Activity 4.2.6

Rapid Assessment of Selected STPs in Prayagraj, UP

October 2019

in consortium with

Consulting Services on Rehabilitation Measures on behalf of the National Mission on Clean Ganga

"Support to Ganga Rejuvenation"
Phase II
Uttarakhand and Uttar Pradesh

India

Indo-German Development Cooperation
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

GOPA Infra GmbH
Hindenburgring 18, 61348 Bad Homburg, Germany
Phone +49 6172 6817-0 Fax: +49 6172 25748 Email: info@gopa-infra.de

Table of Contents

Abbreviations

ASCE	American Society of Civil Engineers
ASP	Activated Sludge Process
AT	Aeration Tank
BOD	Biochemical Oxygen Demand
BOD_3	Biochemical Oxygen Demand (3 days)
BOD_5	Biochemical Oxygen Demand (5 days)
BT	Bio Tower
CA	Concession Agreement
CAR	Condition Assessment Report
CASP	Conventional Activated Sludge Process
CCT	Chlorine Contact Tank
CDR	Central Dispatcher Room
CHAZOP	follows HAZOP with focus on controls and instrumentation
CHP	Combined Heat & Power unit
CMD	Central Mimic Diagram
CNG	Compressed Natural Gas
CoA	City of Allahabad
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organisation
CS/MS	Case Study / Model Solution
CTO	Consent to Operate
CWSBR	Constant Water Level Sequencing Batch Reactor
DG	Diesel Generator
DG Sets	Digestor Sets
Dia	Diameter
DIN	Deutsches Institut für Normung (German Institute for Standardiza-tion)
DO	Dissolved Oxygen
DPR	Detailed Project Report
DS	Dry Substance
DW	Dry Weather
DWA	German Association for Water, Wastewater and Waste (former ATV-DVWK)
E&M	Electrical & Mechanical
EAs	Executing Agencies

EN	European Norm
EOI	Expression of Interest
ESHS	Environment, Social, Health and Safety
F/M	Food : Microorganisms ratio
FAB	Fluidised Aerobic Bio-Reactor
FB	Free Board
FC	Fecal Coliforms
FOG	Fat, Oil & Grease
FST	Final Settling Tank
GAP	Ganga Action Plan
GDP	General Drainage Plan
GIZ	German Corporation for International Cooperation GmbH
GOI	Government of India
HAZOP	Hazard and Operability
HRT	Hydraulic Residence Time
I&C	Instrumentation and Control
I&D	Interception and Diversion
IFAS	Integrated Fixed Film Activated Sludge
IIT	Indian Institute of Technology
IPS	Intermediate Pumping Station
KLD	Kilolitres per day
KPIs	Key Performance Indicators
KV	Kilovolt
KVA	Kilo Volts-Amperes
MBBR	Moving Bed Biofilm Reactor
MCC	Motor Control Center
MEP	Mechanical, Electrical and Plumbing
mg/l	milligram/litre
MLD	Million Litres Per Day
MLSS	Mixed Liquor Suspended Solids
Mm	Millimetre
MOC	Material of Construction
MoEFCC	Ministry of Environment, Forest and Climate Change
MoWR, RD, & GR	Ministry of Water Resources, River Development and Ganga Rejuvenation
MPN	Most Probable Number
MPR	Monthly Progress Report
MPS	Main Pumping Station

MS/MW	Monsoon Season / Monsoon Weather
MT	Microturbine
nb pON	Non-biodegradable Particulate Organic Nitrogen
nb VSS	Non-biodegradable Volatile Suspended Solids
NGT	National Green Tribunal
NH_3 - N	Ammonia Nitrogen
NRV	Non Return Valve
O&M	Operation and Maintenance
OP	Oxidation Pond
Org - N	Organic Nitrogen
P&ID	Piping & Instrumentation Diagram
PCRI	Pollution Control Research Institute
PCS	Process Control System
PD	Programme Director
PLC	Programmable Logic Controller
PPP	Public Private Partnership
PS	Pumping Station
PSA	Pressure Swing Adsorption
PST	Primary Settling Tank
PT	Pilot Test
RAS	Return Activated Sludge
rb (COD)	Readily Biodegradable COD
RCC	Regional Control Centre
RTEQMS	Real Time Effluent Quality Monitoring System
RTMS	Real Time Monitoring Station
Sbod	Soluble BOD
SBR-CAST	Sequencing Batch Reactor - Cyclic Activated Sludge Technology
SBT	Soil Bio Technology
SCADA	Supervisory Control and Data Acquisition
sCOD	Soluble COD
SDB	Sludge Drying Bed
SDU	Solar Drying Units
SoW	Scope of Work
SPS	Sewage Pumping Station
SRT	Solids Retention Time
SST	Secondary Sedimentation Tanks
ST	Sludge Thickener

STP	Sewage Treatment Plant
SVI	Sludge Volume Index
SWD	Side Water Depth
TC	Total Coliforms
TKN	Total Kjheldal Nitrogen
TN	Total Nitrogen
TP	Total Phosphorous
TRF	Tanker Reception Facility
TSS	Total Suspended Solids
UPJN	Uttar Pradesh Jal Nigam
UPPCB	Uttar Pradesh Pollution Control Board
UASB	Up flow Anaerobic Sludge Blanket
UV	Ultraviolet
VSS	Volatile Suspended Solids
WDC	Wastewater Disposal Concept

1 Introduction

To ensure better co-ordination and improved quality of water, the Union Ministry of Jal Shakti, through the National Mission for Clean Ganga (NMCG), is implementing the "One City One Operator" (1C1O) concept for comprehensive sewerage management in the critical cities along the Ganga. Under this approach, one single operator is selected through an open and competitive tender process to Design, Finance, Build (new) and upgrade/ rehabilitate (existing), Operate and maintain all sewage treatment plants (STPs) in one city under a hybrid annuity-based (HAM) public private partnership Concession Agreement (CA).

Under the Indo-German Cooperation, the consulting company GOPA-Infra in consortium with the consulting company Fichtner, has been contracted by GIZ to implement several activities in support to reduction of pollution from municipal and industrial sources in the states of Uttarakhand and Uttar Pradesh. Among these, GOPA-Infra is tasked to support SMCG, Jal Nigam and NMCG (when required) in the implementation of the concept One City One Operator (1C1O) in the city of Prayagraj.

In Prayagraj, Prayagraj Water Private Limited (a subsidiary of M/s. Adani Enterprises Ltd.) has been selected to rehabilitate the six existing STPs and operate them as well construct and maintain three new STPs; operate & maintain 17 sewage pumping stations (7 new and 10 existing ones to be rehabilitated) and the three (3) new Interception & Diversion structures are to be built and integrated.

The GOPA-Infra team has been working on the 1C1O assignment in Prayagraj since February 2019. The first step to support implementation of the 1C1O concept has been to carry out a rapid assessment of the six existing STPs and SPSs covered by the agreement. This report presents the findings and recommendations of the assessment and it is structured as follows:

- **Chapters 2 and 3** give an overview of the city of city's sewage system, population and sewage production.
- **Chapter 4 and 5** present the assessment's findings for each of the STPs
- **Chapter 6** discusses findings for the SPSs.
- **Chapter 7** presents an assessment of STPs and SPSs in relation to the Concession Agreement.
- **Chapter 8** lists recommendations for improvement
- **The Annex** includes Minutes of Meeting of a Progress Review for Allahabad STP Projects on 04/06/2019.

2 History of Sewerage System in Prayagraj

After implementation of piped water supply in Prayagraj in the year 1892, the Sewerage system in the Prayagraj city was first introduced in the year 1910. The facility was subsequently extended in a number of developing areas according to the need and financial position of the local body. Old sewers are egged shaped brick sewers.

In the year 1915, Government acquired 115-hectare land in Mahewa and Jahagirabad area across the Yamuna river for disposal of sewage and night soil generated in the city. In the year 1954, State Government conceptualized sewage utilization scheme and implementation of the works proposed that scheme were completed in the year 1963-64. Under this scheme following works were carried out:

- Construction of Gaughat Sewage Pumping Station
- Construction of sewage farm channel.
- Laying of 36" and 27" diameter rising mains from Gaughat Sewage Pumping Station to Head works of the Sewage farm channel.

Ganga Action Plan Phase-I (GAP-I) was conceptualize by Govt. of India in year 1985 to prevent heavy pollution of river Ganga. The works of GAP-I was completed in Prayagraj in the year of 1999. After finding and recognizing the results of GAP-I, Ganga Action Plan Phase-II (GAP-II) was launched by the Ministry of Environment and Forest, Govt. of India in the year 1993, GAP-II in Prayagraj were implemented during the year 2000-07. Other major works related to reduce pollution load in the river Ganga and Yamuna were constructed under JNNURM Programme of Ministry of Urban Development, Government of India.

3 Population Projection and Sewage Generation

The population of the city as per census of 2011 has been recorded as 12,16,719. The future population of the city in the year 2020, 2035 and 2050 along with sewage generation has been projected as below:

Year	Projected Population	Sewage Generation in MLD
2020	1,681,600	182
2035	2,218,100	240
2050	2,754,700	298

This does not include the floating population, population of Jhunsi and Phaphamau. The sewage generation is based on 135 litres per capita per day of water supply and then applying an interception factor of 0.80.

4 Rapid Assessment of Individual STPs selected in Prayagraj

The sewage treatment plants in Prayagraj have been constructed under Ganga Action Plan Phase-I, Ganga Action Plan Phase-II and JNNURM programme of Government of India. All the treatment plants are functioning but require some improvements in operation to perform more effectively and efficiently.

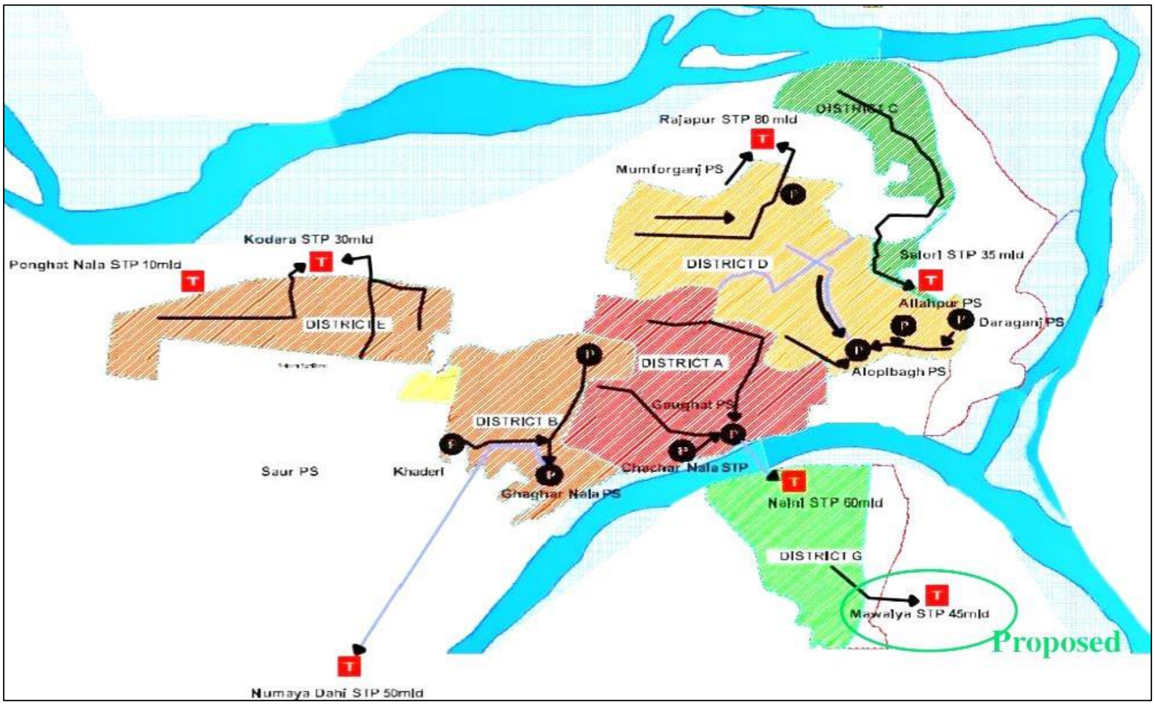

Figure 1 Map of existing Prayagraj STPs

The scope of the present assessment is limited to the STPs covered under the One City One Operator (1C1O) Concessionaire Agreement as follows:

S. No.	Location of STP	Capacity (MLD)	Technology/ Process Adopted	Year of Commissioning
1	Naini	80	ASP	1999
2	Salori	29	MBBR	2007
3	Ponghat	10	Bio-tower + ASP	2013
4	Kodra	25	Bio-tower + ASP	2013
5	Numayadahi	50	Bio-tower + ASP	2013
6	Rajapur	60	UASB+ Polishing Pond	2013

The above listed sewage treatment plants have been visited by experts in the May and June in the Year 2019. The report is based on visits to respective sewage treatment plants during 17th-18th of May, 17th -20th of June 2019 and 5th - 7th August 2019.

All the sewage treatment plants mentioned above were designed for removal of BOD, TSS and Faecal Coliforms. The influent and effluent parameters for which the plants were designed are given in the respective pages covering the specific sewage treatment plant. This report covers general information of STPs, their functioning and the problems/ shortcomings noticed during visit of respective sewage treatment plant.

4.1 80 MLD Sewage Treatment Plant at Naini

The salient information of the 80 MLD capacity sewage treatment plant based on conventional activated sludge process is briefly described as under:

4.1.1 Introduction

The sewage treatment plant is based on conventional activated sludge process and was commissioned in 1999. The plant was constructed under Ganga Action Plan Phase-I. The initial capacity of the STP was only 60 MLD. Its augmentation was taken up and the capacity of existing STP was enhanced by another 20 MLD in the year 2013. Presently, the total capacity of the plant is 80 MLD.

4.1.2 Total Flow at STP

The plant normally receives about 60-65 MLD of sewage during dry weather conditions against a designed capacity of 80 MLD. At present, approximately 40% of the treated effluent is used for irrigation purposes and remaining 60% is discharged to River Ganga. The channel used for carrying the treated effluent water for irrigation is damaged at some locations is main reason for lesser utilisation of treated water for irrigation purposes. During rains when there is no demand of water for irrigation, the effluent is discharged to the river Ganga.

4.1.3 Design Parameters

The sewage treatment plant was designed for following influent and effluent parameters:

S.No.	Parameters	Unit	Influent	Effluent
1	pH	-	7-8	7-8
2	BOD_5	mg/l	300	< 30
3	COD	mg/l	500	< 250
4	TSS	mg/l	600	< 50

The additional 20 MLD capacity was designed to achieve a BOD less than 20 mg/l.

4.1.4 Unit Sizes of Existing STP

Following units have been constructed to treat the domestic sewage:

Sl. No.	Name of the Unit	60 MLD STP		20 MLD STP	
		Nos	Size of Units	Nos	Size of Units
1	Inlet Collection chamber	1	4.5 m X 3.0 m X 3.50 m	1	
2	Manual screens	3	20mm bar spacing	-	
3	Mechanical Screen			2	6 mm opening Drum type
4	Detritors Tanks	3	8.0 X 8.0 X 1.0 m	1	6.71mx6.71mx1.0m
5	Flow measuring Device	1	Magnetic Type	1	Magnetic Type
6	Distribution chambers for PST	1		1	
7	Sludge Thickener	2	19 m Ø, 3.0 m SWD	-	
8	Primary settling tanks (PST)	3	31 m Ø, 3.0 m SWD	1	33 m Ø, 3.0 m SWD
9	Thickened sludge pump house	1		-	
10	D.C. for Biological treatment	1		1	
11	Activated sludge - Aeration Tank	3	49.80mx17.80mx3.90 m SWD	1	49.80mx15.0mx 4.5 m SWD
12	D.C. for secondary clarifier	1		1	
13	Final Settling Tank (FST)	3	34 m Ø, 3.0 m SWD	1	34.1 m Ø, 3.0 m SWD
14	Return sludge pump house	1		1	
15	Treated Effluent pump house	1		-	
16	Sludge Digesters	3	27 m Ø, 6.0 m SWD	-	
17	Gas holders	2	17 m Ø, 6.0 m SWD	-	
18	Sludge drying beds	22	24.8 m x 24.80 m	6	
19	Power Generation room	1		-	
20	Filtrate pump house	1			

4.1.5 Test Report of the Effluent

The water sample of the influent and effluent was collected and tested by U.P. Jal Nigam, Ganga Pollution Control Unit, Prayagraj which is tabulated below:

Month	Parameters				
	Flow, MLD	Influent, mg/l		Effluent, mg/l	
		BOD_5	TSS	BOD_5	TSS
October 18	48	115	354	25	44
November 18	60	112	352	28	44
December 18	Data Not Available				
January 19	65	117	357	25	46
February 19	65	115	360	27	48
March 19	65	118	364	27	40
April 19	63	117	358	26	47
May 19	61	115	354	24	47

4.1.6 Operational Problems & Solutions

4.1.6.1 Quantity of Return Sludge

The problem of recirculating correct quantity of return activated sludge to the aeration tank and taking excess sludge to thickener is affecting the performance of the plant. Ut-most care has to be taken to maintain the required MLSS in the aeration tank to improve the performance of the plant. It has to be managed correctly as has been summarised in the recommendation part titled "General Recommendation."

4.1.6.2 Under Utilization of the Capacity

The STP is getting only 60 MLD of sewage and is operating at 75% capacity. It was reported that two rising mains each of 900 mm diameter pass through the Naini Railway Bridge in which one rising main has developed some leakage which is under repair. The sewage to 80 MLD capacity Naini STP is pumped from Gaughat main SPS through these two rising mains. After repairing of rising main under repair, the STP shall receive total flow of 80 MLD.

4.1.6.3 Screens and Grit Chambers

The 60 MLD STP has three manual screens with 10 cm c/c spacing which has to be replaced by 6 mm c/c fine mechanical screens. The rubber pad scrappers fitted at the bottom of scrapping mechanism of grit chamber are worn out and therefore scrapping of collected grit at the bottom of grit chamber cannot be effectively removed. The gear box at the grit chamber is frequently damaged and has to be repaired. The slope of the concrete surface meant for movement for taking out the grit is uneven and is not effective. The organic pumps installed are also not functioning properly.

4.1.6.4 Primary Clarifiers, Secondary Clarifiers and Gravity Sludge Thickeners

The Weirs and V-notches installed in Primary, Secondary and Thickeners are rusted and damaged causing uneven flow from V-notches and needs replacement. The walkaway bridge of both thickeners is damaged and needs replacement or repair. The skimmer arm of primary clarifier including the scum box are not functioning properly and needs repair or replacement. The drain valve from primary clarifiers to thickeners with extended spindle gets damaged and has to be changed or repaired at some time intervals. When the thickened sludge line gets choked, the thickener is required to be emptied to clean the sludge line. Therefore, some additional facility of flushing arrangement is required to be provided in thickened sludge line.

4.1.6.5 Sludge Dumping at STP site

There is no consistent sludge disposal concept as is clearly visible at the site. The sludge is dumped on site or around the plant. The surrounding area is directly polluted posing environmental challenges.

4.1.6.6 Power Generation System

During the design stage, the detailed characteristics of sludge were not available, hence the design of biogas generation was based on assumptions. During commissioning of 60 MLD capacity, the thickened sludge was taken to digesters and the resulting biogas was stored in the gas holders. Duel fuel engines were installed and operated at mixed fuel mode in the ratio of 40% diesel and 60% biogas and power was generated. In due course, the non-availability of sufficient funds, the purchase of diesel and the maintenance of duel fuel engines became difficult. In addition to it, the cost of power generated by duel fuel engine was much higher than the cost of power available from the grid. The digested sludge was then taken to sludge drying beds.

4.1.6.7 Digesters, Gas Holders and Dual Fuel DG Sets

As mentioned earlier, the sludge feeding to digesters was stopped and all the sludge from thickener was taken directly to sludge drying beds. The digesters should have been cleaned when the power generation system was made inoperative. It was reported that the intermittent filling of the digesters was done before completely stopping the filling of the digesters. Presently, the digesters are fully filled up with grit and sludge. The duel fuel engines are inoperative since long time. Therefore, the gas holders and the dual fuel DG sets are also not functional and lying idle.

Therefore, it is recommended that the duel fuel engines should be replaced with pure gas engines. The scrubbing arrangement to bring down the concentration of H_2S to a level below 200 ppm should also be installed. It is also recommended that heating arrangements using heat exchangers to digester should also be made to increase the power generation. It shall immensely help in generating enough power to operate the plant with only 50% of power that is required today to operate 80 MLD sewage treatment plant and huge saving in the power bill.

4.1.6.8 Replacement of Hose Pipes in 20 MLD Treatment Train

Flexible hose pipes used for aeration in 20 MLD STP may require immediate replacement by diffused aeration system.

4.2 29 MLD Sewage Treatment Plant at Salori

The salient information of the plant is briefly described as under:

4.2.1 Introduction

The sewage treatment plant is based on Moving Bed Bio Reactor process and was commissioned in 2007. The plant was constructed under the Ganga Action Plan –Phase II (GAP-II).

4.2.2 Total Flow at STP

The 29 MLD sewage treatment plant currently receives about 35 to 45 MLD which is 38% to 55% higher than the designed capacity. The treated effluent is discharged to River Ganga through a drain. Two streams each of 14.5 MLD has been constructed.

The sewage reaching the main pumping station is reported to be in the range of 48-61 MLD which accounts for an excess of about 12%-47% of the combined installed capacity of the two STPs (43 MLD), i.e. 14 MLD and 29 MLD at Salori.

4.2.3 Design Parameters

The sewage treatment plant was designed for following influent and effluent parameters:

S.No.	Parameters	Unit	Influent	Effluent
1	pH	-	7-7.5	7-8
2	BOD_5	mg/l	250	<30
3	COD	mg/l	450	<250
4	TSS	mg/l	400	<50
5	Total Coliforms	MPN/100 ml	10^6 to10^7	<1000

4.2.4 Unit Sizes of Existing STP

Following units have been constructed to treat the domestic sewage:

S. No.	Unit	Size	Quantity (No.)
1	Inlet cum Stilling Chamber	4.1m x 4.1m x 3m SWD	1
2	Mechanical bar screen chambers	1m x 5.50m x 0.75m SWD	2
3	Manual bar screen chamber	1m x 5.50m x 0.75m SWD	1
4	Grit Separators	5.8m x 5.8m x 1m SWD	3
5	Distribution chamber	3.2m x 3.2m x 2.5m SWD	1
6	Fab reactors	10.7m dia x 5m SWD	4
7	Secondary clari-settler	9.5m dia x 3.75m SWD	2
8	Chlorine contact tank	1.8 m wide around clari-settler x 2.5 m SWD	2
9	Sludge Sump for clari-settler	6.5 m dia x 3m SWD	1
10	Sludge dewatered beds (A)	14.5 m L x 27.1W	6
11	Sludge dewatered beds (B)	14.5 m L x 27.1W	4
12	Filtrate/overflow sump	7.2 m dia x 3m SWD	1
13	Neutra pit	3m x 2m x 2.5m SWD	2
14	Blower room	8m x 6m x 3.5m HT	1
15	MCC room	8m x 6m x 3.5m HT	1
16	Chlorination room	4.5m x 4.5m x 3.5m HT	1
17	Operator room/toilet	6m x 3m x 3.5m HT	1
18	Treated effluent line	1000 mmm dia x 85m	1

4.2.5 Test Report of the Effluent

The water sample of the influent and effluent was collected and tested by U.P. Jal Nigam, Ganga Pollution Control Unit, Prayagraj which is tabulated below:

Month	Parameters				
	Flow, MLD	Influent, mg/l		Effluent, mg/l	
		BOD_5	TSS	BOD_5	TSS
October 18	20	119	368	26	46
November 18	19	111	347	8.33	113
December 18	Data Not Available				
January 19	45	120	362	27	48
February 19	41	121	366	29	50
March 19	36	120	368	26	48
April 19	33	119	364	28	50
May 19	33	118	363	26	44

4.2.6 Operational Problems and Solutions

4.2.6.1 Unequal Treatment Efficiency in Fab Reactors

It was observed during the visit that the attachment of biomass to the media and thickness of the biomass varies between all the 4 Fab Reactors which indicates that the treatment efficiency is not equal among the reactors. Few media from the individual fab reactors were taken out and compared. It was clearly visible that the layers of biomass on the media were not uniform. The media having a thick biomass from the particular rector indicated that the reactor having such accumulation of biomass on the carrier was not performing well.

There may be many reasons for this variation. The quantity of media may not be the same, the flow may not be equally distributed between reactors, the air supply required in reactors may be varying etc. The screens provided at the bottom to prevent media from overflowing to the clarifier may have some accumulation of media at the screens or damaged diffusers. It needs to be checked and corrective measures taken. It was reported that some part of the screens installed at the bottom to prevent media from overflowing has been partially closed.

This STP was commissioned in the year 2007. Its design needs to be rechecked in light of the technological advancements made for designing of the MBBR plants. The typical biofilm thickness in the carrier should be between 50 µm to 500 µm. The design of MBBR should be done on BOD loading rate not exceeding 45 g/m^2. d at 15°C and 10 g/m^2. d at 10°C in case of high rate MBBR and normal rate MBBR respectively. The recommended loading rate can be checked from the available design. The volume of reactors shall depend on the media fill fraction in the reactor. Revisiting the design shall help in quantifying the media required to be filled in the reactor as it is already constructed.

As per available design, it was found that net volume of each reactor has been adopted as 453 m^3 mentioning (As per Thermax Design). The parameters for the design of fab reactors such as BOD_5 loading and media fill fraction was not provided to the department.

4.2.6.2 Sludge Management

The draining of sludge from clari-settlers is not done in a systematic and planned manner mud pumps have been installed in 6m deep sludge sump and pumped to the thickener. It causes high to vary high loading on the sludge drying beds and leaves no further space for application of sludge. The filtrate pumps, SDB feed pumps and thickeners feed pumps were installed in the year 2007 and their efficiency has greatly reduced. Therefore, installation of mud pumps was taken up to encounter the problem of reduced efficiency of pumps.

4.2.6.3 Deficiency in Aeration System

It was reported that there is leakage in the airline supplying air to grid diffusers installed at the bottom of the fab reactors. The leakage in the airline can be seen at top of reactors before it enters into the reactor. The required quantity of air i.e., oxygen is not supplied to the diffusers which is greatly affecting the performance of the reactors. As per design, it was found that while calculating oxygen demand the contractor has taken the liberty of subtracting outlet BOD5 of 30 mg/l which works out to be (250-30) x 29000/1000 = 6380 kg/day. Only fraction of soluble BOD_5 is subtracted in calculations for oxygen which normally ranges from 3to 5 mg/l. Adopting a figure of 5 mg/l, the requirement of oxygen shall be (250-5) x 29000/1000 = 7105 kg/day. Normally, the requirement of oxygen is calculated at the rate of 1.2 kg O_2/kg BOD_5 removed due to kinetic considerations which has been adopted as 1.0 kg O_2/kg BOD_5 removed resulting lower provision in the capacity of blowers.

It is also recommended that it should also be checked whether the diffuser grid located at the bottom of reactor is fine bubble or coarse bubble. Normally, coarse bubble diffusers of 6 to 12 mm size are recommended instead of 2 mm diameter of fine bubble diffusers. The presence of plastic biofilm carriers decreases fine bubble aeration system oxygen transfer efficiency by 20% to 30%. Hence, the capacity of blower shall be required to be changed once the plant receives the BOD_5 load exceeding 200 mg/l.

4.2.6.4 Disinfection facility

Chlorination tank has been provided as an integral part of claritube settler as circular in annular construction around secondary claritube settler. Detention period of 30 minutes of average flow has been adopted which gives a volume of 302 m^3. Detention period of 30 minutes of average flow is applicable when the peak factor is 2. In this case peak factor is 2.5, therefore it should have been designed for a detention period of 15 minutes at peak flow. The volume of chlorine contact tank shall be 14500 x 2.5 x 15/(60 x 24) = 378 m^3. The volume of chlorine contact tank is undersized by (378-302) x 100/378 = 20%. and therefore, shall not function efficiently and effectively. The capacity of chlorine contact tank needs to be increased at both the claritube settlers. Excess foaming was also observed in claritube settlers.

4.3 50 MLD Sewage Treatment Plant at Numayadahi

4.3.1 Introduction

The sewage treatment plant is based on Bio-Tower with Activated Sludge Process and was constructed in 2013.

4.3.2 Total Flow at STP

The sewage treatment plant currently receives 53 to 66 MLD sewage, higher than 30% of the installed capacity of 50 MLD. The plant is performing well due to lower organic load i.e., BOD in the range of 110 to 130 mg/l in spite of higher hydraulic load.
The treated effluent is discharged to River Ganga.

4.3.3 Design Parameters

The sewage treatment plant was designed for following influent and effluent parameters:

S.No.	Parameters	Unit	Influent	Effluent
1	Temperature	˚C	25 - 30	25 - 30
2	pH	-	6.5 - 8.5	6.5 - 8.5
3	BOD_5	mg/l	250	20
4	COD	mg/l	550	200
5	TSS	mg/l	500	30
6	Total Kjeldahl Nitrogen	mg/l	25	<0.5 NH_3-N
7	Phosphorus (Total as P)	mg/l	10	5
8	Total coliform	MPN/100 ml	10^7	< 1000
9	Oil & Grease	mg/l	5	< 5

4.3.4 Unit Sizes of Existing STP

Following units have been constructed to treat the domestic sewage:

S. No.	Unit	Size	Quantity (No.)
1	Inlet chamber	3.9 m x 1.8 m x 2.5 m SWD	1
2	Mechanical fine screen channel (2W)	4.4 m x 1.1 m x 1 m SWD	2
3	Manual fine screen channel (1 Standby)	4.4 m x 1.1 m x 1 m SWD	1
4	Grit chamber	8 m x 8 m x 0.65 SWD	2
5	Manual grit channel	12 m x 1 m x 0.375 SWD	1
6	Distribution chamber/splitter box	3.9 m x 1.8 m x 2.5 m SWD	1
7	Bio tower	17.8 m dia x 4.8 m SWD	3
8	Mixing chamber	15 m x 5 m x 3.5 SWD	1
9	Aeration tank	20 m x 34.75 x 4 m SWD	3
10	Secondary clarifier	38 m dia x 3 m SWD	2
11	Chlorine contact tank	12 m x 30 m x 3 m SWD	1
12	Secondary sludge sump	7.5 m dia x 2 m SWD	1
13	Sludge thickener	22.5 m dia x 3m SWD	1
14	Centrifuge feed pump house	10 m x 6 m x 5 m Height	1
15	Centrifuge platform	10 m x 5 m x 3.5 m Height	1
16	Chlorinator house/room	6 m x 4 m x 4.5 m Height	1
17	Blower room & MCC room	20 m x 6.85 m x 5m Height	1
18	Workshop/store room	12 m x 6.7 m x 4.5 m Ht.	1
19	MEP building & Panel room-2	10 m x 6 m x 4.5 m Ht.	1
20	Administrative/lab building	200 sq.m x 4.5 m Ht.	GF+1
21	DG room/platform	10 m x 6 m x 4.5 m Ht.	1
22	Staff Quarter (A type)	34.2 sq.m	4
23	Staff Quarter (A type)	67.7 sq.m	2
24	Staff Quarter (A type)	62. sq.m7	1

4.3.5 Test Report of the Effluent

The water sample of the influent and effluent was collected and tested by U.P. Jal Nigam, Ganga Pollution Control Unit, Prayagraj which is tabulated below:

Month	Parameters				
	Flow, MLD	Influent, mg/l		Effluent, mg/l	
		BOD_5	TSS	BOD_5	TSS
October 18	30	94	242	13	16
November 18	53	108	266	12	14
December 18	Data Not Available				
January 19	66	123	271	13	15
February 19	66	128	271	13	15
March 19	66	126	271	13	15
April 19	59	120	264	12	14
May 19	57	122	276	13	16

4.3.6 Operational Problems and Solutions

4.3.6.1 Mechanical issues

- The distributor arms of rotary distributor are propelled by thrust from hydraulic discharge. The velocity of rotation which dictates the instantaneous dosing (mm/pass of an arm) has to be checked and corrected to increase the efficiency of bio-tower. Flow distribution through staggered nozzles did not appear to be equal which needs optimization to keep the media wetted and unclogged.

- The head required for minimum flow is about 0.30 to 0.60 m above centreline of the orifices of the distributor arms. Greater head is needed to accommodate wide flow ranges. It can be seen whether an overflow device that doses using additional arms during high flow periods ca reduce the head requirement. Maintaining the flow to the nozzle at the minimum velocity enhances distribution.

4.3.6.2 Biological treatment

- The historical data of effluent parameters indicate that some time BOD and TSS marginally exceeded the required discharge parameters. Effectiveness of screenings removal can be improved.
- The media provided in the Bio-tower needs to be checked for clogging, sagging in the media not visible from outside. If some problem is found, the same shall need corrective measures.

4.3.6.3 Sludge management

- The quantity of sludge generated in bio-tower is always less than that of activated sludge process as the kinetics of treatment in bio-tower is an attached growth process. It is recommended that the effluent parameters after the respective bio-towers should be checked to ascertain the efficiency of respective bio-tower. It shall help in determination as to which bio-tower is not performing well. The corrective measures then can be taken up to improve the performance of bio-towers. These measures shall improve the efficiency of treatment.
- Issues of sludge management are common at all STPs which needs to be carefully addressed. The subject of sludge management has been covered in the recommendation part of this report.

4.4 25 MLD Sewage Treatment Plant at Kodra

4.4.1 Introduction

The sewage treatment plant is based on Bio-Tower with Activated Sludge Process and was constructed in 2013.

4.4.2 Total Flow at STP

The sewage treatment plant currently receives about 34-36 MLD sewage which is approximately 40% higher than the installed capacity. The plant is performing well due to lower organic load i.e., BOD in the range of 110 to 130 mg/l in spite of higher hydraulic load. The treated effluent is discharged to River Ganga.

4.4.3 Design Parameters

The sewage treatment plant was designed for following influent and effluent parameters:

S. No.	Parameters	Unit	Influent	Effluent
1	Temperature	°C	25 - 30	25 - 30
2	pH	-	6.5 - 8.5	6.5 - 8.5
3	BOD_5	mg/l	250	20
4	COD	mg/l	550	200
5	TSS	mg/l	500	30
6	Total Kjeldahl Nitrogen	mg/l	25	<0.5 NH_3-N
7	Phosphorus (Total as P)	mg/l	10	5
8	Total coliform	MPN/100 ml	10^7	< 1000
9	Oil & Grease	mg/l	5	< 5

4.4.4 Unit Sizes of Existing STP

Following units have been constructed to treat the domestic sewage:

S. No.	Unit	Size	Quantity (No.)
1	Inlet chamber	3.3 m x 1.1 m x 2.5 m SWD	1
2	Mechanical fine screen channel (2W)	3.6 m x 0.9 m x 0.625 m SWD	2
3	Manual fine screen channel (1 Standby)	3.6 m x 0.9 m x 0.625 m SWD	1
4	Grit chamber	5.5 m x 5.5 m x 0.65 SWD	2
5	Manual grit channel	12 m x 1 m x 0.375 SWD	1
6	Distribution chamber/splitter box	3.3 m x 1.1 m x 2.5 m SWD	1
7	Bio tower	15 m dia x 4.8 m SWD	2
8	Mixing chamber	6.25 m x 4 m x 3.5 SWD	1
9	Aeration tank	17.75 m x 29.55 x 4 m SWD	2
10	Secondary clarifier	26.8 m dia x 3 m SWD	2
11	Chlorine contact tank	10 m x 18 m x 3 m SWD	1
12	Secondary sludge sump	5.5 m dia x 3.5 m SWD	1
13	Sludge thickener	16 m dia x 3m SWD	1
14	Centrifuge feed pump house	10 m x 6 m x 5 m Height	1
15	Centrifuge platform	7 m x 5 m x 3.5 m Height	1
16	Chlorinator house/room	6 m x 4 m x 4.5 m Height	1
17	Blower room & MCC room	16 m x 6 m x 5m Height	1
18	Workshop/store room	6 m x 4 m x 4.5 m Ht.	1
19	MEP building & Panel room-2	10 m x 6 m x 4.5 m Ht.	1
20	Administrative/lab building	200 sq.m x 4.5 m Ht.	GF+1
21	DG room/platform	10 m x 6 m x 4.5 m Ht.	1
22	Staff Quarter (A type)	34.2 sq.m	4
23	Staff Quarter (A type)	67.7 sq.m	2

4.4.5 Test Report of the Effluent

The water sample of the influent and effluent was collected and tested by U.P. Jal Nigam, Ganga Pollution Control Unit, Prayagraj which is tabulated below:

Month	Parameters				
	Flow, MLD	Influent, mg/l		Effluent, mg/l	
		BOD_5	TSS	BOD_5	TSS
October 18	36	111	274	6	8
November 18	31	113	276	7	8
December 18	Data Not Available				
January 19	26	100	227	3	4
February 19	35	130	284	9	12
March 19	35	128	284	9	11
April 19	34	120	274	9	11
May 19	34	119	280	12	15

4.4.6 Operational Problems and Solutions

4.4.6.1 Mechanical Screen Damaged

The mechanical screen installed at the plant is damaged. The clear opening of the screen has increased and the screening is not effective. It was noticed that the floating material like pouch and plastic etc. are entering in the downstream processing units. It has great impact on the performance of the plant.

4.4.6.2 Chlorination Tank

The dosing of sodium hypo chlorite should be checked daily for average and peak flow conditions. It is not proper to apply a standard dose all the time.

Operational issues mentioned for Numayadahi STP shall be applicable at Kodra STP also as it is also based on Bio-tower system.

4.5 10 MLD Sewage Treatment Plant at Ponghat

4.5.1 Introduction

The sewage treatment plant is based on Bio-Tower with Activated Sludge Process and was constructed in 2013.

4.5.2 Total Flow at STP

The sewage treatment plant currently receives about 6 - 8 MLD sewage against the installed capacity of 10 MLD.

4.5.3 Design Parameters

The sewage treatment plant was designed for following influent and effluent parameters:

S. No.	Parameters	Unit	Influent	Effluent
1	Temperature	°C	25 - 30	25 - 30
2	pH	-	6.5 - 8.5	6.5 - 8.5
3	BOD_5	mg/l	250	20
4	COD	mg/l	550	200
5	TSS	mg/l	500	30
6	Total Kjeldahl Nitrogen	mg/l	25	<0.5 NH_3-N
7	Phosphorus (Total as P)	mg/l	10	5
8	Total coliform	MPN/100 ml	10^7	< 1000
9	Oil & Grease	mg/l	5	< 5

4.5.4 Unit Sizes of Existing STP

Following units have been constructed to treat the domestic sewage:

S. No.	Unit	Size	Quantity (No.)
1	Inlet chamber	2.4 m x 0.75 m x 2 m SWD	1
2	Mechanical fine screen channel (2W)	2.4 m x 0.6 m x 0.375 m SWD	2
3	Manual fine screen channel (1 Standby)	2.4 m x 0.6 m x 0.375 m SWD	1
4	Grit chamber	3.5 m x 3.5 m x 0.65 SWD	2
5	Manual grit channel	12 m x 1 m x 0.375 SWD	1
6	Distribution chamber/splitter box	2.4 m x 0.75 m x 2 m SWD	1
7	Bio tower	10.5 m dia x 4.2 m SWD	2
8	Mixing chamber	5 m x 3 m x 3.5 SWD	1
9	Aeration tank	12 m x 17.5m x 4 m SWD	2
10	Secondary clarifier	17 m dia x 3 m SWD	2
11	Chlorine contact tank	12 m x 6 m x 3 m SWD	1
12	Secondary sludge sump	3.5 m dia x 2 m SWD	1
13	Sludge thickener	10 m dia x 3m SWD	1
14	Centrifuge feed pump house	7 m x 6 m x 5 m Height	1
15	Centrifuge platform	7 m x 5 m x 3.5 m Height	1
16	Chlorinator house/room	5 m x 4 m x 4.5 m Height	1
17	Blower room & MCC room	14 m x 6 m x 5m Height	1
18	Workshop/store room	6 m x 4 m x 4.5 m Ht.	1
19	MEP building & Panel room-2	10 m x 6 m x 4.5 m Ht.	1
20	Administrative/lab building	60 sq.m x 4.5 m Ht.	GF+1
21	DG room/platform	10 m x 6 m x 4.5 m Ht.	1
22	Staff Quarter (A type)	34.2 sq.m	4
23	Staff Quarter (A type)	67.7 sq.m	2

4.5.5 Test Report of the Effluent

The water sample of the influent and effluent was collected and tested by U.P. Jal Nigam, Ganga Pollution Control Unit, Prayagraj which is tabulated below:

Month	Parameters				
	Flow, MLD	Influent, mg/l		Effluent, mg/l	
		BOD_5	TSS	BOD_5	TSS
October 18	7	81	183	6	8
November 18	7	82	170	6	8
December 18	Data Not Available				
January 19	8	85	174	6	8
February 19	7	89	181	9	9
March 19	7	93	176	8	10
April 19	6	84	159	7	9
May 19	6	90	178	13	15

4.5.6 Operating Problems and Solutions

Following operation and maintenance problems were visible during the visit to the site of STP:

4.5.6.1 Underutilisation of Capacity

Due to the presence of earth/soil in the incoming sewage, the aeration tank gets silted. Therefore, frequent desilting of aeration tank is required. This is causing problems in maintaining MLSS in the aeration tank and has an effect on the operation of centrifuge.

4.5.6.2 General Upkeep of Campus

General upkeep of the compound is unsatisfactory.

- Operational issues mentioned for Numayadahi STP shall be applicable at Ponghat STP also as it is also based on Bio-tower system.
- The BOD of about 80 mg/l at the inlet is extremely low when compared to the design value of 250 mg/l. The BOD gets reduced after passing through the bio-tower. Moreover, the TSS is also extremely low in the range of about 180 mg/l. In such case, the aeration tank shall not perform as it would be not possible to maintain the MLSS. To increase the organic load, it is recommended that the sewage is carried to the plant through sewerage network.

4.6 60 MLD Sewage Treatment Plant at Rajapur

4.6.1 Introduction

The sewage treatment plant is based on Up-flow Sludge Blanket Reactor (UASB) Technology and was commissioned in 2013.

4.6.2 Total Flow at STP

The sewage treatment plant currently receives about 65 to 90 MLD sewage against its installed capacity of 60 MLD. Thus, the plant is operating at 40% additional hydraulic load. The treated effluent is discharged to river Ganga.

4.6.3 Design Parameters

The sewage treatment plant was designed for following influent and effluent parameters:

S. No.	Parameters	Unit	Influent	Effluent
1	pH	-	7 - 8.5	7 - 8.5
2	BOD_5	mg/l	200	< 10
3	COD	mg/l	450	-
4	TSS	mg/l	500	< 20
5	VSS	mg/l	300	-

4.6.4 Unit Sizes of Existing STP

Following units have been constructed to treat the domestic sewage:

S. No.	Unit	Size	Quantity (No.)
1	Inlet chamber	2.9m x 7.8m x 3m	1
2	Bypass chamber	2.9m x 1m x 3m	1
3	Mechanical screen channel	8m x 1.45m x 0.6m	2
4	Manual screen channel	8m x 1.90m x 0.6 m	2
5	Grit chamber (Mechanical)	7.5m x 7.5m x 0.8m	2
6	Manual grit chamber	18.5m x 3.55m x 0.8m	2
7	Parshall flume	12m x 2.72m x 1m	1
8	Division Box No.-1	11.4m x 2.1m x 2m	1
9	Division Box No.-2	4.6m x 1.3m x 2m	1
10	Distribution box	2.3m x 0.85m x 2m	12
11	UASB reactor	32m x 24m x 5.5m	6
12	Gas holder	10 m dia Volume 378 m^3	1
13	Aeration pond	90m x 96m x 3.5m	1
14	Polishing pond	4000 sq.m x 1.8m	1
15	Chlorine mixing tank	6m x 4m x 3.5m	1
16	Chlorine contact tank	34.3m x 27.3m x 3m	1
17	Outlet chamber	20.5m x 2.5m x 1.8m	1
18	Sludge drying bed	30m x 20m	20

4.6.5 Test Report of the Effluent

The water sample of the influent and effluent was collected and tested by U.P. Jal Nigam, Ganga Pollution Control Unit, Prayagraj which is tabulated below:

Month	Parameters				
	Flow, MLD	Influent, mg/l		Effluent, mg/l	
		BOD_5	TSS	BOD_5	TSS
October 18	65	176	374	41	74
November 18	65	174	393	107	156
December 18	Data Not Available				
January 19	87	166	421	25	46
February 19	91	157	387	23	47
March 19	85	139	351	23	53
April 19	78	144	366	23	52
May 19	73	137	346	22	50

4.6.6 Operational Problems and Solutions

4.6.6.1 Excess Hydraulic Overloading

The plant is designed for a hydraulic loading of 60 MLD against which it is receiving a higher hydraulic load of 25% to 50%. There are 6 no. of UASB reactors each to handle a hydraulic load of only 10 MLD but operating at a hydraulic load of 12.5 MLD to 15 MLD. This excessive loading upsets the performance of the reactors. This excess flow causes an increase in the up-flow velocity which should remain less than 0.5 m/ hr and 1.5m/hr at average flow conditions and peak flow conditions respectively. Excessive up-flow velocities damage the sludge blanket which is most important function in UASB process.

4.6.6.2 Lower Organic Loading

The problem gets further deteriorated due to lower availability of organic matter i.e., BOD/COD. The UASB functions most efficiently and effectively under excessive organic loading. The UASB are best suited for higher BOD/COD. The formation of required height of sludge blanket with required solids concentration of about 65 kg/m^3 does not happen in case of lower organic loading.

The excess hydraulic load having higher up-flow velocity damages the sludge blanket which is already thin because of lower organic loading. These two factors coupled with each other reduce the performance of UASB reactors. Therefore, it is recommended that excess flow in addition of 60 MLD should be diverted elsewhere or new units should be constructed to encounter the problems. It is also recommended that the concentration of sludge being withdrawn from the reactors should be measured regularly and every attempt should be made by monitoring the sludge withdrawal timing and permitting formation of a better sludge blanket with whatever organic load is available. It shall not solve the problem fully but the performance of the UASB reactors shall definitely improve.

4.6.6.3 Unequal Flow in Launders from V-Notches

During site visit, unequal flow from V-notches to the launders were observed. This was visible almost in all the reactors and all the launders. All the V-notches should discharge equal amount of water to their respective launder which was not noticed. The V-notches are not installed in levelled position due to which the problem persists. Occasionally, the carryover of solids is also a possibility which shall deteriorate the quality of effluent of the UASB reactor.

4.6.6.4 Possibility of Sand Accumulation in Reactors and Polishing Pond

The sewage pumping station located within the premises of sewage treatment plant was facing problem of sand deposition in the sump of the pumping station. It was being cleaned from time to time but the sand, an inorganic material was also pumped along with wastewater which might have mixed with sludge and accumulated in the reactors or polishing pond. This has to be checked by taking samples of the deposited sludge in the reactors as well as polishing pond and as assessment can be made as to what extent the accumulation has taken place. It can be done only by cleaning the reactors or polishing ponds. The problem was faced due to transportation of sand due to some leakage in the sewer line gravitating in the last manhole adjacent to the pumping station.

4.6.6.5 Inlet Chamber and Polishing Pond

Problems of excessive foaming occurs at the inlet chamber and continues up to the conveyor belt of the screen and in the polishing ponds. Foaming was also observed at outlet chamber of the chlorination contact tank.

- **Sludge Withdrawal from UASB Reactor -** The sludge is withdrawn from the UASB reactor twice a day each time about 20 to 25 minutes. The application of sludge is about 10 cm per day and one sludge drying bed of 30 m x 20 m size is filled continuously for three days with total application of 30 cm depth of sludge. The concentration of sludge is not measured.
- **Polishing Pond -** There are 14 aerators each of 12.5 HP capacity in which 12 are working and 2 are kept as a standby. It was reported that the capacity of aerators is not sufficient to bring down influent BOD to the polishing pond to the desired level in case of excess hydraulic load to the STP.
- **Chlorination Tank -** 2 no. chlorinators (1W+1SB) each of 15 kg/hour have been installed and operated at 12.5 kg/hour. When the chlorinators are operated at full capacity i.e., 15 kg/hour in case of excess flow being received at the STP, chlorination is not effective to the desired level. Residual chlorine of 0.1 to 0.3 mg/l has been measured.
- **Biogas Generation -** Due to lower content of incoming BOD, very little gas is collected in the gas holder which is flared. Any arrangement for power generation such as installation of pure gas engine along with H_2S scrubbing unit has not been installed at the plan

5 Summary of STPs data

STP details	Inlet Parameters						Outlet Parameters				Remarks
	Design flow (MLD)	Actual (MLD)	Design BOD	Actual BOD	Design TSS	Actual TSS	Design BOD	Actual BOD	Design TSS	Actual TSS	
Naini	80	60-65	300	110-120	500	350-370	30	24-28	50	40-48	Satisfactory
Salori	29	35-45	250	110-121	400	347-368	30	26-29	50	44-50	Satisfactory
Numayadahi	50	53-66	250	120-128	500	271-276	20	12-13	30	14-16	Satisfactory
Kodra	25	34-36	250	100-130	500	227-284	20	3-9	30	4-12	Satisfactory
Ponghat	10	6-8	250	81-93	500	159-183	20	6-13	30	8-15	Satisfactory
Rajapur	60	65-90	200	137-176	500	346-421	10	22-25	20	46-52	Unsatisfactory

6 Details of MPS / SPS at Prayagraj

S. No.	Name of SPS	Capacity	Sanctioned Load (KVA)	Pump set (Qty)	Transformer	D.G. Set
1	Gaughat MPS	80 MLD	1175	4200 lpm,36 m head, 400 HP, 6 Nos 21000 lpm,24 m head, 200 HP,3 Nos	800 KVA 911/3.3 KVA), 3 Nos,800 KVA (11/0.415 KVA), 2 Nos	1000 KVA, 500 KVA, 40 KVA, 400 KVA (2 Nos)
2	Alopibagh SPS	45 MLD	563	16000 lpm,24 m head,150 HP,4 Nos 16000 lpm,24 m head, 150 HP,2 Nos	630 KVA (2 Nos)	400 KVA , 320 KVA
3	Morigate SPS (Old)	12 MLD	52	7000 lpm,22 m head,55 HP,1 No 4200 lpm, 12 m head, 25 HP,1 No 8500 lpm, 12 m head, 35 HP,1 No	---------	---------
4	Morigate SPS (New)	12 MLD	165	8500 lpm, 19 m head,70 HP,3 Nos 4200 lpm, 19 m head, 40 HP, 2 Nos	250 KVA, 2 nos	125 KVA , 2 Nos
5	Chachar Nala SPS	35 MLD	237	18000 lpm, 17 m head,125 HP,3 Nos 9000 lpm, 17 m head, 75 HP, 2 Nos	400 KVA, 2 Nos	160 KVA, 3 Nos
6	Allahpur SPS	5 MLD	45	2600 lpm, 20 m head,25 HP,2 Nos 1300 lpm, 20 m head, 20 HP, 2 Nos	---------	70 KVA
7	Daraganj SPS	2 MLD	46	1700 lpm, 22 m head,20 HP,3 Nos 850 lpm, 22 m head, 15 HP, 2 Nos	---------	62.5 KVA
8	Lukarganj SPS	16.5 MLD	86	3600 lpm, 12 m head,20 HP,6 Nos	160 KVA, 2 Nos	100 KVA
9	Ghaghar Nala SPS	50 MLD	815	18000 lpm, 36 m head,240 HP,6 Nos	1000 KVA, 2 Nos	500 KVA, 2 Nos
10	Mumford Ganj SPS	55 MLD	563	17450 lpm, 22 m head,150 HP,6 Nos	800 KVA, 2 Nos	400 KVA, 2 Nos
11	Sasur Khaderi SPS	15 MLD	161	6000 lpm, 20 m head,50 HP,6 Nos	400 KVA, 2 Nos	125 KVA, 2 Nos
12	Vivekanand Park SPS	15 MLD	93	3000 lpm, 13 m head,20 HP,6 Nos	160 KVA, 2 Nos	125 KVA
13	Kali mandir SPS	10 MLD	75	2000 lpm, 15 m head,15 HP,6 Nos	160 KVA, 2 Nos	125 KVA
14	29 MLD Salori SPS	29 MLD	800	14250 lpm, 20 m head,120 HP-6 no.	800 KVA, 2 Nos	500 KVA,2 Nos
15	14 MLD Salori SPS	14 MLD	643	345m3/hr, 19m head-6no	800 KVA, 2 Nos	400 KVA, 320 KVA
16	Ponghat SPS	10 MLD	290	209m3/hr,21m head-6no	400 KVA, 2 Nos	160 KVA,2 Nos
17	Kodra SPS	25 MLD	732	588m3/hr,18m head 6 no	800 KVA, 2 Nos	380 KVA,2 Nos
18	Rajapur SPS	25 MLD	850	7850lpm, 16m head, 60 HP- 6no.	1000 KVA, 2 Nos	320 KVA,2 Nos

6.1 Operational Problems noticed at Sewage Pumping Stations

- **Chachar Nala IPS & Gaughat MPS-** Performance of screenings separation by the raking system of mechanical screens need to be fine- tuned.
- **Lukarganj SPS**- NRV provided on the rising main does not operate with single pump running so counterweight of the NRV is kept in lifted position all times by external support.
- **Sasur Khaderi SPS-** During the visit to the site, it was observed that after removal of screenings, the screenings are dumped from operating floor to the ground, which needs to be improved by providing vertical chute. Access to the pumping station is not well made and is unapproachable during floods.
- **Morigate Old SPS-** The access to the pumps within the pumping station is congested.
- **Morigate New SPS-** Access to the bar screenings at nala tapping is limited.
- **Allahapur SPS-** Minor maintenance is required to the pumps to fix leakage through glands.
- **Daraganj SPS-** The pumping station receives very less flow. Operating level of pumps is very high from the surrounding ground level to protect it from flood.
- **Alopibagh SPS-** The screens need to be replaced immediately. Temporary flow diversion shall be required for replacement of screens. The existing old structures require minor repairing like plastering, handrails etc. The pumping station receives flow from 4 sewage pumping stations and sewage by gravity flow from its own contributory area. Alopibagh pumping station pumps to gravity system which leads to Mumford Ganj MPS which pumps further to Rajapur STP. This is very critical link within the collection system for Sewerage District-D.
- **Rajapur SPS-** This pumping station is encountering problems of sand accumulation within the sump. The problem of sand getting transported from the sewer lines gravitating into the last manhole adjacent to the pumping station. During Kumbha Mela, the problem was resolved to some extent but it still continues. All the sewer lines terminating into the last manhole has to be checked and repaired at the specific location. The pumping station is receiving excess flow than the installed capacity resulting in an overflow.
- **Ponghat SPS-** The incoming sewage has larger quantity of earth/soil.
- **Vivekanand Park SPS and Kali Mandir SPS-** The screenings removal conveyor belt support system needs to be improved by way of providing cross bracings. The incoming sewage flow is very less at present.

7 Assessment of STPs vis-à-vis Concessionaire Agreement

The current status of performance, the immediate works to be done and the required measures for further development of the above mentioned STPs and SPS have been outlined in chapter 5 and 6 of this report as well as in Progress Review MoM received from ED Mr Kumar (see Annex).

A detailed assessment of the Concessionaire Agreement (CA) for construction, renovation and management of STPs in Prayagraj is presented in a separate report[1]. Here below, we present a brief overview **of the potentially critical interfaces of the related CA considering the current status of infrastructure (SZPs and SPSs). The situation is as follows:**

- The operator of none of the STPs has control on development and O&M of the sewage collection system (increase of connection rate of house connections, increase of separated sewer systems, storm water management)
- All STPs receive less concentrated influent compared to the design values and must be operated with low pollutant loads
- All STPs are negatively influenced by events of heavy rain fall and Monsoon (high dilution rates, flushing effect, increase in O&M cost)
- The effluent standards of all STPs are based on the Environment (Protection) Amendment Rule published in the Official Gazette of India at 13th of October 2017 but finally established by the U.P. PCB acc. to the specific local requirements for each individual STP (exclusively for parameters pH, BOD, TSS and Faecal Coliforms - no standards for nitrogen and phosphorus removal have been introduced)
- All disinfection facilities using chlorine as disinfectant
- All STPs apply mechanical sludge dewatering mostly by centrifuges, sludge drying beds
- In Naini STP a anaerobic digestion with biogas utilisation has been implemented (however, because of less sludge production, low content of volatile solids, low biogas generation and high O&M cost of the co-generation unit the facilities could not be used effectively).

8 General Recommendations

The visit to the sewage treatment plants, interaction with operation and maintenance staff and a perusal of available records at the plants revealed the fact that some basic requirements summarised below have to be fulfilled in order to improve the performance of the plants.

[1] Technical Review of Concession Agreement at Prayagraj, November 2019

Integrative multi-level approach involving economic, technical, environmental and organisational dimensions should be considered for effective and efficient operation of sewage collection, treatment and disposal facilities. The priority issues identified are summarized as under:

8.1 Training the Operation and Maintenance Staff

The O&M function is performed by (a) operating staff and (b) supervisory staff. While the former actually runs the system, the latter monitor the operations and provide managerial support. The O&M staff should know the procedures for routine tasks to be performed by them and supervision and inspection managers should know the checks and inspections to be carried out by them at specified intervals to monitor and evaluate the status of operation and maintenance. The supervision or inspecting officers have to ensure that the operation and maintenance staff perform their assigned duties promptly.

A systematic plan of action of any training program includes;

- Identification and assessment of the need for planned training
- Defined training objectives.
- Appropriate strategy for training.
- Provision for assessing effectiveness of training.
- Determine what is required or expected in the job.
- Determine the degree to which this requirement is being met.
- Determine whether training can bridge the gap between what is required in the job and the present knowledge, skills, attitudes or behaviour of the employees.
- Problems faced by jobholders in learning basic skills and applying them successfully in work.
- Weakness in performance of existing jobholders due to gap in knowledge, lack of skills or motivation.
- Areas where competence levels are not up to standards required.
- Area where future changes in work process or methods or job responsibilities indicate training needs.

8.2 Process Design

The process design of STPs were available during the time of site visit. It is very important to have basic and thorough understanding of the process design. It was noticed that the engineers are not fully aware of the design parameters of various units which is a major setback in operation and maintenance of the plants and not in a position to find out the lapses or omissions in the design.

It is very essential for the engineers involved in construction and maintenance of the plants to understand the functioning of individual units of the process train and importance of operations such as sludge withdrawal etc. It will help the site staff to overcome and encounter problems arising during maintenance.

8.3 Return Sludge and MLSS

Sufficient return sludge capacity should be provided if the biological solids are not to be lost in the effluent. However, a return flow rate higher than what is required unnecessarily increases solids loading on settling tank and results in withdrawal of dilute sludge. The ratio of return sludge flow to average flow can be set on the basis of SVI. It is defined as the volume in ml occupied by one gram of activated sludge mixed liquor solids, dry weight, after settling of 30 min. in a 1,000mL graduated cylinder. SVI values in the range of 50 to 100 ml/g indicates good settling characteristic of the sludge. Higher values of SVI normally indicates filamentous growth which has poor settling properties. A value of over 200 definitely indicates sludge bulking. A good operation calls for prompt removal of excess sludge from the secondary tanks to ensure that the sludge is fully aerobic.

Control of the concentration of solids in the mixed liquor of the aeration tanks is an important operating factor. It is most desirable to hold the MLSS constant at the suggested concentration. The test of MLSS should be done at least once a day on large plants, preferably during peak flow. As the MLSS will be minimum when the peak flow starts coming in and will be maximum in the night hours when the flow drops, operating MLSS value would be the average hourly value in a day; the same should be verified at least once a month. In case of large plants, daily check at a fixed time is desirable. These suggestions can be applied in STPs having aeration tanks and secondary clarifiers such as Naini, Numayadahi, Kodra and Ponghat.

8.4 Holistic Approach to Urban Sewage System

Capacity of STP is directly linked with conveyance and collection system, coverage of service areas, sewerage network having connections of households, SPSs and increase in sewage generation in years to come and possibilities of recycling/reuse of the treated water.

The CPHEEO Manual on Sewerage and Sewage Treatment Systems, issued by Ministry of Urban Development, GoI in its Volume named as Part-A Engineering Chapter 7: Recycling and Reuse of Sewage, (Page 7-1) has clearly spelled out that at least 20% of treated waste water shall be used in gardens, parks and agriculture etc. to begin with. Necessary infrastructure facilities need to be planned and developed for reuse of treated water. The largest reuse resides in Agriculture. The construction of canals, drains, pipes, arrangements for necessary control measures for discharge of required quantity of water etc. are needed to maximise the reuse of treated water which is a precious resource. The possibilities to supply treated water for further use such as at thermal power stations, discharging of treated water in nearby irrigation canal or for restoration of minimum flow in some nearby river, form forestry, toilet flushing, industrial use as in non-human contact and fish culture etc. should be seriously explored.

At present some water is being used at Naini STP for agriculture purposes but it is also not adequate as the canal carrying the treated water is damaged at many places and needs repair. At other STPs, infrastructure facilities for reuse of treated water needs to be developed.

8.5 Technical Analysis of Test Results

It was observed that the composite sampling has not been undertaken; therefore, the test results based on random sampling may not indicate the actual performance of the STP. The test results of Total Nitrogen, NH_4-N and PO_4-P were not available. It is therefore required to determine all required parameters including all bio nutrients of raw wastewater at the inlet and effluent at the outlet by way of composite sampling.

8.6 Sludge Management

There is no consistent sludge treatment concept on all the STPs. It was observed that wet as well as dried sludge were dumped here and there on the site or around the plant. It creates serious environmental issues of air and water pollution. Surrounding areas especially farms and river Ganga are directly polluted. Sludge composition is required to be looked into as farmers may take sludge at some places for application in the fields. The sludge stabilization was found to be insufficient. Sludge drying should be optimized to dry contents > 50% for using it for landfills. Overall sludge handling and management issues should be critically viewed including provision of covering some of the sludge drying beds with simple sheds to provide space for storage and drying during monsoon season. Composition of presence different elements should also be recorded occasionally to know presence of toxic substance, if any.

All the STPs have been provided with sludge drying beds/ mechanical dewatering equipment which have some advantages and some disadvantages. The technological advancements as suggested in CPHEEO Manual on Sewerage and Sewage Treatment Systems (Chapter 6 ,Page no. 6-69 to 6-90), like heat drying, incineration, sludge composting, chemical conditioning, solar sludge drying beds, sludge storage, sludge as soil filler, sludge storage yard, sanitary land fill and co-incineration with municipal solid waste can be studied and applied as per suitability of site, applicability of particular method and financial resources. For example, the cost of disposal is reduced by 75% to 80% as the solids content in the sludge is increased from 20% to 80% during solar sludge drying and the dried sludge can be used as manure/soil conditioner. These steps shall help in minimising the bacterial counts in the sludge. Normally, most of common pathogens are destroyed within a period of 1 hour at 55°C.

8.7 Economic Aspects

The operation and maintenance of STPs has become extremely difficult due to increasing cost of materials, manpower and electricity. It is needed that the current scenario of sewer charges etc. should be relooked to make the O&M sustainable. During earlier years after setting up of 60 MLD STP in Naini, the treated water was used by the farmers for irrigation purposes and some revenue was collected by the Nagar Nigam, Prayagraj. The practice was discontinued after the channel carrying the treated water was damaged. Therefore, it is suggested that the use of treated water should be explored at every STP to earn some revenue as well as save a precious resource like water. Similarly, the sludge generated should be treated so that it can be used as biosolids in the fields. Generation of power by using the available biogas shall also save money being spend on power. Some part of the expenditure on O&M of STPs, sewage pumping stations and the collection system can be set off by adopting these methods.

8.8 Measurements of Parameters

It was observed at all the STPs that the measurement of influent and effluent parameters is measured properly and the test results of all treatment plants are within the design parameter. The component of VSS in the wastewater should also be measured to ascertain the quantum of inert TSS. Similarly, Total Nitrogen, TKN, NH_3-N and Org-N should be recorded both for influent as well as effluent. The quantity of soluble BOD (sBOD), soluble COD (sCOD) and readily biodegradable COD rb (COD) should also be tested at least once in six months. In case, it is not possible to measure sBOD, sCOD and rb (COD), then these parameters can be computed by using the method of fractionation of COD. It is highly recommended that the laboratory staff engaged for carrying out testing of samples should be imparted sufficient training to conduct all tests themselves.

A list of instruments/equipment should be prepared for all tests that are required to be carried out in the laboratory. All such necessary instruments/equipment should be arranged which are not available in the laboratory or have served their useful lives.

The analysis shall help to have clear knowledge of non-biodegradable VSS (nbVSS), non-biodegradable particulate Organic nitrogen (nbpON), fraction of Organic-N content of VSS and total degradable TKN. It shall immensely help the authorities to run the STPs properly. It is also suggested that the parameters should also be measured occasionally, after each unit in respective STP to ascertain the proper functioning of respective units of these STPs.

8.9 O&M Manual

O&M manual is strongly needed to maintain the assets defining maintenance schedules of respective units including pump and machinery, following occupational health and safety guideline, defining preventive maintenance and routine observations to be carried out. O&M manual shall also clearly define the roles of the individuals involved at various levels and their responsibilities, needs of training, institutional development and capacity building and making arrangements for finances required for effective and efficient maintenance of STPs and related works.

Annex - Minutes of Meeting of a Progress Review for Prayagraj STP Projects on 04/06/2019

Minutes of the Meeting for review of progress of achievement of conditions precedent by the stakeholders of the Prayagraj, Allahabad STP projects under HAM on 4th June 2019 under the chairmanship of Shri G. Asok Kumar, Executive Director(Projects), NMCG.

1. List of participants is enclosed in Annexure 1.
2. As this meeting was follow-up of the review meetings held on 6/3/19 and 6/5/19, the Action Taken Reports (ATR) on the minutes of these meetings were taken up first. UP Jal Nigam(UPJN) informed that revised design & drawings for Naini 2 and Phaphamau of Package-I have been submitted to IIT-BHU on 14th May 2019 for vetting. But IIT-BHU is yet to finalize the review/comments. It was informed that formal consent/quote from IIT_BHU is yet to be received. ED (Projects) instructed that the Project Engineer (i.e. AECOM), UPJN and Concessionaire shall jointly follow up with IIT- BHU for early clearance of drawings. These are very critical issues affecting the conditions precedent and may result in postponing the effective date unnecessarily. He directed the Project Engineer (PE) to bring to the notice of NMCG, such critical issues without waiting till the last day. UP Jal Nigam, AECOM and Concessionaire shall take necessary steps expedite the process of vetting of the drawings by IIT BHU at the earliest. In any case, UPJN should ensure that the approval for design & Drawings is given on or before 20th June 2019.
3. UPJN has raised certain comments on the rehabilitation plan for Package II and III facilities(Existing Assets) submitted by concessionaire on 17th May 2019. It was directed that the Concessionaire shall submit the compliance report on the comments received on or before 8th June 2019 and UPJN to approve the final rehabilitation plan for Package II & III facilities on or before 12th June 2019.
4. It was informed that as decided in the previous meeting, *all existing* 10 SPSs and 6 STPs (under Package II & III facilities) have been taken over by the Concessionaire and Operation & Maintenance work has been started. The cost for O &M of these assets till the announcement of effective date needs to be paid separately.
5. Consent to Establish (CTE) and Consent to Operate (CTO) for the existing STPs have been filed and joint inspection with Regional Officer of UP Pollution Control Board was conducted on 3rd June 2019. It was informed by UPJN that CTE for Naini 2 and Phaphamau STPs are expected to be received within 15 days. Similarly permission for tree cutting in Phaphamau STP site has been applied on 25th May 2019. ED(Projects) instructed that UPJN shall actively coordinate with the respective departments to get all necessary permissions for road/railway crossing, tree felling etc required for early start of the project.
6. M/s Adani has submitted revised comments on design & drawings of Phaphamau STPs on 7th May 2019. AECOM is working on it and will give their comments tomorrow.
7. As far as land issues are concerned, UPJN informed land for Phaphamau STP site is already in possession and will be handed over to the concessionaire on or before 12th June 2019. There are still may land related issues to be sorted out fully. The current status of possession of land for other sites is as follows:

Sl.No	Location	Asset Details	Issues raised by Concessionaire	Information by UPJN	Directions by ED(Projects)
1	Naini-II	STP	Land is *yet to be transferred* to UPJN. In the proposed land, cultivation is being carried by the local farmers. So and if there is any lease with farmers then it would be required to cancel such lease.	Prayagraj Nagar Nigam has passed a board resolution on 28th May 2019 for exchange of land with ADA. But UPJN is yet to receive the copy of resolution. Once it is received the matter will be taken up with the concerned authority. Total area of 8-hectare is available in the site and after the board resolution, the matter shall go to Revenue Department, Govt. of UP for approval & handing over to UPJN.	ED (P) instructed UPJN to follow-up with authorities to resolve the issues and hand over the land on or before 20th June 2019.
		Mawaiya SPS	Land for both the SPS are identified *but yet to be acquired by UPJN.*	Proposal has already been submitted to the State Government and the GO is expected within two weeks.	UPJN shall coordinate with the concerned department so as to ensure the acquisition of the land for both SPS at the earliest.
		Mahewa Ghat SPS			
2	Phaphamau	Basana Nala SPS	Land is *yet to be transferred to UPJN by ADA*	ADA has already passed a board resolution on 3rd June 2019. It is expected that land transfer will happen within a week.	UPJN shall ensure the handing over of the SPS site along with the STP on or before 12th June 2019.

3	Jhunsi	STP	*The site is now changed.* UPJN has identified 0.76 Ha of land. But *the new site has not been transferred to UPJN.*	For Jhunsi STP 0.76 Ha of land of Gram Samaj has been demarcated. The work can start once the land is handed over. Also for additional 1.25 Ha for future expansions and septate treatment local public/sellers have agreed to sell the land in a meeting held on 30th May 2019 in the presence of SDM. Once acquired sufficient land will be made available.	UPJN shall hand over the 0.76 Ha of land to the concessionaire on or before 15th June 2019. Also Consent to Establish the STP at new site has to be reapplied at the earliest.
		Shastri Bridge SPS	Land is available but yet to be transferred to UPJN	Vacant Land of Gram Samaj has been identified and demarcated.	UPJN shall handover the site on or before 15th June 2019.

8. Concessionaire informed that voluminous sludge is generated by all STPs in Prayagraj and UPJN is yet to identify a suitable site for disposal of the same. ED(Projects) requested the concessionaire to explore the commercial possibility of such huge volume of sludge. Concessionaire informed sucha possibility is being actively considered and will take another 6 months to finalize. Till such time UPJN may identify a suitable site for sludge disposal. In view of this ED(Projects), directed that till the concessionaire develop an alternate business proposition for sludge disposal. UPJN may identify the existing sites for disposal of sludge and instruct the concessionaire accordingly.
9. All concerned parties shall complete their conditions precedent at the earliest. The Effective Date for the project will be declared on 20th June 2019.
10. Next review meeting will be held on 18th June 2019.
11. The meeting ended with vote of thanks to the chair.

SGR - GOPA Infra GmbH Team

Laura Sustersic
Team Leader
GIZ-Support to Ganga Rejuvenation Project-UK & UP (2018-20)

John Thomas
Technical Advisor & Sr. Long Term Expert
GIZ-Support to Ganga Rejuvenation Project-UK & UP (2016-20)

EW

Evers Willing
International Short-term Expert, Wastewater & Sludge Treatment
GIZ-Support to Ganga Rejuvenation Project-UK & UP (2016-20)

DPS

Durga Prasad Singh
National Short-term Expert, Wastewater Management
GIZ-Support to Ganga Rejuvenation Project-UK & UP (2016-20)

Ruchi Yadav
Project Support Manager
GIZ-Support to Ganga Rejuvenation Project-UK & UP (2016-20)

We can be contacted at;

State Programme Management Group (SPMG)
117, Indira Nagar
Dehradun, Uttarakhand, India

State Mission for Clean Ganga (SMCG)
Plot no 18, Sector 7
Gomti Nagar Extension
Lucknow, Uttar Pradesh, India

Laura Sustersic
Team Leader
M - +91 93686 13625
E – Laura.Sustersic@gopa-infra.de