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Design and Performance Evaluation of Wastewater Treatment Plant at Biratnagar Metropolitan City

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Abstract

Biratnagar metropolitan city (BMC) faced a significant issue caused by human activities: the discharge of untreated wastewater into water bodies. To address this problem, the city collaborated with the Government of Nepal (GoN) and the Asian Development Bank (ADB) to build a wastewater treatment facility having capacity of 18,490 m^3 per day. However, the plant is currently partially operational. Developed infrastructure for the treatment of wastewater reduced the environmental risk associated with health hazards. The main aim of this paper is to assess the design and performance evaluation of the same domestic wastewater treatment plant (WWTP). The WWTP comprised of diversion chamber, bar screen, sump well, oil and grease, three anaerobic ponds, three facultative ponds, and a sludge drying bed. The BOD and COD removal efficiency of plant during summer season was 74.66% and 93.65% respectively.Similarly during winter season BOD and COD removal efficiency of plant was 32.12% and 52.68% respectively.The treatment plant can be recommended for Private-Public Participation (PPP) for full-fledged operation and environment-friendly discharge of domestic wastewater.

Keywords

Waste water, Waste water treatment plant, Chemical oxygen demand, Biological oxygen demand, Biratnagar Metropolitan

1. Introduction

Wastewater is essentially the utilized water or liquid waste a community produces, including human and household waste and street cleaning water[1]. Wastewater refers to domestic (grey and black) water that is negatively impacted in quality by human activities. This wastewater is conveyed through a sewer system and then treated at a waste water treatment plant(WWTP). Sewage (black water) is the subset of wastewater contaminated with feces and urine[2].Wastewater treatment methods includes physical, chemical, and biological processes to remove insoluble particles and soluble contaminants from effluents[3].

1.1 The then Scenario of Sewerage

Biratnagar Metropolitan City lacked sewerage system and it was assumed that some 30% of the total population had pit latrines, and about 15% of them had septic tanks. Due to insufficient toilets Open defecation along river banks and farmland were common. Raw sewage and outfalls from the hospitals were disposed directly into Singhiya Khola . The water quality of these streams got extremely polluted by both human activity and industrial discharges upstream[4].

1.2 Wastewater Characteristics

The pH of the wastewater is in the range of 7.36 to 7.88, indicating the alkaline nature of the wastewater. The wastewater also contains many suspended, dissolved, and settle-able solids. Oil and grease are present in a smaller amount than the usual value of 50-150 mg/l. The Biochemical oxygen demand (BOD) was found to vary from 154.43 to 239.76 mg/l, with the average value being 180.68 mg/l indicating medium to strong characteristics of raw domestic wastewater. Hence, the biochemical oxygen demand (BOD) of raw wastewater has been adopted as 250 mg/l for the design of the wastewater treatment plant [4].

1.3 Effluent Sewage Discharge Quality Standard

It must be made mandatory for all such polluting sources to have their own treatment plants and treat with requisite treatment processes as per the generic standards set by the Ministry of Science, Technology, and Environment, Government of Nepal, before its release into the environment or in the public storm/sewer drain system or its reuse Acts. Biochemical oxygen demand (BOD) is the most widely used water quality parameter to indicate its suitability for disposal into the water course.The biological treatment unit consisting of anaerobic and facultative ponds is mainly responsible for the removal of the BOD during wastewater treatment. There is a guideline available for the

Table 1: Reference Standard Value of effluent discharge quality at WWTP Biratnagar

Test	Standard Value
Temperature (°C)	<40
PH	6.5 to 9.0
Electrical Conductivity (µs/cm)	100 to 1500
Turbidity (NTU)	<10
TDS (mg/l)	<1000
TSS (mg/l)	<100
Fe (mg/l)	<2
As (mg/l)	<0.2
COD (mg/l)	<250
BOD (mg/l)	<50

effluent standards concerning (BOD and TSS) for discharging to the receiving body. Other effluent standards such as E. coli, phosphorous, and nitrogen (TKN) are not available because of the scope of the Project. However, the effluent concentration levels may be stated as in Table 1.

1.4 Description of Available Treatment Process

There are numerous types of treatment processes for treating wastewater. No single process will suit all circumstances, and the combination of systems that will provide the desired treatment at minimum cost and with maximum reliability should be selected. The various treatment options of wastewater treatment are presented in Figure 1.

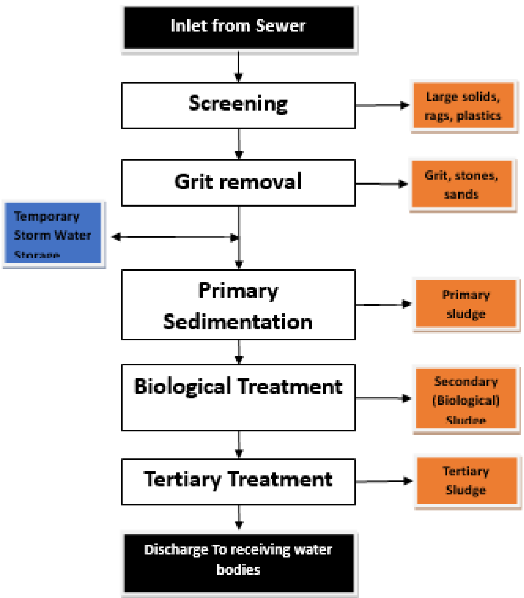

Figure 1: Typical wastewater treatment process

2. Objective

The objectives of the study are:

- To assess the design criteria of the Wastewater treatment plant(WWTP).
- To evaluate the removal efficiency of different components of Wastewater treatment plant (WWTP).

3. Methodology

3.1 Study Area

A separate sewerage system (three trunk sewers)was constructed and collector sewers were provided on either side of the road to pick up house connections. The length of collector sewers was normally 4 or 5 times the length of trunk sewers and 5,900 households connections.

3.2 Service Area

The socio-economic part covers the low economic level of the people and the ethnic community residing in the area. The sewerage and storm-water drainage improvement sub-project are limited to parts of Jatuwa, only covering an area of 10 ha. Three trunk sewers running along the main roads discharging the sewage to the Singhiya River on the east, after treatment, serve as the main service area of Biratnagar.

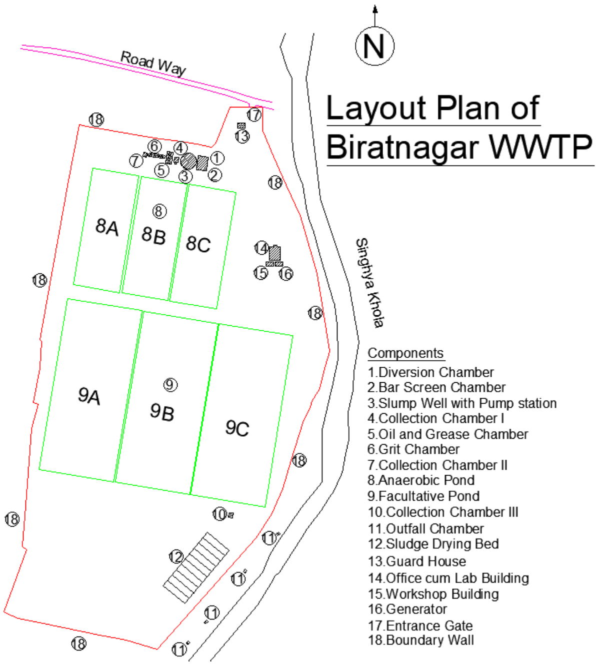

Figure 2: Layout of WWTP at BMC [5]

Figure 3: Aerial view of built up WWTP at BMC [6]

3.3 Design Criteria

The components of WWTP consists of bar screen, oil and grease chamber, grit chamber, sump well, waste stabilization ponds consisting of anaerobic and facultative ponds, and sludge drying bed. Treated wastewater is being discharged into Singhiya Khola, through effluent sewer.The amount of household wastewater is determined by using a water supply rate of 90 liters per person per day in the year 2035, with 80% of it being converted into wastewater.The maximum amount of wastewater is calculated by taking a peak factor of 1.99 to 2.5. The minimum amount of sewage is taken as 30% of the average amount. The amount of commercial, institutional, and industrial wastewater is calculated to be 0.10 LPS/ha, while infiltration is calculated to be 0.14 LPS/ha in the year 2035. In the year 2035, the total amount of commercial, institutional, and industrial wastewater and infiltration is estimated to be 237.79 LPS, which is larger than the amount of household wastewater, which is 207.18 LPS. The maximum amount of wastewater in the year 2035 for both Phase I and Phase II is estimated to be 650.08 LPS. The maximum amount of wastewater for Phase I is estimated to be 213.97 LPS, and the Phase I WWTP has a capacity of 214 LPS. The Phase II WWTP will have a capacity of 436 LPS.A WWTP has been built, which discharges treated sanitary sewage into Singhya River. The plant does not treat storm water.The WWTP proposed at Jatuwa comprises of various components as shown in Figure 4.

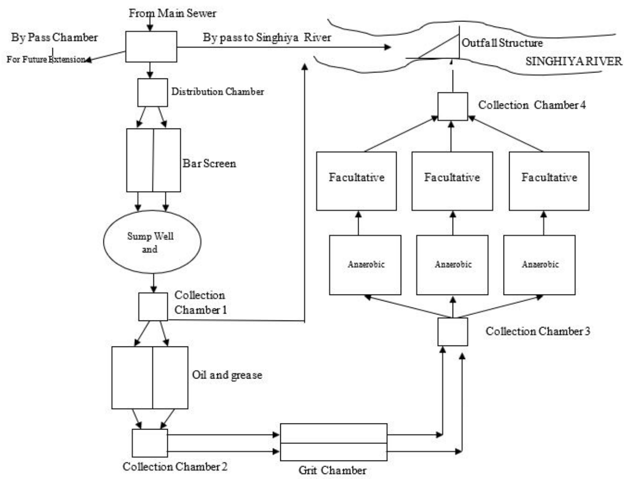

Figure 4: Schematic diagram showing salient features of WWTP

3.3.1 Geometric Sizing of Wastewater Treatment Plant

The selection of the wastewater treatment processes depends on the characteristics of raw wastewater, type of effluent required, land requirement and availability, degree of treatment required, cost of the treatment plant, operation and maintenance costs, the potential demand for reuse of effluent for irrigation or industry, options for the location of disposal of the effluent, the complexity of the process and equipment with reference to operation and maintenance, etc. There are numerous types of treatment processes for treating waste water. No single process will suit all circumstances, and the combination of systems that will provide the desired treatment at minimum cost and with maximum reliability should be selected. The geometric sizing of the various components of WWTP has been calculated based on hydraulic process design considerations and the design criteria.

Table 2: WWTP components and the dimensions [7]

S.N.	WWTP Component	Number	Length (m)	Diameter (m)	Width (m)	Total Depth (m)
1	By Pass Chamber	1		3		5.6
2	Distribution Chamber	1	3		2.5	1.97
3	Bar Screen	2	3		0.55	0.75/0.9
4	Sump Well with Pumping	2	6		10	3.35
5	Collection Chamber 1	1	3		3	1.5
6	Oil and Grease Chamber	2	5.4		4.8	1.6
7	Collection Chamber 2 (Attached to Grit Chamber)	1	2.4		2.2	1.41
8	Grit Chamber (Including Collection Chamber-1)	2	14.4		1.1	1.71/2.07
9	Collection Chamber 3	1	3.5		3	1.75
10	Anaerobic Pond (at mid depth)	3	96		32	4.5
11	Facultative Pond (at mid depth)	3	142.75		55.75	3.3
12	Collection Chamber 4 (with Straight overflow weir depth)	1	3.7		2.5	2
13	Outfall Structure	1	1.42		1	
14	Sludge drying bed	10	25		6	0.45

Table 3: Waste water Capacity of WWTP [7]

S.N.	Parameter	Phase I	Phase II	Total
1	Population coverage	96433	152182	248615
2	Area coverage (ha)	598.69	392.07	990.76
3	Domestic wastewater quantity (lps)	62.69	144.79	207.18
4	Commercial/Institutional/Industrial wastewater quantity (lps)	41.91	57.17	99.08
5	Infiltration quantity (lps)	47.90	90.81	138.71
6	Total wastewater quantity (lps)	152.20	292.77	444.97
7	Peak flow (lps)	213.97	436.11	650.08
8	Adopted peak flow (lps)	214.00	436.00	650.00

3.3.2 Electro-Mechanical Works

The design and installation of electrical equipment are in accordance with the Regulations for the Electrical Equipment of Buildings of the Standard as prevailed in Nepal . The design of the Electro-mechanical Components of the treatment plant consists of the following:

(i) Mechanical Screen

There is one mechanical screen in operation and another manual screen on standby with a clear spacing of 30 mm and a capacity to handle peak flows. The manual bar screens are made of Stainless Steel flats with a thickness of 10 mm. The mechanical screen is of the Vertical/Inclined Rake type with a 25 mm opening. There is a conveyor belt and chute arrangement to transport the screenings to a wheelbarrow for collection. CI gates, which are manually operated, are located at the upstream and downstream ends to regulate the flow. Adequate RCC platforms are available at the upper level to facilitate operations, and railings surround the entire perimeter of the platform.

(ii) Raw Sewage Pump

Raw sewage enters into Sump Well (Wet Well) after screening and grit removal. The sump is circular in shape with a detention capacity of 20 minutes at maximum flow. Five sets of Pump with automatic level switches have been installed.

(iii) Sludge transfer pump

The sludge accumulated in the bottom of three anaerobic ponds is carried out by raft mounted (boat or floating platform) in case other than manual removal and carting away. From ponds, sludge is pumped to drying beds located in the same premises.

4. Data Collection

During the study,the design, construction, and monitoring, along with the project completion report of WWTP, were studied. The WWTP site was visited to understand the component of WWTP. Interactions with the project manager and the lab in-charge officer of the WWTP project were done frequently.To analyze the quality of wastewater, test report provided by WWTP laboratory from different units of the treatment plant was taken.

The lab data collected includes various parameters such as temperature, pH, electrical conductivity (EC), turbidity, total dissolved solids (TDS), total suspended solids (TSS), chemical oxygen demand (COD), and biological oxygen demand (BOD). The Project Implementation Unit(PIU)of Biratnagar Metropolitan City for Implementation and Monitoring of the Secondary Towns Integrated Urban Environmental Improvement Project (STIUEIP) provided the data for the years 2020, 2021, and 2022 for the study of the wastewater treatment process. The test were conducted by the lab of WWTP in the table 4 format:

Table 4: Minimum frequencies of waste water quality monitoring for Lab Test [8]

WWTP Units	Minimum monitoring frequencies							
	Tempr (°C)	PH	EC µs/cm	Turbidity (NTU)	TDS mg/l	TSS mg/l	COD mg/l	BOD mg/l
Diversion Chamber(DC)	once in a week	once in a week	once in a week	once in a week	once in a week	once in a week	once in a week	once in a week
O/G Chamber								
Girt Chamber (GC)								
Anaerobic Pond(8A)								
Anaerobic Pond(8B)								
Anaerobic Pond(8C)								
Facultative Pond(9A)								
Facultative Pond(9B)								
Facultative Pond(9C)								
Out Fall Chamber								

5. Result and Discussion

The primary sources of wastewater in the wastewater treatment plant include urban waste from households. Sewer lines were constructed to collect sewer discharge from the community. Mainly average data of months of July,December and January of three consecutive years (2020,2021,2022)were taken and analyzed for seasonal variation of summer and winter.

5.1 Temperature:

Regarding temperature (as shown in Table 3),in the summer season, the sewage temperature was recorded at 32.42°C and 31.00°C at DC and Outfall Chamber.Similarly, in the winter season, the sewage temperature was recorded at 32.42°C and 31.00°C at DC and facultative pond (9C).Water temperature varies due to seasonal changes. The water temperature at different WWTP units were similar for the same season.

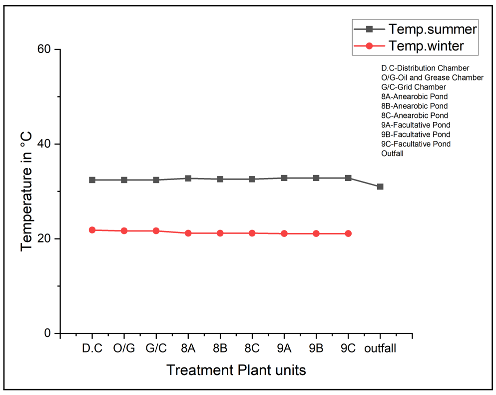

Figure 5: Temperature at different WWTP units

5.2 pH:

The pH level was highest in summer, reaching 8.48, 8.49, and 7.85, respectively, at the DC, O/G chamber, and outlet. However, in winter, the pH level remained at 8.40,7.35 at the DC and facultative pond (9C). Although the pH level at the inlet was alkaline, it remained within the range of the Standard Guidelines followed by WWTP Biratnagar.

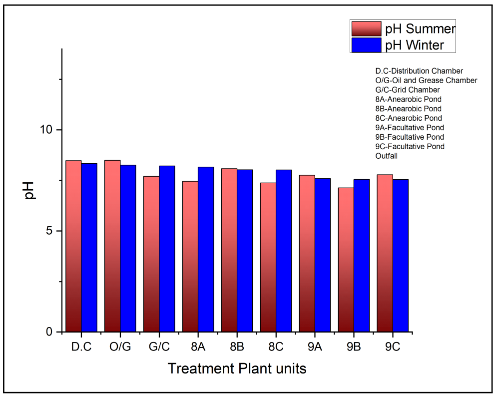

Figure 6: pH at different WWTP units

5.3 Electrical Conductivity:

In the winter season, EC was recorded to be 693.75 μm/cm and 449.08 μm/cm in DC and facultative pond(9C), respectively. Similarly, in the summer season, EC was recorded to be 681.83 μm/cm and 292.50 μm/cm in DC and outfall chamber.The EC values of both inlet and outlet are within the Guidelines followed by WWTP Biratnagar. Electrical conductivity represents the quantity of dissolved substances, chemicals, and minerals in less amount.

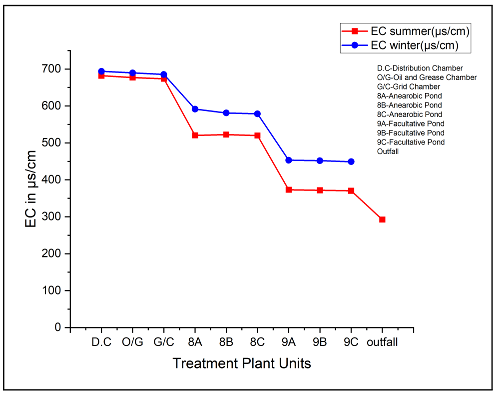

Figure 7: EC at different WWTP units

5.4 Turbidity:

The data shows that the maximum turbidity value at the DC occurred in summer, which was 62.58 NTU, according to Table 3. Conversely, the minimum turbidity value was recorded in summer at 5.55 NTU. Turbidity is an indication of the presence of suspended and colloidal substances from various sources in the water. During the rainy months, turbidity is high, possibly due to the inflow of organic and inorganic matter, including clay and sand, mixed with wastewater.

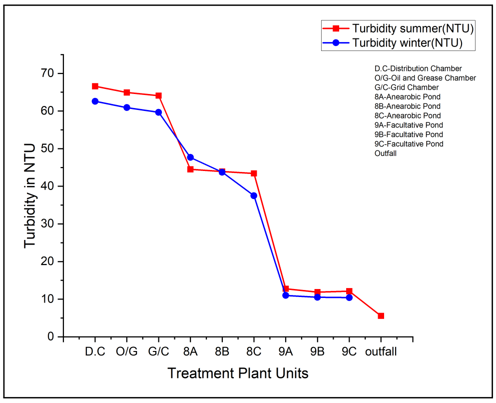

Figure 8: Turbidity at different WWTP units

5.5 TDS and TSS:

During the winter season, TDS was recorded to be 531.92mg/l and 362.83mg/l in DC and facultative pond(9C), respectively. Similarly, in the summer season, TDS was recorded to be 529.75mg/l and 129 mg/l in DC and outlet chamber, respectively.

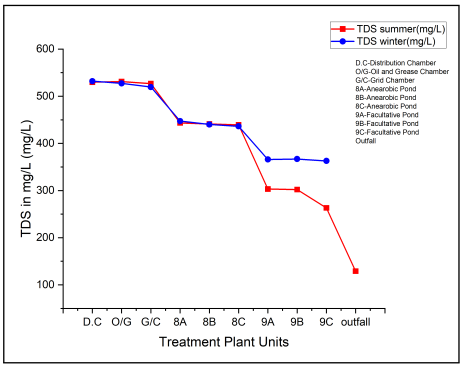

Figure 9: TDS at different WWTP units

Similarly, TSS was recorded as 98mg/l,43.75mg/l in winter, and 104.33mg/l,13.5mg/l in summer at inlet and outlets units, respectively.The TDS and TSS values of both inlet and outlet are within the Guidelines followed by WWTP Biratnagar.TSS has a significant impact on water clarity, and water with high TSS content represents less clear than water with lower TSS levels.

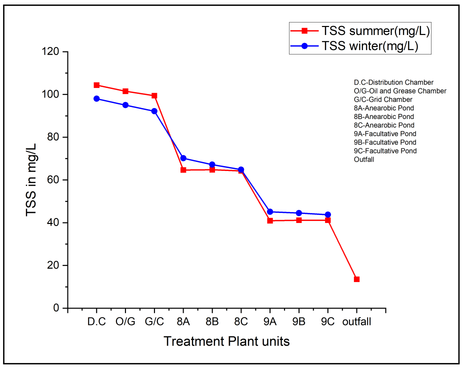

Figure 10: TSS at different WWTP units

5.6 Chemical Oxygen Demand

The average COD value at the inlet and outlet are 201mg/l and 60mg/l, respectively, in winter and 91.33mg/l and 5.8mg/l, respectively, in summer, which doesn't exceed the standard guidelines followed by WWTP Biratnagar . Similarly, the percentage reduction of the COD is 52.68% and93.65%during the winter and summer seasons respectively. The COD usually becomes high if the industry discharges the wastes containing large amounts of chemical compounds. The sources of COD at the Biratnagar wastewater treatment plant are only general households waste water . Hence the COD rate is less.

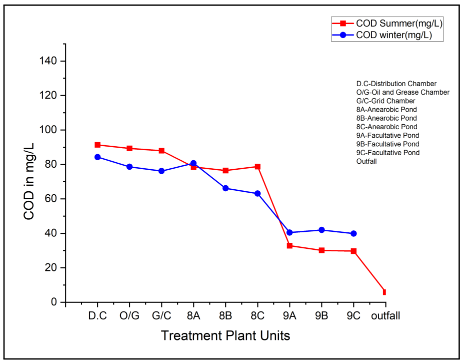

Figure 11: COD at different WWTP units

5.7 Biological Oxygen Demand

The average BOD value at the inlet and outlet is 14.60mg/l and 3.7mg/l in summer and 17.33mg/l and 11.77mg/l in winter respectively. The BOD value is high during the winter months and low in the rainy months. It is due to that in the rainy season, the amount of wastewater is high due to the addition of rainwater in the effluent, which increases the DO so that BOD is low in the rainy season. Similarly, the percentage reduction of the BOD is very high with an average of 32.12%and 74.66% in winter and summer respectively. When large amounts of sewage and different effluents with huge amounts of biodegradable wastes mixed with the effluents of wastewater, the BOD remains high. The BOD of the wastewater in Biratnagar is low because it contains few household wastes. The high amounts of biodegradable wastes increase, and the microbial activities also increase to decompose such materials (which need a large amount of oxygen) because the rate of use of oxygen is greater than the recreation rate of oxygen from the atmosphere.The average BOD value of both inlet and outlet is very low than the Guidelines followed by WWTP Biratnagar.

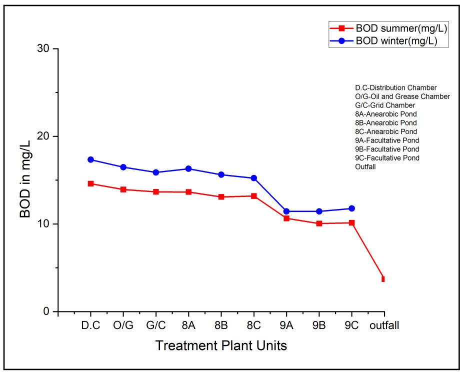

Figure 12: BOD at different WWTP units

Table 5: Winter season physio-Chemical Parameters of the Wastewater Treatment Plant of Biratnagar

		Tests							
S.N.	**WWTP Units**	**Tempr (°C)**	**PH**	**EC μs/cm**	**Turbidity (NTU)**	**TDS mg/l**	**TSS mg/l**	**COD mg/l**	**BOD mg/l**
1	Diversion Chamber(DC)	21.83	8.33	693.75	62.58	531.92	98.00	84.27	17.33
2	O/G Chamber	21.67	8.25	689.58	60.92	527.33	95.00	78.60	16.48
3	Girt Chamber (GC)	21.67	8.22	685.25	59.67	519.58	92.17	76.13	15.88
4	Anaerobic Pond(8A)	21.17	8.16	591.50	47.67	447.33	70.17	80.67	16.30
5	Anaerobic Pond(8B)	21.17	8.03	581.08	43.75	440.17	67.17	66.13	15.62
6	Anaerobic Pond(8C)	21.17	8.02	578.67	37.50	436.25	64.83	63.07	15.23
7	Facultative Pond(9A)	21.08	7.59	453.17	11.00	365.92	45.08	40.47	11.43
8	Facultative Pond(9B)	21.08	7.55	451.83	10.50	366.92	44.50	41.93	11.43
9	Facultative Pond(9C)	21.08	7.54	449.08	10.42	362.83	43.75	39.88	11.77
10	Out Fall Chamber								

Table 6: Summer season physio-Chemical Parameters of Wastewater Treatment Plant of Biratnagar

		Tests							
S.N.	**WWTP Units**	**Tempr (°C)**	**PH**	**EC μs/cm**	**Turbidity (NTU)**	**TDS mg/l**	**TSS mg/l**	**COD mg/l**	**BOD mg/l**
1	Diversion Chamber(DC)	32.42	8.48	681.83	66.58	529.75	104.33	91.33	14.60
2	O/G Chamber	32.42	8.49	677.00	64.92	531.17	101.50	89.32	13.93
3	Girt Chamber (GC)	32.42	7.70	673.58	64.08	526.83	99.42	87.97	13.67
4	Anaerobic Pond(8A)	32.75	7.46	520.42	44.50	443.50	64.67	78.49	13.65
5	Anaerobic Pond(8B)	32.58	8.08	522.42	43.92	441.25	64.75	76.45	13.09
6	Anaerobic Pond(8C)	32.58	7.38	520.00	43.42	439.17	64.25	78.73	13.18
7	Facultative Pond(9A)	32.83	7.76	373.08	12.78	303.17	40.92	32.82	10.63
8	Facultative Pond(9B)	32.83	7.13	371.67	11.88	302.08	41.17	30.15	10.05
9	Facultative Pond(9C)	32.83	7.78	370.42	12.12	263.25	41.17	29.68	10.13
10	Out Fall Chamber	31.00	7.85	292.50	5.55	129.00	13.50	5.80	3.70

Table 7: Removal Efficiency in summer

Sewage Type	**WWTP Units**	**Tempr (°C)**	**PH**	**EC μs/cm**	**Turbidity (NTU)**	**TDS mg/l**	**TSS mg/l**	**COD mg/l**	**BOD mg/l**
influent	Diversion Chamber(DC)	32.42	8.48	681.83	66.58	529.75	104.33	91.33	14.60
effluent	Out Fall Chamber	31.00	7.85	292.50	5.55	129.00	13.50	5.80	3.70
Overall Treatment Plant removal effieciency %		**4.37**	**7.37**	**57.10**	**91.66**	**75.65**	**87.06**	**93.65**	**74.66**

Table 8: Removal Efficiency in winter

Sewage	**WWTP Units**	**Tempr (°C)**	**PH**	**EC μs/cm**	**Turbidity (NTU)**	**TDS mg/l**	**TSS mg/l**	**COD mg/l**	**BOD mg/l**
influent	Diversion Chamber(DC)	21.83	8.33	693.75	62.58	531.92	98.00	84.27	17.33
effluent	Facultative Pond(9C)	21.08	7.54	449.08	10.42	362.83	43.75	39.88	11.77
Overall Treatment Plant removal effieciency %		**3.44**	**9.50**	**35.27**	**83.36**	**31.79**	**55.36**	**52.68**	**32.12**

Table 9: Removal efficiency of each units in WWTP in summer

S.N.	**Locations**	**Unit wise Removal Efficiency %**							
		Tempr (°C)	**PH**	**EC μs/cm**	**Turbidity (NTU)**	**TDS mg/l**	**TSS mg/l**	**COD mg/l**	**BOD mg/l**
1	Diversion Chamber(DC)								
2	O/G Chamber	0.00	-0.20	0.71	2.50	-0.27	2.72	2.21	4.57
3	Girt Chamber (GC)	0.00	9.32	0.50	1.28	0.82	2.05	1.51	1.91
4	Anaerobic Pond(8A)	-1.03	3.14	22.74	30.56	15.82	34.95	10.77	0.12
5	Anaerobic Pond(8B)	0.51	-8.38	-0.38	1.31	0.51	-0.13	2.60	4.09
6	Anaerobic Pond(8C)	0.00	8.76	0.46	1.14	0.47	0.77	-2.98	-0.70
7	Facultative Pond(9A)	-0.77	-5.20	28.25	70.56	30.97	36.32	58.32	19.34
8	Facultative Pond(9B)	0.00	8.06	0.38	7.04	0.36	-0.61	8.13	5.49
9	Facultative Pond(9C)	0.00	-9.11	0.34	-1.96	12.86	0.00	1.55	-0.83
10	Out Fall Chamber	5.58	-0.86	21.03	54.20	51.00	67.21	80.46	63.49

Table 10: Removal efficiency of each units in WWTP in winter

S.N.	**WWTP Units**	**Unit wise Removal Efficiency %**							
		Tempr (°C)	**PH**	**EC ms/cm**	**Turbidity (NTU)**	**TDS mg/l**	**TSS mg/l**	**COD mg/l**	**BOD mg/l**
1	Diversion Chamber(DC)								
2	O/G Chamber	0.76	1.00	0.60	2.66	0.86	3.06	6.72	4.95
3	Girt Chamber (GC)	0.00	0.40	0.63	2.05	1.47	2.98	3.14	3.59
4	Anaerobic Pond(8A)	2.31	0.71	13.68	20.11	13.91	23.87	-5.95	-2.62
5	Anaerobic Pond(8B)	0.00	1.63	1.76	8.22	1.60	4.28	18.02	4.19
6	Anaerobic Pond(8C)	0.00	0.10	0.42	14.29	0.89	3.47	4.64	2.45
7	Facultative Pond(9A)	0.39	5.30	21.69	70.67	16.12	30.46	35.84	24.95
8	Facultative Pond(9B)	0.00	0.55	0.29	4.55	-0.27	1.29	-3.62	0.00
9	Facultative Pond(9C)	0.00	0.11	0.61	0.79	1.11	1.69	4.91	-2.92
10	Out Fall Chamber								

6. Pearson Correlation of various parameters

Table 11: Pearson correlation coefficients of various parameters during summer

	Temperature	PH	EC	Turbidity	TDS	TSS	COD	BOD
Pearson Correlations	Pearson Correlations	Pearson Correlations	Pearson Correlations	Pearson Correlations	Pearson Correlations	Pearson Correlations	Pearson Correlations	Pearson Correlations
Temperature	1	-0.23734	0.20784	0.15355	0.41856	0.29029	0.33655	0.66986
PH	-0.23734	1	0.52199	0.51181	0.37846	0.52117	0.37751	0.24444
EC	0.20784	0.52199	1	0.99189	0.96443	0.99137	0.95129	0.84307
Turbidity	0.15355	0.51181	0.99189	1	0.95776	0.96807	0.96693	0.82893
TDS	0.41856	0.37846	0.96443	0.95776	1	0.96346	0.98233	0.94635
TSS	0.29029	0.52117	0.99137	0.96807	0.96346	1	0.92961	0.86462
COD	0.33655	0.37751	0.95129	0.96693	0.98233	0.92961	1	0.9211
BOD	0.66986	0.24444	0.84307	0.82893	0.94635	0.86462	0.9211	1

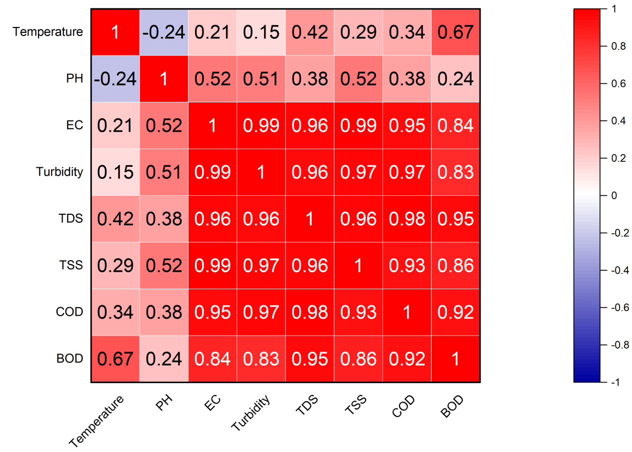

Figure 13: Pearson correlation coefficient plot of various parameters during summer

Table 12: Pearson correlation coefficients of various parameters during winter

	Temperature	PH	EC	Turbidity	TDS	TSS	COD	BOD
Pearson Correlations	Pearson Correlations	Pearson Correlations	Pearson Correlations	Pearson Correlations	Pearson Correlations	Pearson Correlations	Pearson Correlations	Pearson Correlations
Temperature	1	0.79101	0.88346	0.83261	0.92398	0.93303	0.75081	0.71833
PH	0.79101	1	0.97632	0.99149	0.95627	0.9528	0.9884	0.98758
EC	0.88346	0.97632	1	0.99139	0.99496	0.99153	0.94682	0.94234
Turbidity	0.83261	0.99149	0.99139	1	0.97818	0.97488	0.97523	0.97095
TDS	0.92398	0.95627	0.99496	0.97818	1	0.99922	0.92589	0.9131
TSS	0.93303	0.9528	0.99153	0.97488	0.99922	1	0.92451	0.90856
COD	0.75081	0.9884	0.94682	0.97523	0.92589	0.92451	1	0.98263
BOD	0.71833	0.98758	0.94234	0.97095	0.9131	0.90856	0.98263	1

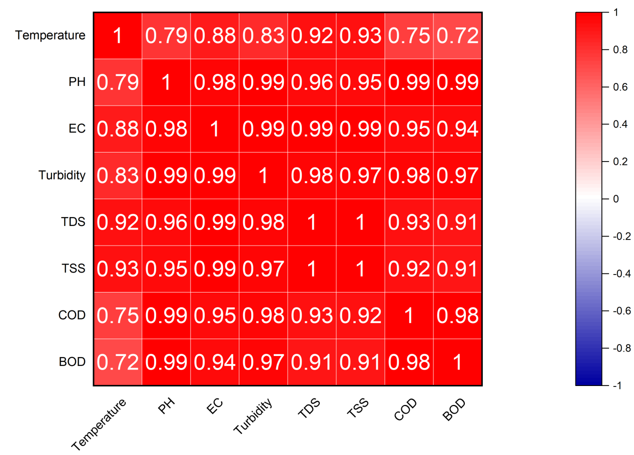

Figure 14: Pearson correlation coefficient plot of various parameters during winter

From the above table and correlation plot it is clear that there is relation among various parameters.

7. Conclusion and Recommendation

As per the design target, the sewer lines could not be connected to the connection chamber due to built-in septic tanks in beneficiaries' households.The discharge was very low in WWTP. BOD,COD concentrations and other parameters were also found lesser than as assumed in the design due to absence of industrial waste water.

For the initial phase, the tariff connection should be waived to encourage the household beneficiaries to connect to the sewer chamber. The treatment plant can be recommended for Private-Public Participation (PPP) in order to have a full-fledged operation and environmentally friendly discharge of domestic wastewater.

8. Limitations

All the test data were taken from laboratory reports of the WWTP.No test were conducted during the study.Biological parameters data were not available.Actual discharge data of sewage at inlet was not found.During winter the data at the outlet chamber was not available due to insufficient discharge of effluent to the drying bed.

Acknowledgments

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