.018	550	16	0.000	0.018	428	428	-	778	550	778	0	-
	TON-02	0.100	200	16	0.056	0.044	1,065	262	803	5,123	137	1,912	250	3,211
	TON-03	0.198	400	16	0.111	0.087	3,823	2,217	1,605	10,159	593	3,737	250	6,422
	TON-04	0.370	68	16	0.044	0.326	1,245	612	633	16,617	43	14,085	250	2,533
	TON-05	0.050	240	16	0.022	0.028	599	278	321	2,481	232	1,197	250	1,284
Savar	SAV-01	0.067	245	16	0.024	0.043	795	451	344	3,238	242	1,863	250	1,376
	SAV-02	0.056	275	16	0.000	0.056	665	665	-	2,419	275	2,419	0	-
	SAV-03	0.045	115	16	0.000	0.045	224	224	-	1,944	115	1,944	0	-
	SAV-04	0.035	48	16	0.000	0.035	73	73	-	1,512	48	1,512	0	-
Narayanganj	NAR-01	0.193	140	16	0.045	0.148	1,330	680	649	8,987	106	6,390	250	2,596
	NAR-02	2.110	65	16	0.000	2.110	5,925	5,925	-	91,152	65	91,152	0	-
	NAR-03	5.830	50	16	0.480	5.350	14,320	7,410	6,911	258,767	32	231,124	250	27,642
	NAR-04	0.150	1150	16	0.000	0.150	7,452	7,452	-	6,480	1150	6,480	0	-
	NAR-05	0.500	42	16	0.033	0.467	1,025	554	471	22,071	27	20,186	250	1,885

Cluster	Outfalls	Q outfall (m3/s) [measured]	BOD at outfall (mg/l) [measured]	Duration of domestic discharge [estimated]	Q dom. at outfall [calculated]	Q ind. at outfall [calculated]	Outfall Load (kg/day) [calculated]	Effluent Load from Ind. (kg/day) [calculated]	Effluent Load from Dom. (kg/day) [calculated]	Total flow from outfall (m3/day) [calculated]	Industry		Domestic	
											Industrial BOD Concentration (mg/l) [calculated]	Industrial Effluent (m3/day) [calculated]	Domestic BOD Concentration (mg/l) [estimated]	Domestic Effluent (m3/day) [estimated]
	NAR-06	1.800	120	16	0.033	1.767	9,449	8,978	471	78,231	118	76,346	250	1,885
	NAR-07	0.650	115	16	0.082	0.568	3,524	2,346	1,178	29,258	96	24,546	250	4,712
Ghorasal	GHO-01	0.720	25	16	0.000	0.720	778	778	-	31,104	25	31,104	0	-
	GHO-02	0.170	500	16	0.000	0.170	3,672	3,672	-	7,344	500	7,344	0	-
	GHO-03	0.150	150	16	0.000	0.150	972	972	-	6,480	150	6,480	0	-
Tarabo	TAR-01	0.049	5700	16	0.000	0.049	12,066	12,066	-	2,117	5700	2,117	0	-
	TAR-02	0.712	130	16	0.000	0.712	3,999	3,999	-	30,758	130	30,758	0	-
	TAR-03	0.560	180	16	0.000	0.560	4,355	4,355	-	24,192	180	24,192	0	-
	TAR-04	0.589	230	16	0.000	0.589	5,852	5,852	-	25,445	230	25,445	0	-
	TAR-05	0.050	320	16	0.000	0.050	691	691	-	2,160	320	2,160	0	-
DEPZ	EPZ-01	1.605	38	16	0.000	1.605	2,635	2,635	-	69,336	38	69,336	0	-
	EPZ-02	2.333	60	16	0.000	2.333	6,047	6,047	-	100,786	60	100,786	0	-
	EPZ-03	0.946	36	16	0.000	0.946	1,471	1,471	-	40,867	36	40,867	0	-
	EPZ-04	0.318	210	16	0.000	0.318	2,885	2,885	-	13,738	210	13,738	0	-
	EPZ-05	0.633	240	16	0.000	0.633	6,563	6,563	-	27,346	240	27,346	0	-
	NKD-01	1.270	190	16	0.000	1.270	10,424	10,424	-	54,864	190	54,864	0	-

Cluster	Outfalls	Q outfall (m3/s) [measured]	BOD at outfall (mg/l) [measured]	Duration of domestic discharge [estimated]	Q dom. at outfall [calculated]	Q ind. at outfall [calculated]	Outfall Load (kg/day) [calculated]	Effluent Load from Ind. (kg/day) [calculated]	Effluent Load from Dom. (kg/day) [calculated]	Total flow from outfall (m3/day) [calculated]	Industry		Domestic	
											Industrial BOD Concentration (mg/l) [calculated]	Industrial Effluent (m3/day) [calculated]	Domestic BOD Concentration (mg/l) [estimated]	Domestic Effluent (m3/day) [estimated]
	SKD-01	0.181	130	16	0.000	0.181	1,016	1,016	-	7,819	130	7,819	0	-
Gazipur	GAZI-01	0.015	260	16	0.000	0.015	168	168	-	648	260	648	0	-
	GAZI-02	3.729	110	16	0.000	3.729	17,720	17,720	-	161,093	110	161,093	0	-
	GAZI-03	0.230	55	16	0.000	0.230	546	546	-	9,936	55	9,936	0	-
	GAZI-04	0.490	23	16	0.000	0.490	487	487	-	21,168	23	21,168	0	-
Hazaribag	HAZ-01	0.250	100	16	0.060	0.190	1,296	432	864	11,664	53	8,208	250	3,456
	HAZ-02	1.100	950	16	0.410	0.690	46,620	40,717	5,903	53,423	1366	29,811	250	23,612
	HAZ-03	0.450	370	16	0.185	0.266	7,857	5,200	2,657	22,097	453	11,470	250	10,627
Norai Khal	N. Khal	4.644	262	20	0.990	3.654	59,611	41,791	17,820	229,133	265	157,853	250	71,280

BOD Loadings at Other Outfalls Carrying Domestic Wastewater

Cluster	Outfalls	Duration of domestic discharge [estimated]	Q dom. at outfall [calculated]	Q ind. at outfall [calculated]	Outfall Load (kg/day) [calculated]	Effluent Load from Ind. (kg/day) [calculated]	Effluent Load from Dom. (kg/day) [calculated]	Total flow from outfall (m3/day) [calculated]
Domestic Outfall	S-3	20	0.745	0.000	1,073	-	1,073	53,640
Domestic Outfall	S-4	16	0.370	0.000	2,515	-	2,515	21,312
Domestic Outfall	S-5	16	0.223	0.000	861	-	861	12,845
Domestic Outfall	S-6	20	0.923	0.000	7,044	-	7,044	66,456
Domestic Outfall	S-10	16	0.086	0.000	3,155	-	3,155	4,954
Domestic Outfall	S-11	20	0.500	0.000	8,316	-	8,316	36,000
Domestic Outfall	Dholai khal	20	0.500	0.000	31,140	-	31,140	36,000
Domestic Outfall	Pagla STP Outfall	24	0.550	0.000	15,064	-	15,064	47,520

Cluster	Outfalls	Duration of domestic discharge [estimated]	Q dom. at outfall [calculated]	Q ind. at outfall [calculated]	Outfall Load (kg/day) [calculated]	Effluent Load from Ind. (kg/day) [calculated]	Effluent Load from Dom. (kg/day) [calculated]	Total flow from outfall (m3/day) [calculated]
Domestic Outfall	Kalibazar khal	16	0.052	0.000	970	-	970	2,995
Domestic Outfall	KB-1	20	0.500	0.000	1,440	-	1,440	36,000
Domestic Outfall	KB-2	20	0.500	0.000	900	-	900	36,000
Domestic Outfall	Tongi-1	16	0.050	0.000	1,688	-	1,688	2,880
Domestic Outfall	Tongi-4	16	0.050	0.000	1,688	-	1,688	2,880

Annex- F: Comparative Analysis of Cluster

Comparative Analysis of Cluster

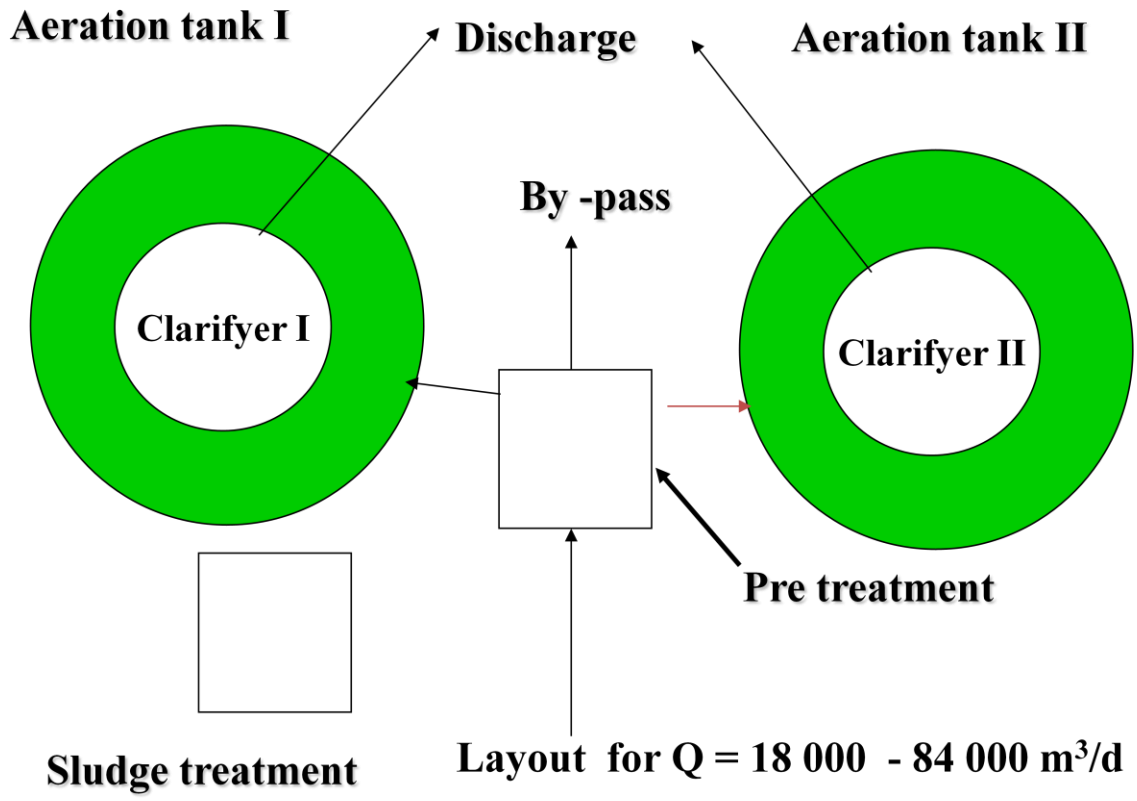
Parameters	Preferred Rating	Tongi I	Tongi II	Tongi III	Narayanganj I	Narayanganj II	Narayanganj III	Narayanganj IV	Ghorashal	Gazipur	SavarI	Savar II	Tarabo
Delineation of area	Yes	Yes	Unclear	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry density	High	Low	Low	Low	Medium	High	High	Low	Low	High	Low	Medium	Low
Water quality impacts	High	Medium	Low	Medium	Low	Low	Low	Low	Medium	Low	Low	Low	Low
Other direct impacts	High	High	High	High	Low	Low	Low	Low	High	High	High	High	Low
Homogeneity of effluent	Yes	No	No	No	No	Yes	Yes	No	No	Yes	No	Yes	Yes
Land for CETP	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Options for pre-treatment	Yes	No	No	Yes	No	Yes	No	Yes	Yes	Yes	No	Yes	No
Type of drainage and distance from river	Low	Low	High	High	Low	Low	Low	Low	High	High	Medium	High	High
History of conflicts / disputes	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	No	Yes
Resettlement issues	No	No	Yes	Yes	No	No	No	No	No	No	Yes	No	No
Disruption during construction	No	Yes	Yes	No	Yes	No	No	No	No	No	No	No	No

Annex- G: Alternative Treatment Options

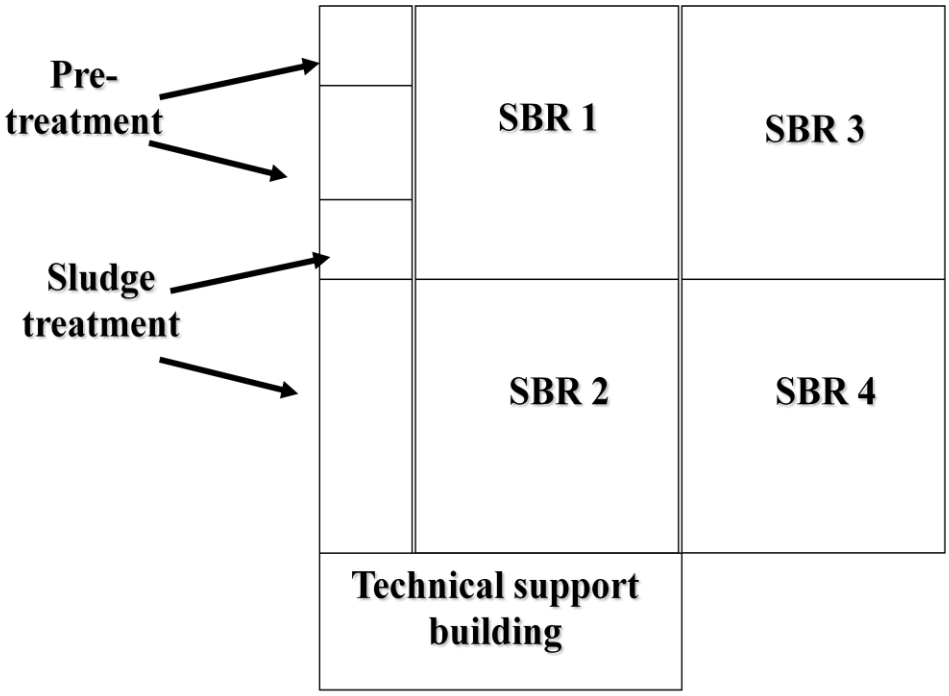
Possible treatment options for Gazipur

1. Extended aeration (Oxidation Ditch);
2. Sequencing Batch Reactor (SBR) system;
3. Dual power aerated lagoons;
4. Anaerobic reactors + polishing aerated lagoon;
5. Trickling filters + Chemical precipitation;
6. Chemical precipitation

Extended Aeration Model (Oxidation Ditch)

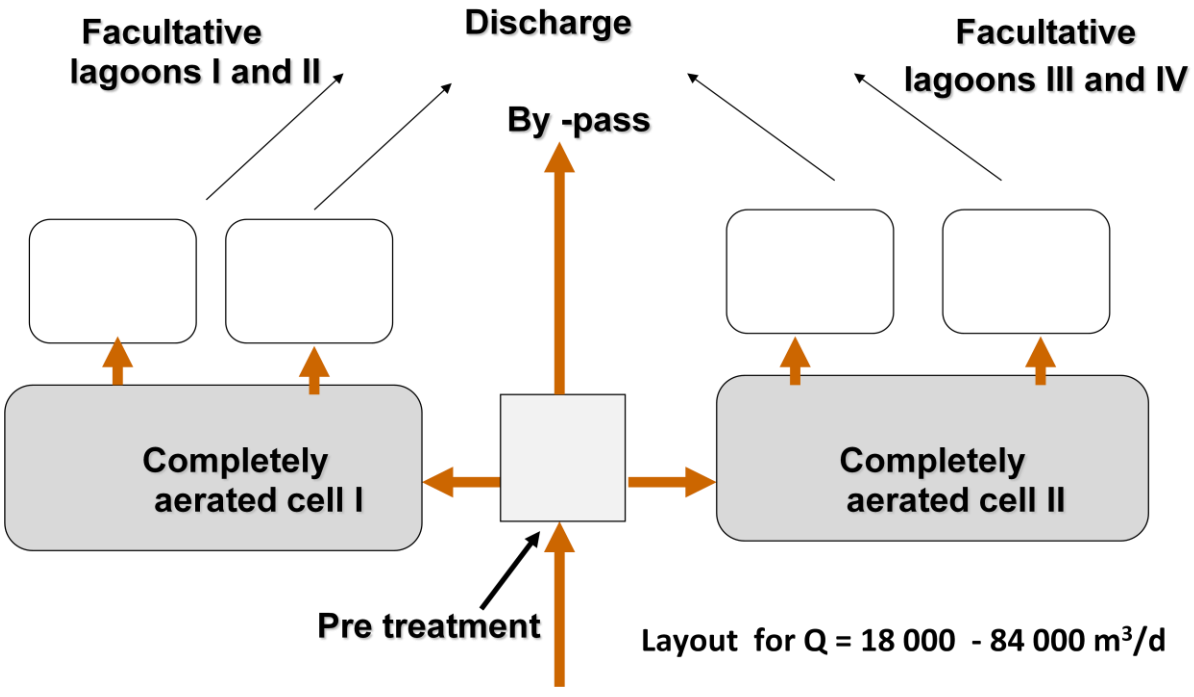


SBR system



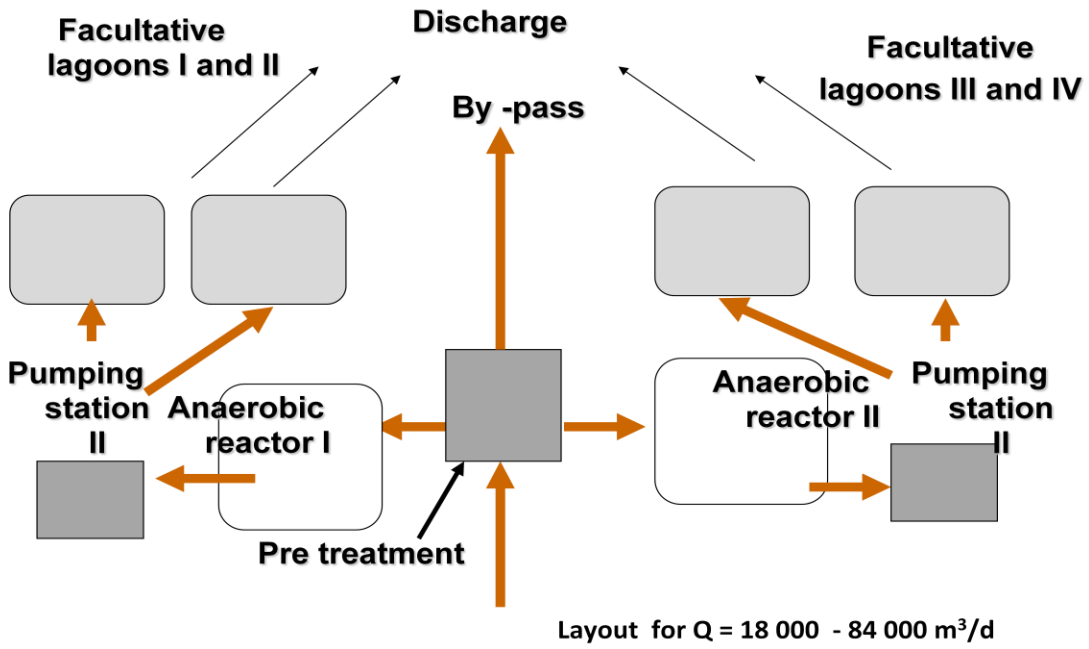
Layout 18 000 – 84 000 m^3/d

Dual Power Aerated Lagoon System



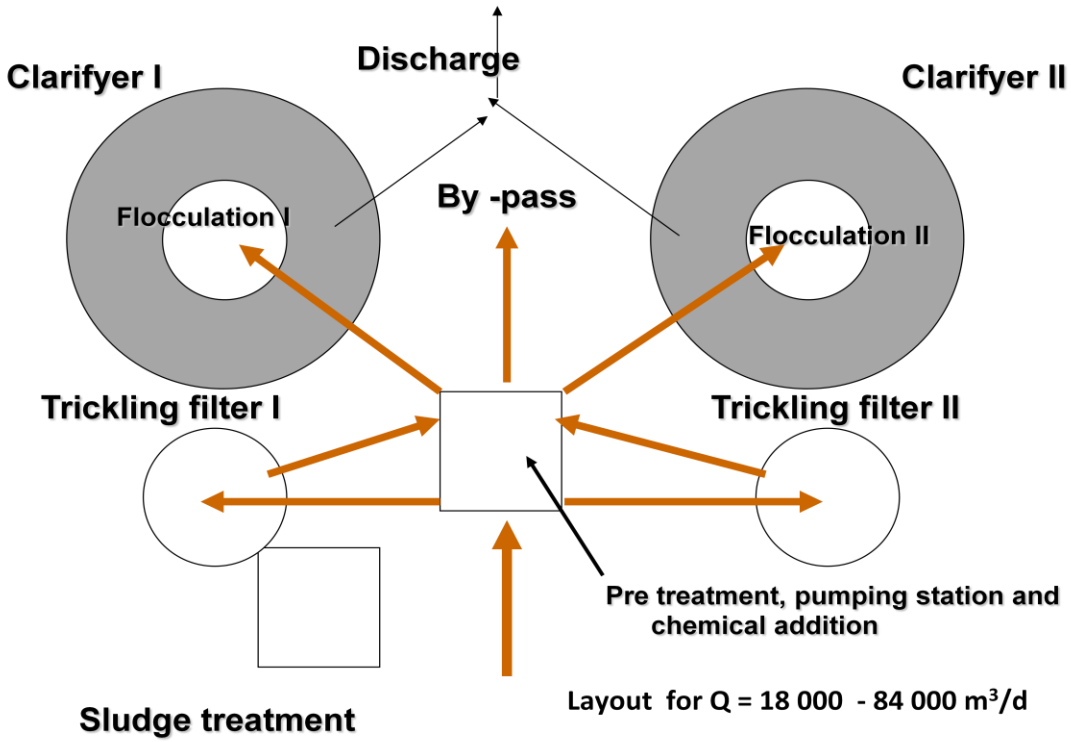
Layout for Q = 18 000 - 84 000 m^3/d

Anaerobic Reactors + Aerated Lagoon System



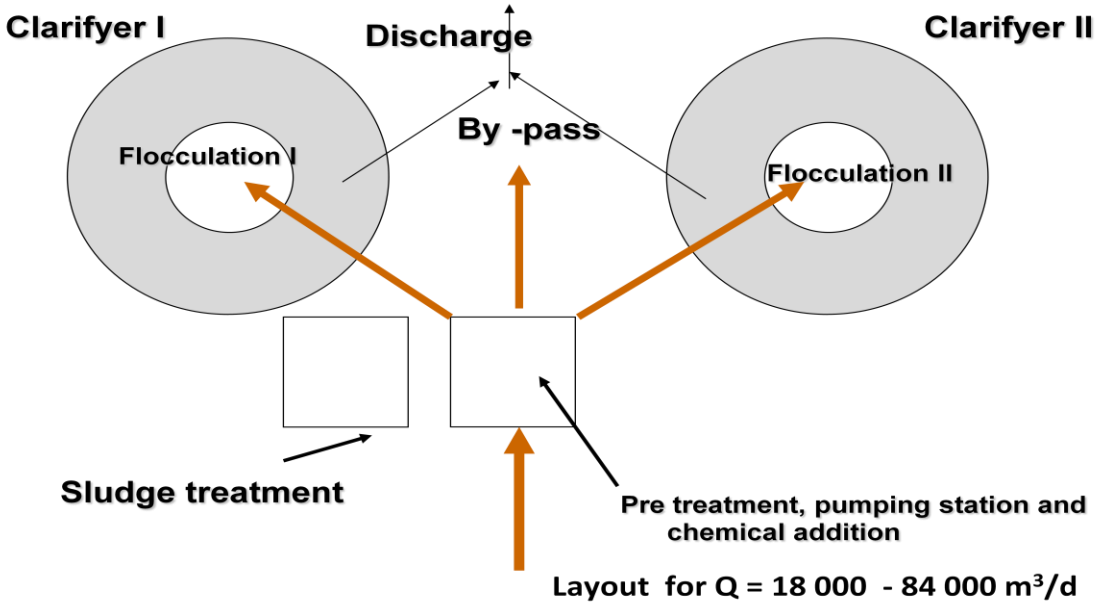
Layout for Q = 18 000 - 84 000 m^3/d

Trickling Filter + Chemical Precipitation System

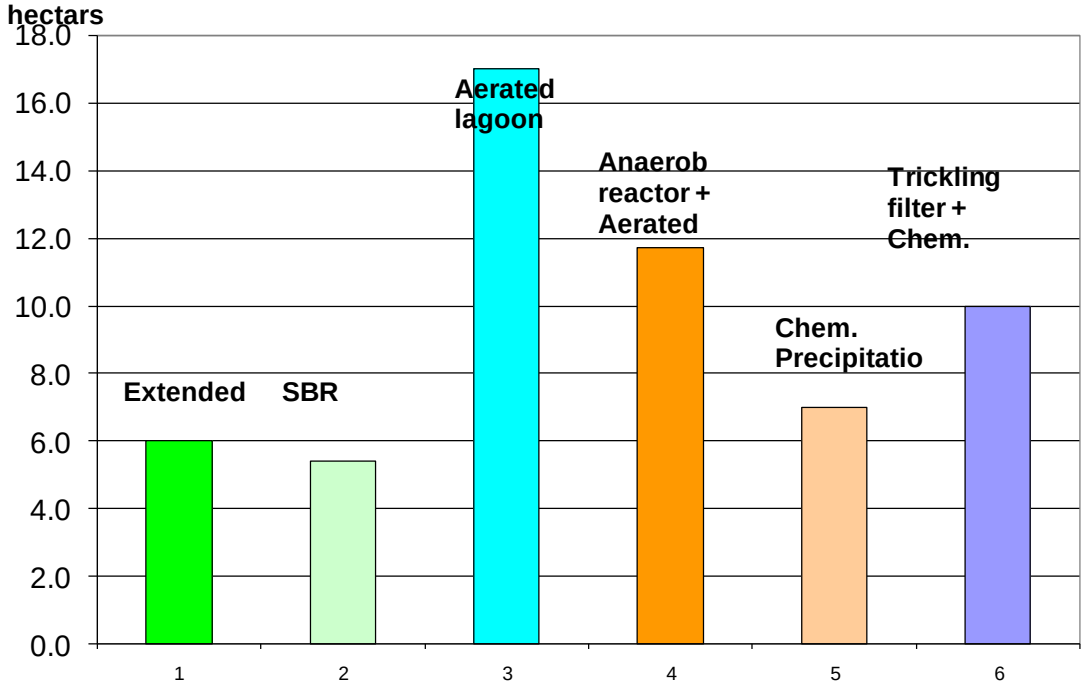


Layout for Q = 18 000 - 84 000 m^3/d

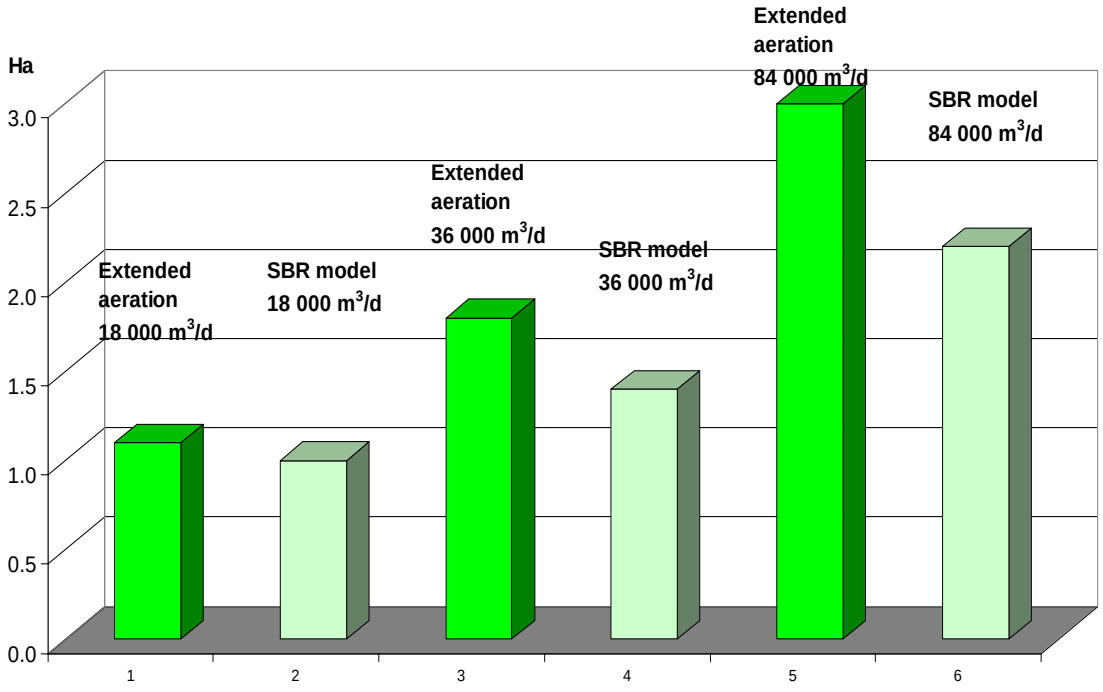
Chemical Precipitation System



Gazipur CETP Q = 36 000 m^3/d, Land Area Needed for Six Treatment Options



Gazipur CETP Q = 18 000, 36 000 and 84 000 m^3/d, Land Area Needed for Two Treatment Options, with Mech. Sludge Dewatering



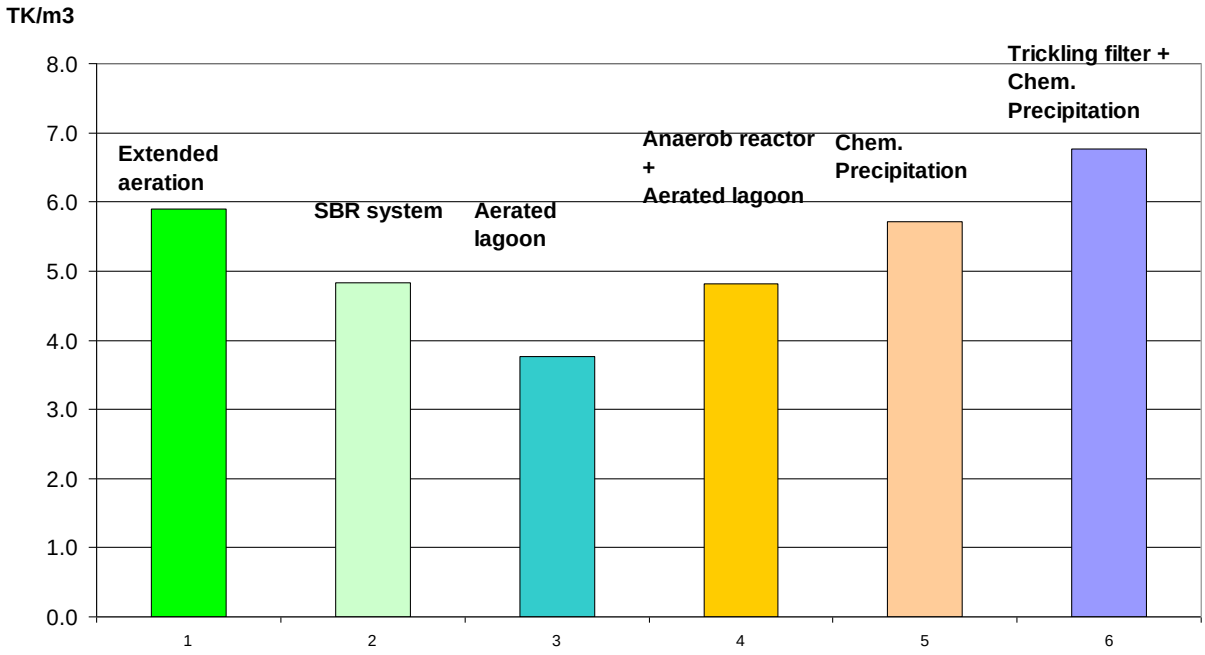
Gazipur CETP, Investment Estimates for Six Treatment Options 36 000 m^3/d

1. Extended aeration (Oxidation Ditch) 43 M US$
2. SBR (Sequencing Batch Reaction system 37 M US$
3. Dual power aerated lagoons 39 M US$
4. Anaerobic reactors + aerated lagoon 43 M US$
5. Trickling filters + Chemical precipitation 37 M US$
6. Chemical precipitation 27 M US$

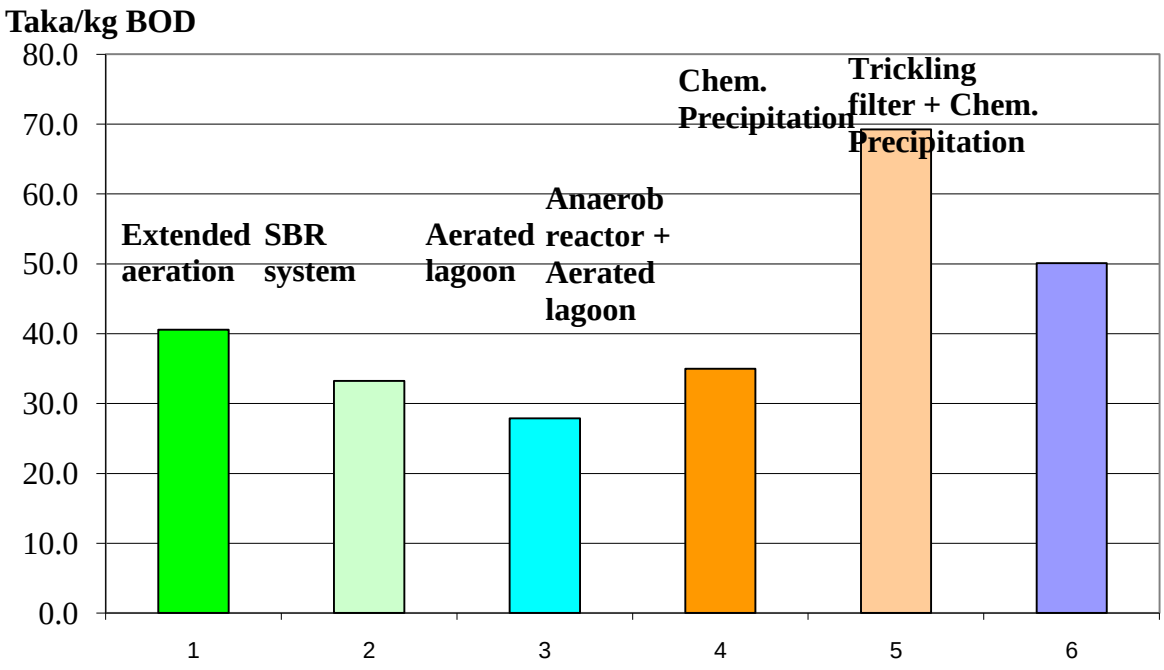
Gazipur CETP, Annual Operation Cost Estimates for Six Treatment Options 36 000 m^3/d

1. Extended aeration (Oxidation Ditch) 1,125,000 US$
2. SBR system 920,000 US$
3. Dual power aerated lagoons 720,000 US$
4. Anaerobic reactors + aerated lagoon 917,000 US$
5. Trickling filters + Chemical precipitation 1,290,000 US$
6. Chemical precipitation 1,090,000 US$

Gazipur CETP, 36 000 m^3/d, Specific Operation Cost Efficiency, Taka/$m^3_{treated}$



Gazipur CETP, 36 000 m^3/d, Specific Operation Cost Efficiency, Taka/kg $BOD_{removed}$



Annex- H: Timeline for Environmental Assessment, Supervision and Monitoring

Timeline for Environmental Studies

Timeline	Responsibility	2011	2012	2013	2014	2015	2015
Task							
Industry Specific Environmental Screening/Assessment for 200 factories	Cleaner Production Consulting Firm						
CETP Environmental Assessment (EA)	Environment Assessment Consulting Firm						
Updating of EA based on Final Design	Design Build Operation Contractor						
Review of updated EA (Distributed over)	International Environment Specialist						
Supervision and Monitoring (Distributed over)	International Environment Specialist						
Supervision and Monitoring	National Environment Specialist						