A
PROJECT REPORT
ON

"A Case Study on: Cost Effective Techniques for Treatment of Domestic Wastewater"

TERM DURATION: - OCTOBER 2021 TO MARCH 2022

GUIDE: -	**SUBMITTED BY: -**
A.N. PACHANI	**'A' GROUP**

DEPARTMENT OF CIVIL ENGINEERING

(NBA Accredited)

TAPI DIPLOMA ENGINEERING COLLEGE,

SHREE SWAMI ATMANAND SARSWATI VIDYA SANKUL

KAPODRA, VARACHHA ROAD, SURAT-395006

GUJARAT (INDIA)

Vision: To impart human values with competency in civil engineering field having innovative approach to satisfy global needs.

Mission: To develop Civil engineers of high technical skills with ethical values & give exposure to them about latest technological development.

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PROJECT – II [3360613]

SUBMITTED BY:

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CERTIFICATE

This to certified that this project report entitled **"A Case Study on: Cost Effective Techniques For Treatment of Domestic Wastewater"** which is being submitted by Mr.____Enrollment No. ______________________ a bonfire student of _______________in partial fulfillment for the award of Diploma in Civil Engineering during for the year 2021-22 **(Term: October 2021 to March 2022)** is record of students own work carried out under my guidance. It is certified that all corrections/suggestions indicated for internal assessment have been incorporated in the report and one copy of it being deposited in the polytechnic library.

The project report has been approved as it satisfies the academic requirements in respect of Project Work prescribed for the said diploma.

It is further understood that by this certificate the undersigned do not endorse or approve any statement made, opinion expressed or conclusion drawn there in but approve the project only for the purpose for which it is submitted.

Guide

A. N. PACHANI

Head of Department

Department of Civil Engineering
Tapi Diploma Engineering College

External Examiners

1.______________

2.______________

Vision: **To impart human values with competency in civil engineering field having innovative approach to satisfy global needs.**

Mission: **To develop Civil engineers of high technical skills with ethical values & give exposure to them about latest technological development.**

ACKNOWLEDGEMENT

I consider it a privilege to be associated with the **Tapi Diploma Engineering College, Surat** in this academic endeavor. I express my heartfelt thanks to my Guide **Mr. A. N. Pachani** Lecturer in civil Engineering Department for his invaluable guidance, continued interest throughout the project work and encouragement towards the successful completion of this preliminary study.

I would also like to thank **Mr. M. P. Jariwala**, Head, Civil Engineering Department, for providing valuable ideas and suggestion in my work. I am very much thankful to **Dr. Y. S. Choupare**, **Principal** of Tapi Diploma Engineering College, Surat for providing all the necessary infrastructure/laboratory facilities during my course.

I am also very thankful to **Surat Municipal Corporation and technical team of Tertiary Treatment Plant of STP – Bamroli** as well as **Mr. Jignesh Mayani (Director of Climate Care Environmental Services, Surat)** for the suggestion of this project and useful technical guidance.

I am also very much thankful to all the faculty members for their valuable suggestions and comments during my dissertation work. I would like to express my appreciation towards all those who gave me the possibility to complete this work. I would also like to thank my friends and classmates for generous encouragement in my life.

Last but not least, I would thank to my almighty **GOD** for giving his blessing which were always encouraging me during my tough time.

Place: Tapi Diploma Engg. Collage, Surat

ABSTRACT

- Wastewater derived from human activities in households such as bath, laundry, dish washing, garbage disposal, toilets etc. is called as Domestic Wastewater which usually contains relatively small amounts of contaminants but even small amount of pollutants can make a big impact on environment. Hence, a properly installed and maintained residential sewage treatment system for treating and disposing of household wastewater will minimize the impact on ground water and surface water.
- Domestic waste water treatment plays an important role in nowadays. Domestic waste treatment ensures that all household sewage is properly treated to make it safe, clean and suitable for releasing back into the environment, lakes, or streams. Home sewage systems are designed to treat all of the liquid waste generated from a residence. Possible contaminants in household wastewater include disease-causing bacteria, infectious viruses, household chemicals, and excess nutrients such as nitrate.
- As per present scenario, around 62000 MLD domestic wastewater is generating in Indian cities (Class I & II cities, as per 2014-15 census) which will increase up to 75,000 MLD in 2021. Presently around existing STP having 23277 MLD capacities which are 35 to 40 % of generating sewage. So, it is required to provide proper treatment system to reduce environmental pollution specially to reduce water pollution and also recycling is present need to avoid water scarcity.
- More than 50% of the population has no access to safe drinking water and about 2, 00,000 people die every year for lack of access to safe water. India is currently facing the biggest crisis in its history about 82% of rural households are without piped water supply.

ABBREVATIONS

MLD	**:**	**Millions of Liters per Day**
GoG	**:**	**Government of Gujarat**
KL	**:**	**Kilo Liter**
Rs.	**:**	**Rupees**
RBI	**:**	**Reserve Bank of India**
km	**:**	**Kilometer**
SMC	**:**	**Surat Municipal Corporation**
M.O.U.	**:**	**Memorandum of Understanding**
PPP	**:**	**Public Private Partnership**
ADB	**:**	**Asian Development Bank**
SJMMSVY	**:**	**Swarnim Jayanti Mukhya Mantri Shaheri Vikas Yojna**
UF	**:**	**Ultra-Filtration**
RO	**:**	**Reverse Osmosis**
STP	**:**	**Sewage Treatment Plant**
TTP	**:**	**Tertiary Treatment Plant**
TDS	**:**	**Total Dissolved Solids**
BOD	**:**	**Biochemical Oxygen Demand**
sec.	**:**	**Second**
min.	**:**	**Minute**
pH	**:**	**Potential of Hydrogen**
CaCO3	**:**	**Calcium Carbonate**
Fe	**:**	**Iron**
Mn	**:**	**Manganese**
COD	**:**	**Chemical Oxygen Demand**
NTU	**:**	**Nephelometric Turbidity Unit**
Mg/L	**:**	**Milligram/Liter**
HCl	**:**	**Hydrochloric Acid.**

CO_2	**:**	**Carbon Dioxide**
IITM	**:**	**Indian Institute of Technology, Madras**
TNPCB	**:**	**Tamil Nadu Pollution Control Board**
ASP	**:**	**Activated Sludge Process**
PE	**:**	**Poly-Electrolytes**
SS	**:**	**Suspended Solids**
MPN	**:**	**Most Probable Number**
BWSSB	**:**	**Bangalore Water Supply and Sewerage Board**
HUDCO	**:**	**Housing and Urban Development Corporation Ltd**
KUIDFC	**:**	**Karnataka Urban Infrastructure Development and Finance Corporation**
RCF	**:**	**Rashtriya Chemicals and Fertilizers**
SDI	**:**	**Silt Density Index**
NEERI	**:**	**National Environmental Engineering Research Institute**
PHED	**:**	**Public Health Engineering Department**
NGO	**:**	**Non-Government Organization**
UNICEF	**:**	**United Nations Children's Fund**
DWR	**:**	**Durban Water Recycling**
BPD	**:**	**Business Partners for Development**
GAC	**:**	**Granular Activated Carbon**
MGD	**:**	**Million Gallons Per Day**
DEP	**:**	**Department of Environment Protection**
WWTF	**:**	**Wastewater Treatment Facilities**
SDWRP	**:**	**South District Water Reclamation Plant**
SDWWTP	**:**	**South District Wastewater Treatment Plant**
HLD	**:**	**High Level Disinfection**
MF	**:**	**Microfiltration**
TOC	**:**	**Organic carbon**
TOX	**:**	**Total organic halides**
EPOC	**:**	**Emerging Pollutants of Concern**
AOP	**:**	**Advanced oxidation processes**
UV	**:**	**Ultraviolet light**
H2O2	**:**	**Hydrogen peroxide**

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CH: 1 INTRODUCTION

1. INTRODUCTION

- Wastewater derived from human activities in households such as bath, laundry, dish washing, garbage disposal, toilets etc. is called as Domestic Wastewater which usually contains relatively small amounts of contaminants but even small amount of pollutants can make a big impact on environment. Hence, a properly installed and maintained residential sewage treatment system for treating and disposing of household wastewater will minimize the impact on ground water and surface water.

- Domestic waste water treatment plays an important role in nowadays. Domestic waste treatment ensures that all household sewage is properly treated to make it safe, clean and suitable for releasing back into the environment, lakes, or streams. Home sewage systems are designed to treat all of the liquid waste generated from a residence. Possible contaminants in household wastewater include disease-causing bacteria, infectious viruses, household chemicals, and excess nutrients such as nitrate.

- More than 50% of the population has no access to safe drinking water and about 2, 00,000 people die every year for lack of access to safe water. India is currently facing the biggest crisis in its history about 82% of rural households are without piped water supply[1]

2. OBJECTIVES

- As per present scenario, around 62000 MLD domestic wastewater is generating in Indian cities (Class I & II cities, as per 2014-15 census) which will increase up to 75,000 MLD in 2021. Presently around existing STP having 23277 MLD capacity which is 35 to 40 % of generating sewage. So, it is required to provide proper treatment system to reduce environmental pollution specially to reduce water pollution and also recycling is present need to avoid water scarcity.[2]

- Main focus of this project is to identify best suitable & cost-effective techniques for the treatment & recycling of domestic wastewater through various case study and available technologies.

- ***Reference for 1 & 2:***
  http://neoakruthi.com/blog/domestic-wastewater-treatment.html
  https://cpcb.nic.in/status-of-stps/
  https://www.financialexpress.com/lifestyle/science/indias-water-crisis-is-there-a-solution/2089860/

CH: 2 EXTERNAL GUIDANCE

We have taken guidance during previous semester (During UDP –I) from the **director (Mr. Jignesh Mayani) of M/s Climate Care Environmental Services**, Surat (Who is already working in the field of Water & Wastewater Management and Environmental Pollution Control having authorization of Schedule – II Environmental Auditor recognized by Gujarat Pollution Control board, Gandhinagar) for successful completion of this project.

For previous (5th) semester, we have visited M/s Climate Care Environmental Services on dated 31/07/2021, 28/08/2021 & 07/10/2021 for necessary guidance.

(Visit Photos at M/s Climate Care Environmental Services, Surat)

CERTIFICATE OF EXTERANAL GUIDE

Climate Care
Environmental Services
Best Solution with Better Technology
ISO 9001:2015 Certified Organization

TO WHM SOEVER IT MAY CONCERN

This is to certify that a group of students **(Project Group: A)** of **Tapi Diploma Engineering College, Surat** who are studding in **5th semester, Department of Civil Engineering** has approached the undersigned under the project guide **Mr. Arvind N. Pachani** (Faculty of Tapi Diploma Engineering College) for obtaining necessary guidance for their project work titled **"A Case Study On: Cost Effective Techniques for Recycling of Domestic Wastewater".**

The students have been guided about basics of wastewater treatment during the semester.

Thanking You,
Yours Faithfully,

Mr. Jignesh Mayani
CEO
Climate Care Environmental Service.

401-402, Shantiniketan Flora Business Hub, B/s Sanskar Tirth School, Abrama Road, Mota Varachha, Surat - 394101.
www.cces.in E-Mail : climatecare.es@gmail.com +91 95101 22444 +91 74349 22444

During current semester (IDP – II) we have further visited **M/s Climate Care Environmental Services**, Surat on dated 23/02/2022 for necessary discussion.

We have also visited **Sewage Treatment Plant of Surat Municipal Corporation** located at **Anjana & Bamroli** on dated **04/03/2022** &**07/03/2022** respectively to know/discuss about the treatment system, cost, etc. Anjana STP was visited with all the eligible students of 6^{th} semester as a part of curriculum subject Water & Wastewater Management while Bamroli – STP was visited by our project group only.

Visit Photo: Anjana STP

	
	

<u>Visit Photos: Bamroli STP</u>

Permission letter for STP – Anjana Visit

Surat Municipal Corporation
Drainage Department, Tadwadi,
Rander Road, Surat
Fax: (0261) 2451935
Phone No. 3041228 Ex.No.228

To,
The Principal,
TAPI DIPLOMA ENGINEERING COLLEGE,
Shree Swami Atmanand Saraswati Vidhya Sankul,
Kapodara,Varachha Road,
Surat -395006

DNC F/No. 7718
Date:- 24/2/22

Sub:- Regarding the Visit of the Sewage treatment plant at Anjana STP & Solid Waste Disposal Site (Khajod).
Reference: Your letter TDEC/2022/114, DTD.22-02-2022

Respected Sir,

With reference to the above subject, you are hereby permitted to visit the Sewage treatment plant at **ANJANA & Solid Waste Disposal Site Khajod on 04/03/2022 For Civil Eng. of 80 Students + 3 Faculty member** subject to following conditions subject to following conditions.

- The visitors shall have to visit the plant under the guidance of site supervisor / laboratory staff at Sewage Treatment Plant.
- **The visit should be completed between 11:00 to 13:00.**
- The visitors shall have to be instructed to behave politely with staff.
- The visitors shall not touch/damage any machineries/equipment at Sewage Treatment Plant.
- The plantation shall not be damaged.
- It is prohibited to throw any paper/garbage within plant campus. The dustbin provided within the campus shall have to be used for the same.
- Photography and video recording through any means is strictly prohibited.
- **Visitors strictly follow Covid 19 guidlines, wear mask and keep social distance.**
- **Surat Municipal Corporation shall not be responsible for any type of accident / damage/ health hazardous during plant visit.**

All the above conditions shall have to be followed strictly. If any mischief is found during visit, Surat Municipal Corporation may terminate the visit and take legal action.

Thanking you,

Yours faithfully

24/2/22

Environment Engineer (Drainage)
Surat Municipal Corporation,
Surat.

Permission letter for STP – Bamroli Visit

Managed By: Shree Tapi Brahmcharyashram Sabha, Surat.

TAPI DIPLOMA ENGINEERING COLLEGE

Formerly : Shree Tapi Brahmcharyashram Sabha College of Diploma Engineering

Approved by AICTE New Delhi & Affiliated to GTU Ahmedabad

ESTD: 2002

Shree Swami Atmanand Saraswati Vidya Sankul

Kapodra, Varachha Road, SURAT-395006 (Gujarat), Email :stbs_29@yahoo.co.in | website : stbscollege.org

Ph. : 0261-2571671/679 Fax : 0261-2571692

Ref. No. TDEC/CIVIL/ 233/05 **Date:** 21/02/22

To,

Drainage Department

Surat Municipal Corporation,

Tadwadi, Opp. Bejanwala Complex,

Rander Road, Surat

K.A. Shri E. H. Pathan (Executive Engineer)

Subject: Permission required to visit STP – Bamaroli for project group of students for academic purpose.

Dear Sir / Madam

We belong to Shri Tapi Brahamcharyashram Sabha, Surat;which is one of the oldest trusts engaged in Education & Social services since 1924. At present our polytechnic offers diploma courses in Civil, Electrical, Mechanical, Computer, Automobile and Information Technology.

Civil engineering related project at any industry/organization & its report submission is a part of syllabus of subject (Project I & II) for the final year student. One of our project group are working on the project titled **"A Case Study on: Cost Effective Techniques for Treatment of Domestic Wastewater"**

Therefore, you are requested to grant the permission (Any one day between **23/02/2022 to 11/03/2022)** to visit the sewage treatment plant located at Bamroli for following students with project guide (Mr. A N Pachani):

Receive Clerk Drainage Department 21/2/22

Sr. No.	Name of Students	Enrolment. No.	Contact No.
1	**Borda Prit V.**	**196470306011**	**9023688496**
2	Tarasariya Jenil	196470306101	7990656988
3	Bakaraniya Ayush A.	196470306005	9099831791
4	Kapdi Poojan D.	196470306051	9510330689
5	Pambhar Ravi V.	196470306065	8000130005
6	Parekh Abrar S.	196470306066	8866542919
7	Jadvani Madhav A.	186470306037	8238165068
8	Patel Shreyash R.	166470306084	7016531633

We request you to provide necessary guidance required for the successful completion of their project work & please provide them certificate of visit in your Industry/Plant.

Thank you for your kind co-operation.

Yours faithfully,

Mr. N. J. Patel
GTU Innovation Club Member

Dr. Y. S. Choupare
PRINCIPAL
TAPI DIPLOMA ENGINEERING COLLEGE
SURAT.

Contact No. 9825542202

Surat Municipal Corporation
Drainage Department, Tadwadi,
Rander Road, Surat
Fax: (0261) 2451935
Phone No. 3041228 Ex.No.228

The Principal,
TAPI DIPLOMA ENGINEERING COLLEGE,
Shree Swami Atmanand Saraswati Vidhya Sankul,
Kapodara,Varachha Road,
Surat -395006

DNG/OUT/No. 7721
Date:- 24/2/22

TAPI DIPLOMA ENGINEERING COLLEGE, SURAT
No. 39
Date 3/3/22

Sub:- Regarding the Visit of the Sewage treatment plant at BAMROLI STP
Reference: Your letter TDEC/CIVIL/233/05, DTD.21-02-2022

Respected Sir,

With reference to the above subject, you are hereby permitted to visit the Sewage treatment plant at **BAMROLI on 07/03/2022 For Civil Eng. of 8 Students + 3 Faculty member** subject to following conditions subject to following conditions.

- The visitors shall have to visit the plant under the guidance of site supervisor / laboratory staff at Sewage Treatment Plant.
- **The visit should be completed between 11:00 to 13:00.**
- The visitors shall have to be instructed to behave politely with staff.
- The visitors shall not touch/damage any machineries/equipment at Sewage Treatment Plant.
- The plantation shall not be damaged.
- It is prohibited to throw any paper/garbage within plant campus. The dustbin provided within the campus shall have to be used for the same.
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- **Surat Municipal Corporation shall not be responsible for any type of accident / damage/ health hazardous during plant visit.**

All the above conditions shall have to be followed strictly. If any mischief is found during visit, Surat Municipal Corporation may terminate the visit and take legal action.

Thanking you,

Yours faithfully

Dipti

Environment Engineer (Drainage)
Surat Municipal Corporation,
Surat.

fwds to Mr R.R. Patel
A.N. Pachani
3/03/22

CH: 3 LITERATURE REVIEW

Case study: 3.1

Tertiary Sewage Treatment Plant at Bamroli, Surat

BASIC DATA

Capacity of the plant: 40 MLD

Contractor: M/s Enviro Control Associates (I) Pvt. Ltd, Surat

Capital Project Cost: Rs. 85.10 Crores (100% Funded by Government of Gujarat (GoG))

Present Fresh Water Cost of Industries: Rs. 23/KL

Recycle water supply Base rate: Rs. 18.20/KL (Yearly increment on RBI indexation base)

PLANING AND IMPLEMENTATION

The Pandesara industrial estate is located only 5 km away from the 100 MLD capacity sewage treatment plant at Bamroli. SMC decided to set up a 40 MLD capacity tertiary treatment plant to treat secondary treated sewage from Bamroli sewage treatment plant to supply industrial grade water to Pandesara industrial estate.

For mutual benefits of SMC & Pandesara industrial, both the parties executed M.O.U. in the year 2013-14 to supply 40 MLD of tertiary treated sewage supplemented with potable grade of water to meet the industrial water demand separately potable grade water for domestic use (drinking etc.) by industrial employees and worker etc.

Initially project was planned to be executed using public private partnership (PPP) model. Asian development bank (ADB) has prepared the report including a revenue model. Tender was also invited to carry out the project on this model where operating agency was to make investment, operate and maintain the plant and collect the user charges from end users. Parts of revenue were to be shared with SMC.

Considering the technical experience available within SMC having experience of operating more than 800 MLD water and sewage treatment plants and also a financial model which could generate revenue for SMC in long term, SMC decided to take the project implementation including operation and maintenance on its own with generating regular income from the industry from sale of the industrial grade water to industries on greed terms.

However, the structural and process design was vetted by technical and academic institutions in Surat and third-party inspection agency was engaged for quality control. The project was funded under Swarnim Jayanti Mukhya Mantri Shaheri Vikas Yojna (SJMMSVY) of government of Gujarat.

DESIGN

The plant is designed to treat secondary treated sewage to obtain net output of 40 MLD of tertiary sewage. The characteristics of raw sewage, secondary treated sewage and the tertiary treated – industrial grade water including the reject water from the tertiary treatment plant were considered in the design.

Pretreatment stage is designed to remove suspended solids, colloidal matter and silica and in general making the treated sewage suitable for treatment by membrane system this pretreatment ensures longer life of the members and delivers expected performance.

Chlorination is provided for effective control of bio fouling in ultra-filtration (UF) and reverse osmosis (RO) membrane system. The chlorination is done in the existing chlorine contact tank to achieve combined chlorine concentration of 2-3 mg/L. Free chlorine is harmful for RO membrane so low fouling RO membrane with chloramines level of 3 mg/L in feed water are used in the plant. Proper monitoring instrumentation and control system provided.

An equalization tank is provided with aeration for mixing to permit a reasonably constant flow of sewage of more or less uniform quality through the plant. Aeration also keeps suspended solids in suspension and prevents sewage from becoming septic.

The ultra-filtration stages are provided to condition the combined treated waste water so that the reverse osmosis plant will operate with as little downtime for cleaning in place as possible.

Thin film composite semi permeable under the influence of external pressure will undergo process of reverse osmosis where water with high total dissolved solids (TDS) is separated into very low TDS permeate (more than 99% salinity rejection) and very high TDS reject streams.

The reject from UF/RO is subjected to chemical treatment for reduction of suspended solid and biochemical oxygen demand (BOD) for this chemical treatment, the reject flow is pumped of flash mixer units having 60 sec. of retention time and then to the flocculator having 30 min. of retention time. After flocculation, reject flow is taken to the clarifier units and then led to existing treated sewage disposal line for final disposal. The sludge from the clarifies is taken to belt filter press system for dewatering.

ACHIVMENT OF PROJECT PURPOSE

After commissioning of tertiary treatment plant at Bamroli and after the initial trial-run period of 3 month, SMC is successfully delivering the desired and quantity and quality of recycled & treated water supply for intended industrial reuse.

This has resulted in saving of about 40MLD potable water which is earlier supplied to Pandasara industries and permitted increases in potable water supply to the citizen of new area of Surat.

Revenue income from the water supply is also as expected. The rate of potable water is RS25.13/- per KL and the base rate of tertiary treated water was Rs.18.20/- per KL with indexation base rise every year. The weighted average rate is now being considered as per the actual consumption. Meter reading, checking, monitoring & surveillance activities are performed regularly by SMC. Computerized bills are generated and issued by-monthly.

<u>Plant performance is presented in the following table.</u>

Sr. No.	parameter	Unit	Feed water secondary treated sewage	Tertiary treated industrial grade water	Actual achieved standard
1	Color	Hazen units	55	<5	<5
2	Turbidity	NTU	16	<5	<5
3	pH	-	6.5-7.5	6.0-7.5	6.0-7.5
4	Total hardness as $CaCO_3$	mg/L	750	<300	<300
5	Iron as Fe	mg/L	0.63	<0.25	<0.25
6	Manganese as Mn	mg/L	0.12	<0.10	<0.10
7	TDS	mg/L	2100	<500	<500
8	BOD	mg/L	20	<5	<5
9	COD	mg/L	100	<50	<50
10	Suspended solids	mg/L	30	<2	<2
11	Total nitrogen	mg/L	14	<10	<10
12	Total phosphorus	mg/L	8	<6	<6

The most advantageous result of implementation of this project is its contribution towards reducing the dependency on conventional resources of water for the benefit of environment.

Overall assessment

The information and details shared above are based on discussion with drainage department of Surat Municipal Corporation (SMC) and subsequent site visit to the plant.

Many national level and even international dignitaries / representative have visited this plant and appreciated its operation and suggest that such paints should be replicated nationwide.

It has been observed that for successful implementation of tertiary treatment plant efficiency of secondary level treatment is very critical. So, before implementation of tertiary level or higher-level treatment, it is necessary to maintain the output quality of secondary treatment which becomes input to the TTP.

The plant is being operated on complete atomized mode with minute quality control and therefore, it has been maintaining desired output operation, maintenance, management and house- keeping.

The economics or the viability of such plant will vary place to place depending on user location, user requirement etc. and warrants a detailed techno-economic analysis to establish its environmental acceptability and economic viability.

I sincerely hope and wish that such projects are implemented the nation.

Reference:
https://publicadministration.un.org/unpsa/Portals/0/UNPSA_Submitted_Docs/2019/19B7BB60-B0D5-49AC-A24C-7FF2A977A005/evaluation%20report%20Bamroli%20TTP.pdf?ver=2018-11-30-113029-307

Case study: 3.2

Reverse Osmosis Plant for Wastewater Reuse, Vadodara, Gujarat, India

Title of Case Study: Reverse Osmosis Plant for Wastewater Reuse, Vadodara, Gujarat, India

Type of Case Study: Reuse of highly polluted wastewater for industrial uses.

Objective of Case Study: Recycling and reuse of highly polluted industrial wastewater for non-potable industry uses.

Background of Case Study: The reverse osmosis-based wastewater reuse plant was established in order to demonstrate the plausibility of reuse of highly polluted complex wastewater consisting of various industrial effluent streams for non-potable uses in the industry.

Salient Features: The reverse osmosis-based wastewater reuse plant uses highly polluted wastewater from an effluent disposal channel into which several industries viz. refineries, fertilizers, petrochemicals discharge their raw wastes. The successful operation of the plant demonstrated that at least 75% of the wastewater could be made available for reuse at treatment cost of Rs. 36/- per 1,000 liters as per the 1999 estimates. The remaining 25% constituted of the rejects and sludge from the reverse osmosis plant and needs to be disposed of separately. The treatment chain for the 3 MLD capacity reverse osmosis plant for wastewater reuse at Vadodara comprises of following units:

Wastewater from Effluent Channel → Chemical Feeding (Lime, Polyelectrolyte, Soda Ash) → Clarification → HCl Addition → Press Filtration → Sodium Bisulfate → Cartridge Filtration → Reverse Osmosis → Degasser to remove CO2 → For Reuse.

The detailed flow diagram of the 3 MLD reverse osmosis plant for wastewater reuse at Vadodara is shown in Figure 1.

Reference:

Arceivala, S.J., Asolekar, S.R., 2007. Water Conservation and Reuse in Industry and Agriculture. In: Wastewater Treatment for Pollution Control and Reuse, 2007, Tata McGraw- Hill Publishing Company Limited, New Delhi, pp. 396–425.

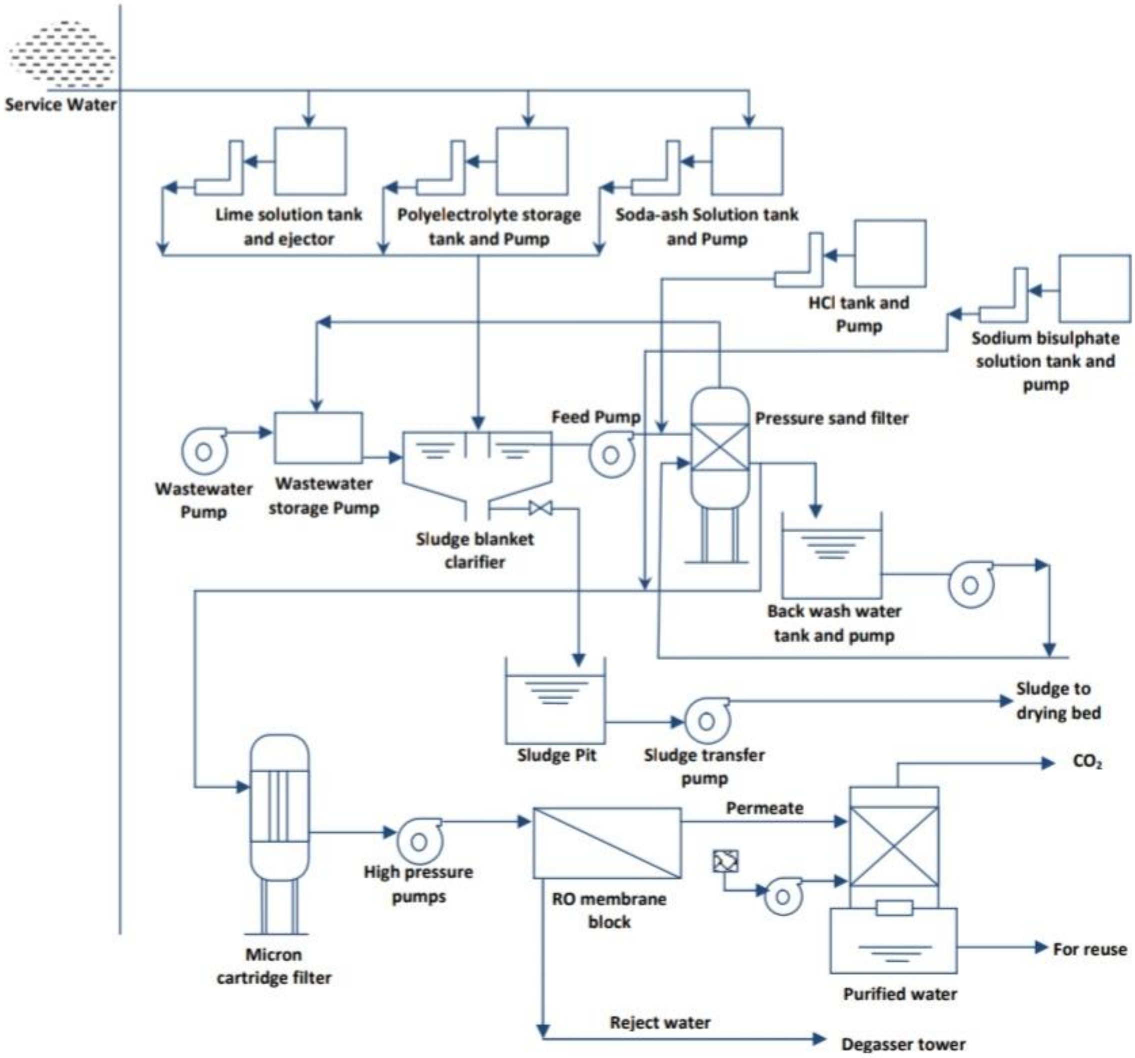


Figure 1: The Detailed Flow Diagram of the 3 MLD Reverse Osmosis Plant for Wastewater Reuse at Vadodara, Gujarat

Case study: 3.3

Water Reuse Facility, Indian Institute Technology, Madras, Tamil Nadu, India

Title of Case Study: Water Reuse Facility, Indian Institute Technology, Madras, Tamil Nadu, India

Type of Case Study: Reuse of campus wastewater for toilet flushing and gardening.

Objective of Case Study: Treatment, storage and reuse of wastewater from hostels, residential apartments and the institution for toilet flushing in the hostels and gardening.

Background of Case Study: The Indian Institute of Technology, Madras (IITM) campus has Thirteen hostels, two guest houses and many residential apartments and bungalows with a total population of nearly 10,000 people. The total water consumption in the IITM campus is around 1.5 MLD and the total quantity of wastewater generated including the institute section varies from 1.0 to 1.2 MLD. Till 2004, the wastewater generated in the campus was treated in two oxidation ponds of capacity 136 m x 136 m x 2.5 m and the characteristics of the treated effluent from the pond was: 200-250 mg/L of BOD_5 (total) and 35-40 mg/L of BOD_5 (soluble), which is highly unsuitable for discharge into existing water bodies as per the Tamil Nadu Pollution Control Board (TNPCB) norms. In order to reuse the water, to prevent the formation of marshy area and to discharge the treated effluent to existing water bodies (Buckingham canal) there was a need to improve the existing treatment system. Moreover, the marshy area existing in and around the wastewater treatment system used to overflow during rainy season and contaminate the lake water as well as the swimming pool water in the campus. On the backdrop of these problems and in order to conserve water in water starved place like Chennai and to reduce the procurement of water from outside, water reuse is viewed as essential in the campus.

Salient Features: A preliminary investigation to come up with a feasible treatment option for the campus suggested that a water reuse facility consisting of aerated lagoon followed by tertiary treatment is the best option for the existing condition with a possibility of around 0.2 to 0.4 MLD of wastewater reuse for toilet flushing and gardening in the hostel zone. The water reuse facility designed and installed to treat 1.4 MLD of wastewater and comprises of aerated lagoon, clariflocculator, chlorination, pressure filter, storage unit and sludge drying bed. There are two units of aerated lagoon with volume of 2600 m^3 each and take care of organic matter in the wastewater. The detention time provided in the aerated lagoon is relatively high compared to conventional ASP and thereby ensuring negligible sludge production. The effluent from the aerated lagoon is subjected to clariflocculation in order to remove colloidal and suspended solids. Alum and poly-electrolytes (PE) are being used as coagulant and coagulant aid respectively. The clariflocculator is also designed for a capacity of 1.4 MLD. After the clariflocculator, about two third of the water (1 MLD) is send to the storage tank which was an oxidation pond earlier. The remaining one-third water (0.4 MLD) is chlorinated and filtered through a pressure filter. The pressure filter improves the quality of the water considerably by further removing the colloidal and suspended solids. Chlorination helps to reduce the pathogenic organisms substantially and keeps the filter relatively free from the microbial growth. The last unit in the reuse facility is the storage tank of water for further distribution.

The performance characteristics of various treatment units of the reuse facility are presented in Table 6. The highly treated effluent is reused for toilet flushing and gardening in the hostel zone alone. The sludge generated in the whole system is disposed of on the sludge drying bed. The schematic of the water reuse facility system is shown in Figure 2. This case study is a good example of sustainable water management and a notable initiative towards the reuse of wastewater from residential as well as from the institution sectors in India.

Table 6: Performance Characteristics of Various Treatment Units of the Water Reuse Facility

Treatment Unit		Parameter			
		Quantity (m^3/d)	**BOD, (mg/L)**	**SS, (mg/L)**	**MPN (ml)**
Aerated Lagoon	Influent	1400	200	100	N.A.
	Effluent	1428	20	49	N.A.
Clariflocculator	Influent	1428	20	49	N.A.
	Effluent	1358	10	29.45	100
Pressure Filter	Influent	400	10	29.45	100
	Effluent	400	4.0	5.0	50

Reference:
Philip, L., 2011. Water reuse facility at Indian Institute of Technology, Madras, Personal Communication.

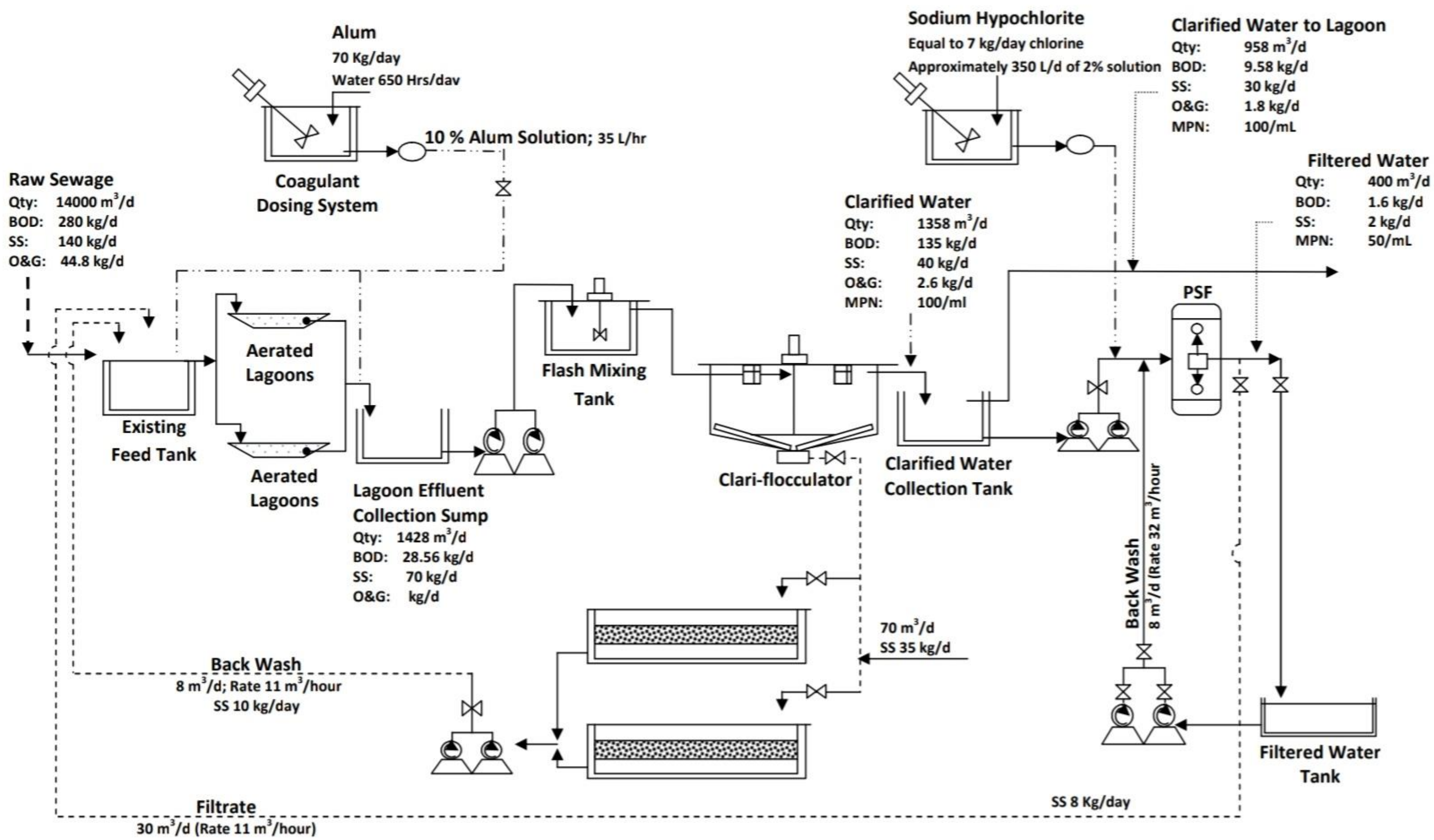


Figure 2: The Detailed Flow Schematic of the Water Reuse Facility at Indian Institute of Technology, Madras, Tamil Nadu

Case study: 3.4

Wastewater Treatment Recycling Plants, Bangalore Water Supply and Sewerage Board (BWSSB), India

Title of Case Study: Wastewater Treatment Recycling Plants (60 MLD Vrishabhavathy Valley TTP; 10 MLD Yelahanka TTP), Bangalore Water Supply and Sewerage Board (BWSSB), India
Type of Case Study: Reuse of municipal and industrial wastewaters for non-potable and industrial uses.
Objective of Case Study: Recycling and reuse of wastewater in order to meet the water demands of ever-growing population of Bangalore city in view of limited water resource and to reduce the high energy cost for pumping of water from Cauvery River.
Background of Case Study: Bangalore city has limited raw water resources to meet its water demands for ever growing population. City is almost completely depending on the Cauvery River, located more than 100 km away from the city for its requirements. The pumping of water from the river for water supply involves an exorbitantly high energy cost. In view of extremely finite source of raw water and high energy cost for pumping of water, the recycling and reuse of wastewater becomes absolutely imperative in Bangalore city and prompted the Bangalore Water Supply and Sewerage Board (BWSSB) to undertake a major initiative towards the recycling of wastewater. The BWSSB planned and established the two tertiary treatment plants (TTPs) in Bangalore at Yelahanka (capacity: 10 MLD) and another at Vrishabhavathy Valley (capacity: 60 MLD) for water recycling and reuse.
Salient Features: The 10 MLD TTP with recycling facilities at Yelahanka with funding support from KUIDFC/HUDCO under Megacity scheme and through Indo-French protocol has been commissioned in May 2003 for the BWSSB. The Yelahanka TTP has three treatment stages, viz., primary treatment, secondary treatment and tertiary treatment. The collected wastewater from Yelahanka is initially subjected to primary stage treatment (screening, grits and grease removal), followed by the secondary stage using primary settling and activated sludge process. Tertiary filtration (using sand and gravel) along with coagulation with aluminum sulphate are provided to the effluent from the secondary stage for removal of suspended solids. The chlorinated recycle water from the TTP is supplied to the ITC Ltd., Wheel and Axel Plant and the new International

Devanahalli Airport to meet the non-potable water requirements. The characteristics of raw influent wastewater and tertiary treated effluent at the Yelahanka plant are shown in Table 5. Representative photographs of 10 MLD TTP at Yelahanka, Bangalore is presented in Figure 3.

Table 5: Characteristics of Raw Wastewater and Tertiary Treated Effluent at Yelahanka TTP

Parameter	Raw Wastewater	Treated wastewater
pH	6.8 – 7.5	7.0 – 8.0
Suspended solids (mg/L)	480	<5
Turbidity (NTU)	N.A.	<2
BOD5 (mg/L)	380	<5
Fecal coliform (MPN/100 ml)	N.A.	<25

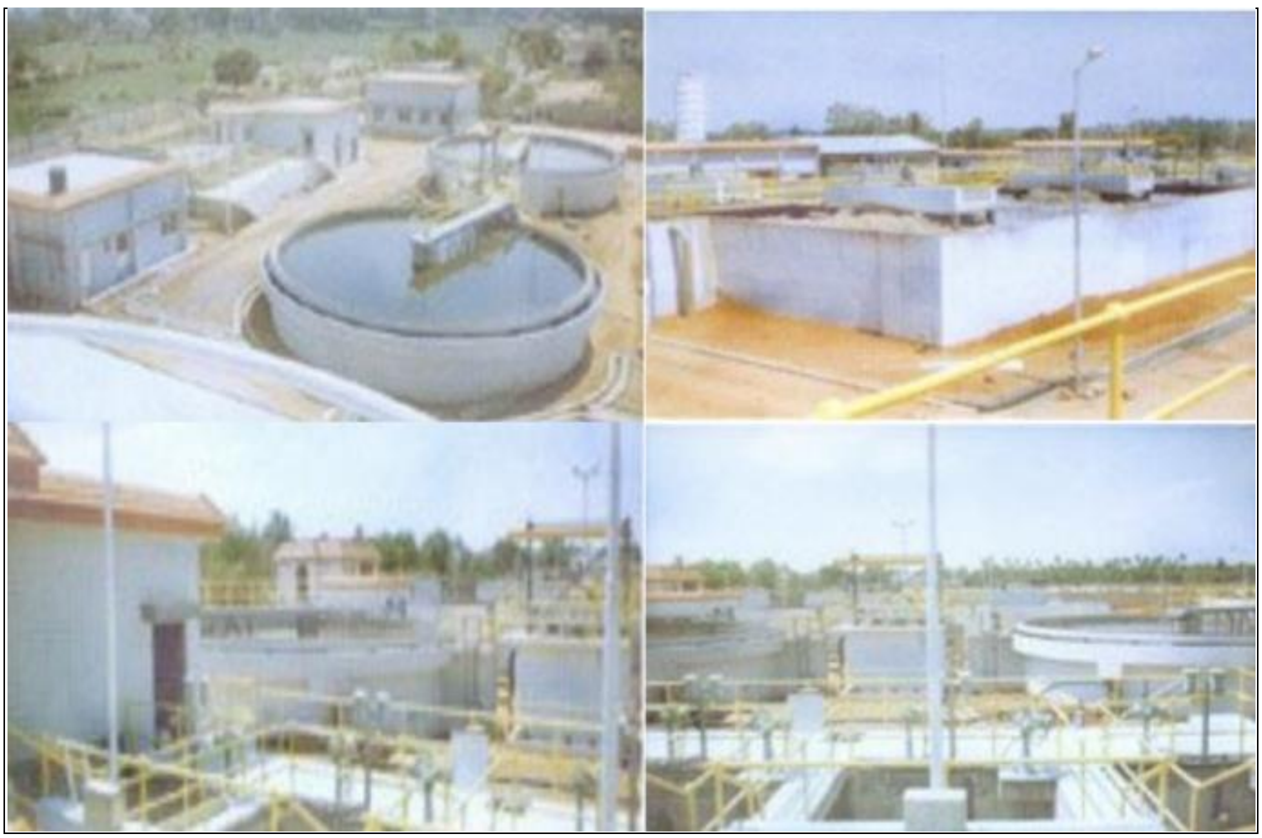


Figure 3: Photographs of 10 MLD Tertiary Treatment Plant (TTP) at Yelahanka, Bangalore

The BWSSB commissioned another 60 MLD capacity tertiary treatment plant (TTP) with recycling facilities at Vrishabhavathy Valley with funding support from KUIDFC/HUDCO under Megacity scheme and through Indo-French protocol in May 2003. The V. Valley TTP provides a combination of biological and physiochemical treatment to the secondary effluent from the existing 183 MLD STP based on conventional bio-filter near Kenchenahally. The treatment chain in the V. Valley TTP consists of trickling filter, DENSADEG high-rate clarifier (combination flash mixer, lamella separators and counter current flow thickener), FLOPAC aerobic biological filtration unit and chlorine-based disinfection. The chlorinated recycle water from the V. Valley TTP is supplied to M/s Karnataka Power Corporation Ltd. at Bidadi and M/s Pulikeshi Power Corporation Ltd. at Kumbalgod for their power generation plants. Figure 4 shows the photograph of 60 MLD TTP at Vrishabhavathy Valley, Bangalore.

Figure 4: Photographs of 60 MLD Tertiary Treatment Plant (TTP) at Vrishabhavathy Valley, Bangalore

Reference:
http://www.bwssb.org/ current_project_recycle_treatment_vvalley.html (Accessed on January 11, 2011).

Case study: 3.5

Sewage Reclamation Plant, The Rashtriya Chemicals and Fertilizers (RCF) Plant, Chembur, Mumbai, India

Title of Case Study: Sewage Reclamation Plant, the Rashtriya Chemicals and Fertilizers (RCF) Plant, Chembur, Mumbai, India

Type of Case Study: Reuse of complex wastewater (municipal sewage polluted with various industrial wastes) for industrial uses.

Objective of Case Study: Recycling and reuse of complex wastewater (municipal sewage polluted with various industrial wastes) for non-potable uses in the industry.

Background of Case Study: Municipal sewage generated in the vicinity of the Rashtriya Chemicals and Fertilizers (RCF) Plant, Chembur, Mumbai is heavily contaminated with various streams of industrial wastes and results into complex wastewater. In order to become water self-sufficient and to meet increasing process water requirements, the RCF plant realizes the importance of recycling and reuse of wastewater for non-potable industrial use and commissioned a sewage reclamation plant for the industry.

Salient Features: The RCF Plant commissioned a 23 MLD capacity sewage reclamation plant involving reverse osmosis in the year 2,000 and treats a complex wastewater comprising of the municipal sewage heavily contaminated with various industries wastes. The sewage reclamation plant at the RCF consists of following treatment units:

Screening → Grit Removal → Activated Sludge System → Clarifier → Sand Filter → Pressure Filter → Cartridge Filters → Reverse Osmosis → Degasser to remove CO2 → Reuse in Industry.

The detailed flow sheet of the sewage reclamation plant for the RCF plant at Chembur is presented in Figure 5.

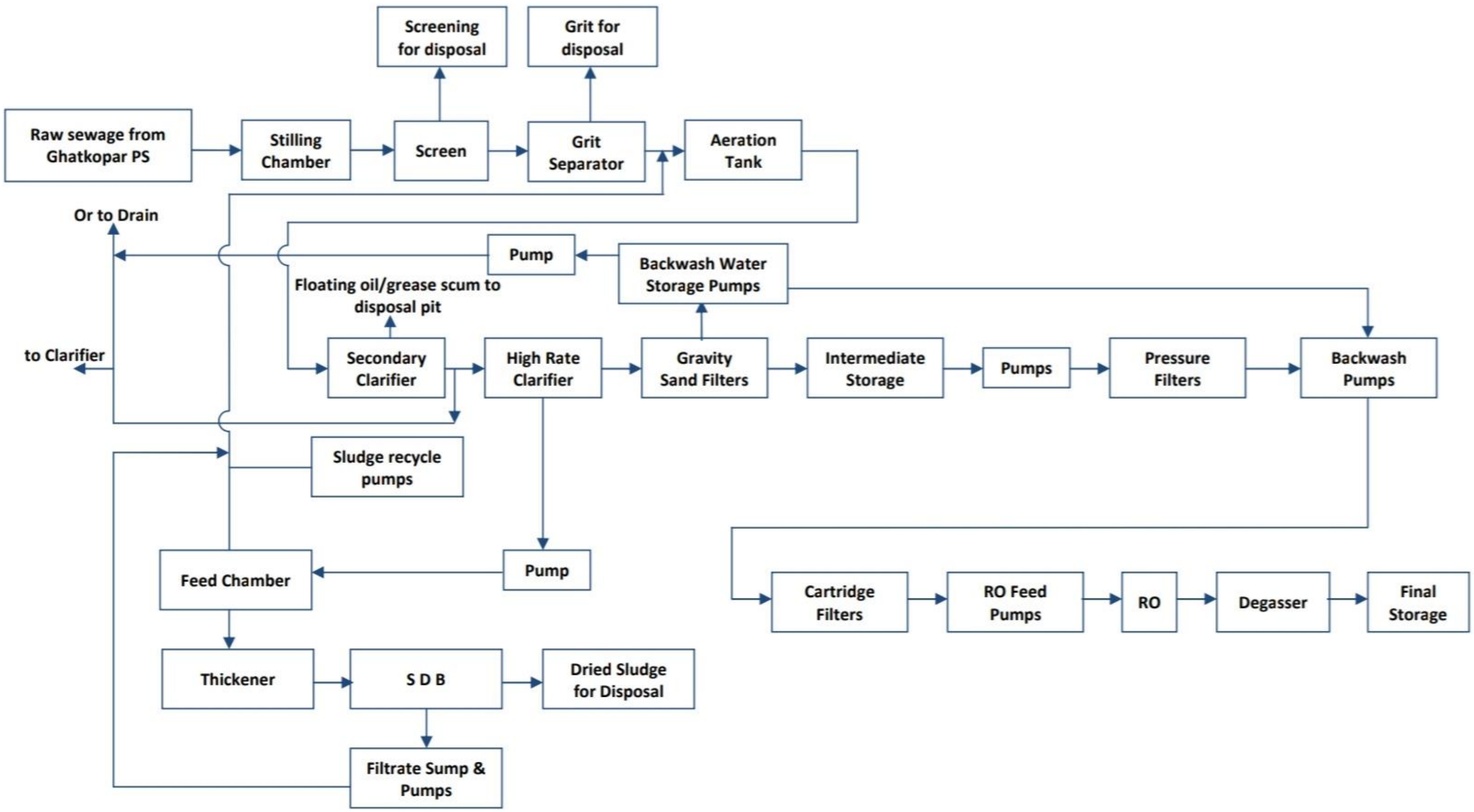


Figure 5: The Detailed Flow Sheet of the 23 MLD Sewage Reclamation Plant for the Rashtriya Chemicals and Fertilizers (RCF) Ltd., Chembur, Mumbai

The plant cost nearly Rs. 40 crores to build in 1998 and the operating cost as reported in 2005 came to Rs. 39/- per m3. With the passage of time and the success of reuse schemes, the municipal charge levied also became higher at Rs 6/- per m3 of raw sewage. Some additional treatment steps like use of Ultra filtration became necessary in order to improve the quality of the water reaching the RO system (keeping the silt density index, SDI < 3.0) owing to the more polluted nature of the influent wastewater.

Reference:

Arceivala, S.J., Asolekar, S.R., 2007. Water Conservation and Reuse in Industry and Agriculture. In: Wastewater Treatment for Pollution Control and Reuse, 2007, Tata McGraw- Hill Publishing Company Limited, New Delhi, pp. 396–425.

Case study: 3.6

Grey water Reuse System in Residential School, Ganganagar, Dhar District, Madhya Pradesh, India

Title of Case Study: Grey-water Reuse System in Residential School, Ganganagar, Dhar District, Madhya Pradesh, India

Type of Case Study: Reuse of treated grey-water for toilet flushing and irrigating the food crops.

Objective of Case Study: Treatment and reuse of grey-water from residential school for toilet flushing and irrigating the food crops.

Background of Case Study: The Central Indian state of Madhya Pradesh has a population of 28,928,245 spanning 308,245 km². The infrastructure for ensuring proper wastewater and its reuse is currently inadequate in the state with a third of the rural, and a quarter of urban, households with no wastewater drainage system. Therefore, there is a necessity to implement wastewater reuse system in the state. Towards the implementation of wastewater reuse, a grey-water reuse system has been initiated in one Girls boarding school in Ganganagar, District Dhar of Madhya Pradesh. The school has following characteristics:

No. of girl inmates: 300

School period: July 1 to April 30

Water requirement: 10,000 L

Grey-water generation: 4000 – 6000 L.

Salient Features: The National Environmental Engineering Research Institute (NEERI), Nagpur, Public Health Engineering Department (PHED), NGO partners and UNICEF, Madhya Pradesh have developed and implemented a grey-water reuse system in the residential school to provide sufficient water for flushing of toilets, cleaning of school floors and small-scale irrigation. The grey-water is treated using following primary, secondary and tertiary treatment technologies:

- ***Primary treatment:*** Absorption of soap suds using a synthetic sponge, sedimentation baffled/graded settlement tank,
- ***Secondary treatment*:** Involves filtration of the reuse water using gravel (10–60 mm size) and sand roughing filtration, and
- ***Tertiary treatment*:** The effluent is treated using aeration and chlorination before being pumped to an overhead tank for toilet flushing.

The techno-economic feasibility of the grey-water reuse system reveals that the system is performing exceedingly well and the internal and external benefits of the system are substantially higher than the internal and external costs. The reuse of grey-water has resulted in no occurrence of diarrhea annually. The public perception study of the reuse system concluded that the grey-water reuse system is acceptable to the community and school children. Considering the successful operation of the grey-water reuse system in the residential school, Government of Madhya Pradesh has allocated funds for construction of 412 grey-water reuse systems in April 2006 and about 200 systems are already built-in schools in Madhya Pradesh, India.

Reference:

Godfrey, S., Labhasetwar, P., Wate, S., 2009. Greywater reuse in residential schools in Madhya Pradesh, India – A case study of cost-benefit analysis. Resour. Conserv. Recycling. 53, 287–293.

Case study: 3.7

Durban, South Africa

Title of Case Study: Durban Water Recycling (DWR) Project.

Type of Case Study: Municipal wastewater reuse for industrial purposes.

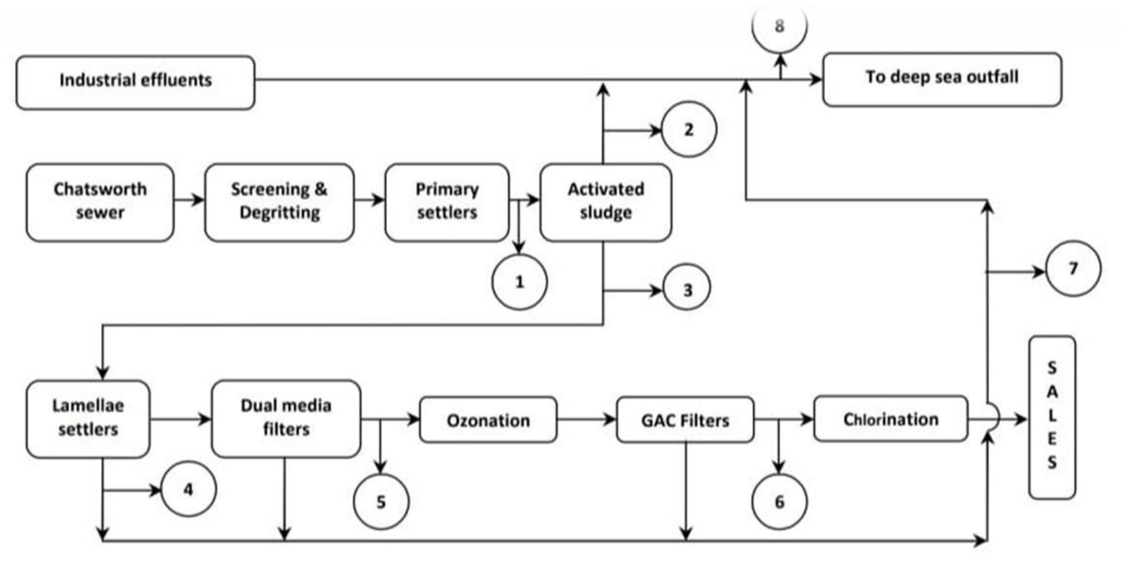
Objective of Case Study: To study a successful case of multi-sector partnership for water management and reuse projects.

Background of Case Study: The municipal authority, called "Durban Metro", experienced a dramatic population increase following the abolition of Apartheid. The population increased from 1 million to nearly 3 million due to the incorporation of 30 local authorities and surrounding townships into the metropolitan area. As a result, Durban Metro was under considerable pressure to provide basic services to its growing domestic customers, among whom 26% live in the townships and rely on standpipes for clean drinking water. Moreover, several industries are located in this area. In particular, Mondi Paper Mill and SAPREF refinery need a continuous supply of high-quality water for process and cooling purposes. Unfortunately, natural water resources are not sufficient in the region to meet the increasing demand for water of drinking and ultrapure quality: the average rainfall is 200 mm/year, and the region suffers from periodic droughts. In order to develop a workable solution to the water and sanitation problems of developing countries, the KwaZulu Natal pilot project was launched. It was part of the Worldwide "Business Partners for Development" (BPD) programmed created by the World Bank in 1998. This project allowed Durban Metro to install and operate a new affordable distribution network for the townships through innovations in service delivery and tariff structures – first 200 l/day of water was free for domestic customers. This was the result of a successful tri-sector partnership (public-private-NGOs). Based on the success of this first initiative, the Durban Metro authority decided to go further by implementing a public-private partnership water reuse project: the Durban Water Recycling (DWR) Project.

Salient Features: The Durban Water Recycling (DWR), run by Vivendi Water in association with the Durban Metro, was commissioned adjacent to the Southern Wastewater Treatment Works in May 2001. The DWR Project receives effluent from the Southern Wastewater Treatment Works and treats it to an acceptable standard for industrial use. The project included treating primary sewage and re-purifying the 47,500 m3/day reclaimed water. As a result, about 7% of Durban's total wastewater generated (i.e., equivalent to the demand for 220,000 households in the area) was reclaimed as high-quality water conforming to the South African water standard (SABS 241:1999) and supplied to the Mondi Paper Mill and SAPREF Refinery at a cost 25% lower than potable water instead of being discharged to the sea. The purification of the wastewater was handled by the newly refurbished Southern Wastewater Treatment Works based on activated sludge process (ASP) and integrating the water recycling plant consisting of tertiary treatment including dual media filtration, ozonation, granular activated carbon (GAC) filters and chlorination. The flow diagram of the Southern Wastewater Treatment Works integrated with the Durban Water Recycling (DWR) Plant is shown in Figure 6.

The Durban Metro was able to overcome the challenge of supplying drinking water to a number of people drastically increased by the abolition of the Apartheid due to the commissioning of the DWR project. The success of this project led to the following beneficial outcomes:

- The reclaimed water produced a low-cost, high-quality water supply for its industrial customers;
- Reclaimed water is more than 25% cheaper than the potable supply;
- Seven percent of Durban's total wastewater generated is recycled, which means that 7% more potable water is available for the community, which is equivalent to the demand for 220,000 households; and
- The flow to the overloaded sea outfall was reduced, thus extending its life and providing environmental protection to the region.



1. Influent to the ASP; **2.** Waste activated sludge (WAS); **3.** Effluent from the ASP; **4.** Sludge underflow from the lamellae settlers; **5.** Effluent from the dual media filters; **6.** Effluent from the GAC filters; **7.** Tertiary sludges underflow; **8.** Sea outfall

Figure 6: Flow diagram of the Southern Wastewater Treatment Works integrated with the Durban Water Recycling (DWR) Plant

Reference:

Friedrich, E., Pillay, S., Buckley, C., 2004. The environmental impacts of potable and recycled water: a case study on effluent toxicity. In: Proceedings of the 2004 Water Institute of Southern Africa (WISA) Biennial Conference, 2-6 May, 2004, Cape Town, South Africa, pp.253–262.

MED WWR WG, 2007. Mediterranean Wastewater Reuse Report, Mediterranean Wastewater Reuse Working Group (MED WWR WG), November 2007.

Case study: 3.8

Florida Water Reuse Program, Florida, USA

Title of Case Study: Florida Water Reuse Program, Florida, USA

Type of Case Study: Reuse of domestic wastewater for the purposes of land application and residential irrigation, groundwater recharge and indirect potable reuse and industrial use of reclaimed water.

Objective of Case Study: To encourage and promote water reuse in Florida in compliance with the state objective for conserving freshwater supplies and preserving rivers, streams, lakes, and aquifers.

Background of Case Study: Florida is the fourth most populous state in the USA and population is projected to grow from about 16 million in 2000 to about 21 million in 2020. While Florida receives a large amount of rainfall every year compared to other states, the distribution is not even throughout the year and across the state. As the state continues to grow, demand for fresh water also will increase. In 1995, Florida used about 7.2 billion gallons of water each day (27,288 MLD). By 2020, water use is forecast to grow to 9.1 billion gallons per day (34,489 MLD). Florida is the largest user of irrigation water east of the Mississippi River. In 2020, agriculture is expected to account for about 46 percent of Florida's total demand for fresh water. Public water supply will account for about 34 percent of the total. The remaining 20 percent of water use will be associated with industrial/commercial/electric generation, recreational irrigation, and domestic self-supply. In 2001, Florida's domestic wastewater treatment plants had a total capacity of about 2,220 MGD (8414 MLD) and actually treated about 1,486 MGD (5,632 MLD). In 2020, it is estimated that wastewater flows to be treated will reach 1,950 MGD (7,390 MLD). This represents 1,950 MGD (7,390 MLD) of a water resource that can and should be reclaimed and reused for beneficial purposes. Periodic droughts combined with increased demand for fresh, clean surface and groundwater for public consumption have resulted in periodic and prolonged water shortages. Conservation measures such as irrigation and groundwater recharge with reclaimed water are viewed as the plausible ways to reduce the use of existing potable water supplies and tackle the water shortages.

Salient Features: The Florida Department of Environment Protection (DEP) began looking at ways to promote reuse of reclaimed water in 1987. Reuse systems serving Tallahassee and St. Petersburg significantly influenced reuse in Florida and paved the way for today's multitude of excellent, innovative reuse projects. Table 3 shows the different types of reuse systems in Florida and a brief description of the treatment and disinfection requirements for each. As per the Florida Water Reuse 2009 inventory, a total of 484 domestic wastewater treatment facilities (WWTF) with permitted capacities of 0.1 MGD (0.379 MLD) or above that make reclaimed water available for reuse are there in the Florida state. These facilities have WWTF capacity totaling 2,287 MGD (8,668 MLD) and treated 1,421 MGD (5,386 MLD) of domestic wastewater in 2009. These treatment facilities serve 433 reuse systems. Approximately 673 MGD (2,551 MLD) of reclaimed water from these facilities is reused for beneficial purposes. The total reuse capacity associated with these systems is 1,559 MGD (5,909 MLD). Figure 7 shows the percentage of reclaimed water utilization by flow for each reuse type as per the Florida Water Reuse 2009 inventory. Irrigation of areas accessible to the public like residential areas, golf courses, athletic fields, parks, etc. represented about 56 percent of the 673 MGD (2,551 MLD) of reclaimed water reused. Reclaimed water from these systems was used to irrigate 276,471 residences, 533 golf courses, 873 parks, and 306 schools. Following public access areas, the next largest uses are industrial uses (14%) such as cooling water in power plants and groundwater recharge (13%). Most of the reclaimed water used for agricultural irrigation is used to grow feed, fiber, or other crops that are not for direct human consumption. Over 12,750 acres of edible crops on 75 farms are reported to be irrigated with reclaimed water. A demonstrative video on the Florida Water Reuse Program is available and can be viewed at: http://www.dep.state.fl.us/water/reuse/ In addition to the Florida Water Reuse Program, the Hazen and Sawyer in partnership with another national firm the Miami-Dade Water and Sewer Department are currently designing 21 MGD (79.6 MLD) South District Water Reclamation Plant (SDWRP), the largest advanced wastewater reclamation plant of its kind in the State of Florida, for replenishment of the Biscayne Aquifer via rapid infiltration, in which the domestic wastewater that has been treated to meet drinking water standards percolates through the soil down to the groundwater level. The SDWRP is planned to upgrade the South District Wastewater Treatment Plant (SDWWTP) and will treat secondary effluent from the SDWWTP which adds High Level Disinfection (HLD) to the existing pure oxygen secondary treatment plant. The first step in the treatment process will be strainers followed by microfiltration (MF) or ultrafiltration (UF) to minimize suspended solids from the secondary effluent. The RO treatment process at the SDWRP will remove organic carbon (TOC), total organic halides (TOX), and significantly reduce nitrogen and phosphorus to satisfy potable reuse and environmental application requirements. Microconstituents and emerging pollutants of concern (EPOC) will also be reduced in the final step of the process which includes advanced oxidation processes (AOP) like ultraviolet light (UV) application and hydrogen peroxide (H2O2) addition to form hydroxyl radicals (OH-) which oxidize most organic compounds.

Table 3: Different Type of Reuse Systems under Florida Water Reuse Program

Reuse System Type	**Reuse Activities**	**Treatment and Disinfection Requirements**
Slow-rate land application systems; restricted public access	• Irrigation of pastures, trees, feed, fodder, fibre, or seed crops	Secondary treatment and basic disinfection
Slow-rate land application systems; public access areas, residential irrigation, and edible crops	• Residential, golf course, and other landscape irrigation • Toilet flushing • Fire protection • Dust control • Aesthetic features (ponds and fountains) • Irrigation of edible crops (direct contact only with crops that will be peeled, • skinned, cooked, or thermally processed)	Secondary treatment, filtration, and high-level disinfection
Rapid-rate land application systems	• Rapid Infiltration Basins (RIBs) • Absorption Fields	Secondary treatment, basic disinfection, < 12 mg/L NO3-N
Groundwater recharge and indirect potable reuse	• Salinity barriers • Augmentation of surface waters	Principal treatment and disinfection or full treatment and disinfection (depending on use)
Industrial uses of reclaimed water	• Cooling water • Wash water	Secondary treatment and basic disinfection (additional treatment may be needed to

	• Process water (not to include food processing for human consumption)	meet needs of a particular application)

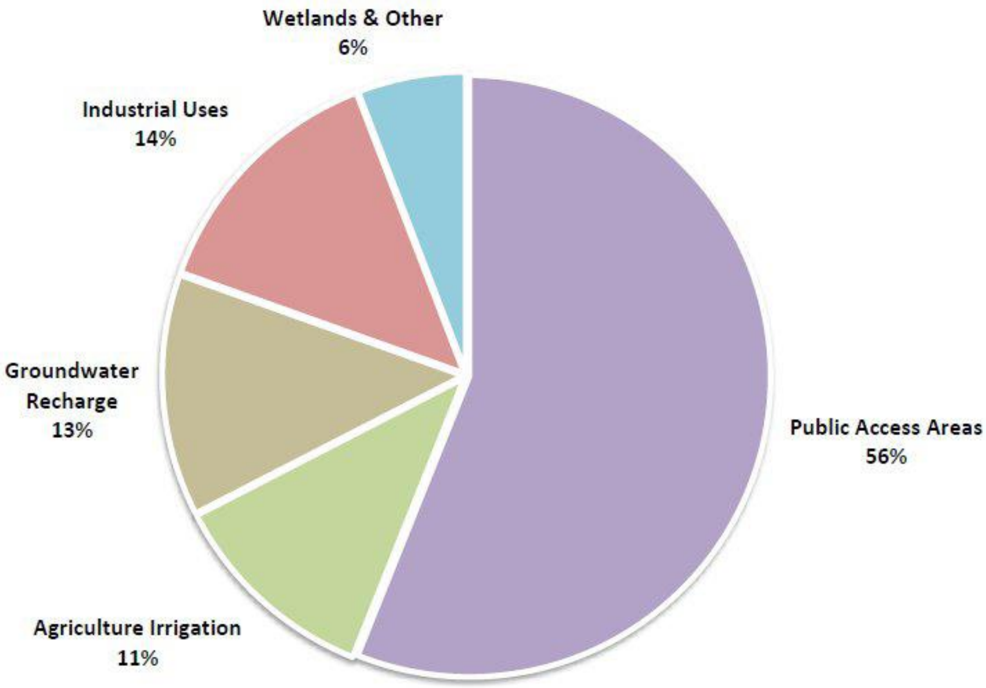


Figure 7: Reclaimed Water Utilization by Flow in Florida as per Water Reuse 2009 Inventory

Reference:

FDEP, 2007. Reuse of Reclaimed Water and Land Application: Rule 62-610 Florida Administrative Code (FAC), Florida Department of Environmental Protection (FDEP), 2007. In Website: http://www.dep.state.fl.us/legal/rules/wastewater/62-610.pdf (Accessed on January 05, 2011).

FDEP, 2010. 2009 Reuse Inventory, Florida Water Reuse Program, Florida Department of Environmental Protection (FDEP), September 2010. In Website: http://www.dep.state.fl.us/water/ reuse/inventory.htm (Accessed on January 05, 2011).

Florida Council of 100, 2003. Improving Florida's Water Supply Management Structure: Ensuring and Sustaining Environmentally Sound Water Supplies and Resources to Meet Current and Future Needs, Florida Council of 100, September 2003. In Website: http://www.fc100.org/reports/ waterreportfinal.pdf (Accessed on January 05, 2011).

Hazen and Sawyer, 2011. Wastewater Reuse Project Will Boost Florida's Water Sustainability, Hazen and Sawyer, P.C., New York, USA, 2011. In Website: http://www.hazenandsawyer.com/news/ wastewater-reuse project-will-boost- floridas-water-sustainability/ (Accessed on January 05, 2011)

CH: 4 STUDY AREA DESCRIPTIONS

Main focus of this project is to identify best suitable & cost-effective techniques for the treatment & recycling of domestic wastewater through various case study and available technologies.

For this, we have studied few case studies (From India as well as abroad based on data available on internet) which is given in this report for the treatment & recycling of domestic wastewater and technologies used for the treatment of wastewater.

We have planned during IDP – I (In 5th Semester) to visit the wastewater recycling plant available in Surat but due to COVID-19 pandemic situation, they have not permit us to visit the plant but in 6th semester (During IDP-II) we have further asked permission but till the end of February 2022, due to COVID -19 pandemic we had no get permission. After that we will get the permission in the month of March 2022 to visit the STP plants to understand the treatment system, operation and maintenance which is mentioned in this report.

Tertiary Sewage Treatment Plant, Bamroli

(Visited on dated 07/03/2022)

- ✓ There are two plants available at there. One is having capacity of 40 MLD & another is having capacity of 35 MLD.
- ✓ Treated wastewater from this plant is supplied to the industries located in GIDC Pandesara & Sachin at reasonable cost & 32 RS / KLD and plant are operating under the rules & regulations of "Gujarat Government policy for Recycling".
- ✓ Total 40-50 employees (Including labors) are deputed for operation & maintenance of this plant. Around Rs. 1.5 crores Electricity is consumed every month.

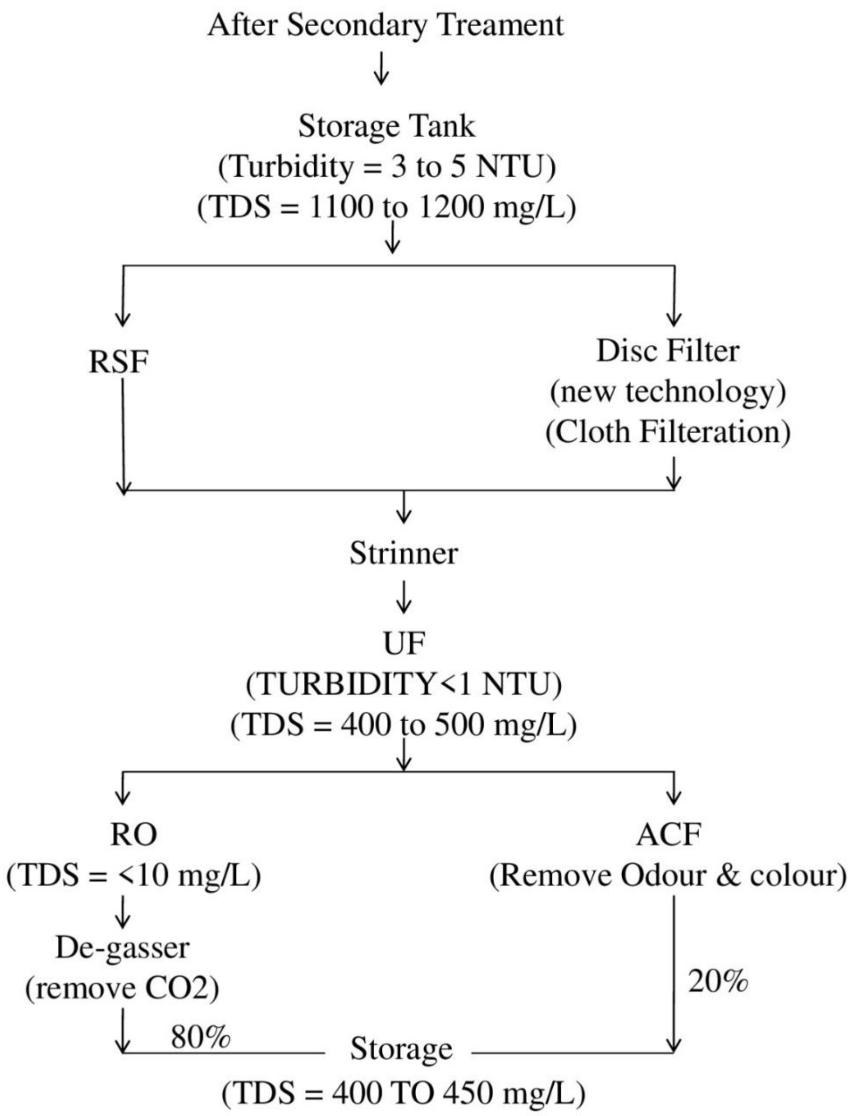
- ✓ **Tertiary Treatment Units Details:**

1) Total 4 no. of RSF available and parallel one DBC filter is also available for the tertiary treatment which can remove turbidity up to 4 to 5 NTU
2) Strinner (Turbidity removal capacity 2 to 3 NTU)
3) UF (For Removal of Turbidity)
4) ACF (For Removal of Colour)
5) RO (Remove TDS) (RO reject water is send to primary treatment of STP for further treatment)
6) Degasser (For Removal of CO_2)

7) Treated Storage Tank (80% RO Water + 20% UF Water) (TDS = 400 TO 450 mg/L)

- ✓ Actually, after RO treatment, TDS is around 10 mg/L but recycling norms is <500 mg/L so for economical treated water, plant authority add 80% RO treat water & 20% UF treat water in Storage Tank. So, this TDS is around 400 to 450 mg/L which will maintain recycling norms and more economical for industry & also reduce treatment cost & time.
- ✓ In 40 MLD water, 17 MLD water is reject which in percentage around 40 to 45% reject

<u>Process Flow Diagram of Tertiary Treatment Plant</u>



Sewage Treatment Plant – Anjana

(Visited on dated 04/03/2022)

✓ **Visit Summary:**

- The purpose of visit is to understand components & process of sewage treatment at Anjana, Surat
- Students understand following Aspects:
    I. Working process of sewage treatment plant.
    II. Treatment provided to sewage (Domestic)
- Capacity of plant: 122 MLD

✓ Anjana STP collect Domestic waste water from 4 pumping station (New Anjana, Pratap Nagar, Umarawada, Limbayat) and provide primary (Physical & chemical) and secondary (biological) treatment to waste water. In this plant, during there is no any chemicals are using in primary and secondary treatment. So operating cost of this plant is minimum except electricity bill & salary of operating staff. However, generated settled sludge are send for biogas generation and from biogas, 0.5 MW electric power generation plant will be operating which will fulfill around 70% of electricity requirements to running this plant and residue sludge is then sold to farmers as a bio-fertilizers at reasonable cost. Hence there is no any generation of waste. We can say it eco-friendly plant.

✓ **Bio-gas Plant:**

Sludge generated during Treatment Process

↓

Biogas production

↓

1% Hydrogen sulphate
65 to 75 % CH_4
25 to 35 % CO_2

Electricity Generation

↓

30% sludge produced

↓

Use as a fertilizer in agriculture (Sold to farmers)

- ✓ **Flow diagram of sewage Treatment plant:**

Inlet (Raw Sewage)

↓

Screening (4 nos.)

↓

Grit Chamber (40 min.)

↓

Primary Sedimentation Tank (4 nos.)
(38 m dia.) (2.5 to 3 Hour)
(600 to 650 m3 Sludge)

↓

Anaerobic Tank (4 nos.)
(25 MLD each)

↓

Aeration (4 nos.)
(25 MLD each) (DO = 2 mg/L)

↓

Secondary Sedimentation Tank (5 nos.)
(42 m dia.) (2.5-to-3-hour HRT)
(900 m3 Sludge)

↓

Chlorination Tank (If required)
(Residual Chlorine = 0.5 mg/L)

↓

Discharge as per norms

CH: 5 CONCLUSION

Based on our study and present treatment systems available in Surat which we have visited, economic treatment can be possible for sewage treatment at minimum cost if treated water will discharge. But if we want to recycle it, it is required give tertiary/advance treatment to remove certain impurities present in wastewater and make it fit for domestic use except drinking.

By recycling of treated water, it will reduce the problems of water scarcity in many areas where sufficient quantity of fresh water is not available. It may present benefits to public health, the environment and economic development. Recycled water may provide significant additional renewable & reliable amount of water and contribute the conservation of fresh water resources as well as reduce the water pollution.

For economic treatment of sewage following unit can be provide:

For Urban Areas:
Screening→ Grit removal cum skimming system→ Primary Sedimentation Tank→ Aeration System→ Secondary Sedimentation Tank→ Sludge drying beds
By using sewage sludge, we can also generate biogas from it and residue solids can be used as an agricultural manure.

For Rural Areas:
Septic Tank & Soak pit system can be used for the treatment of sewage at small scale.

❖ COST OF A TRADITIONAL SEWAGE TREATMENT PLANT

Typical Costs for a Single House (Capacity: 5 KL/day):

- Plant Cost = Rs. 1,51,200 to 2,68,800 (Including Collection tank, Settling Tank, Aeration, Treated storage tank)
- Installation Cost = Rs 1, 68,000 to 2, 52,000 + (depending on the model.)
- Land drainage system (assuming 100 meters of drains) = Rs. 16,000 to 36,000 typical costs if to a ditch with a 10-metre pipe run
- TOTAL COST = Rs. 3,35,000 to 5,56,800

- **Typical Maintenance Costs**
  - ✓ Emptying (either annually or 6 monthly, (depending on the model) Rs. 10,920 to 21,840 per year
  - ✓ Power consumption = Rs. 6,720 to 15,120 per year (depending on the model)
  - ✓ Maintenance Service = Rs. 6,300 to 31,500 (depending on unit chosen) per year
  - ✓ Average annual cost = Rs. 23,940 to 68,460 per year

Sr. No.	STP Process	Energy Requirement	Capital Cost, Rs. /KLD	O&M Cost, Rs. /year/KLD
1	Waste Stabilisation Pond System (WSPS)	5 -10 KWh/ML	Rs.2500 to 5000	Rs.90 to 150 Rs.250 to 410
2	Duckweed Pond System (DPS)	5 - 10 KWh/ML	Rs.2500 to 5000	Rs.250 Rs.680
3	Facultative Aerated Lagoon (FAL)	18 KWh/ML	Rs.2200 to 3000	Rs.150 to 200 Rs.410 to 550
4	Trickling Filter (TF)	180 KWh/ML	Rs.4000 to 5000	Rs.500 Rs.1400
5	Activated Sludge Process (ASP)	180 - 225 KWh/ML	Rs.5000 to 6000	Rs.500 to 700 Rs.1400 to 1920
6	BIOFOR Technology (Biological Filtration and Oxygenated Reactor)	220 - 335 KWh/ML	Rs.10000 to 12000	Rs.1200 Rs.3300
7	High Rate Activated Sludge BIOFOR- F Technology	180 kWh/ML	Rs.7500	Rs.800 Rs.2200
8	Fluidized Aerated Bed (FAB)	99 to 170 kWh/ML	Rs.6000 to 8000	Rs.900 to 1000 Rs.2470 to 2740
9	Submerged Aeration Fixed Film (SAFF) Technology	390 kWh/ML	Rs.9000 to 9000	Rs.1400 Rs.3840
10	Cyclic Activated Sludge Process (CASP)	150 - 200 kWh/ML	Rs.11000	Rs.1400
11	Upflow Anaerobic Sludge Blanket (UASB) Process	10 - 15 KWh/ML	Rs.3000 to 4000	Rs.120 to 170 Rs.330 to 470

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CH: 6 SCOPE OF FUTURE STUDY

In previous semester, we have studied various literatures to understand treatment system of sewage in various cities in India & abroad.

During this semester, we have studied different types of recycling plant which is available in Surat, Vadodara and other cities of India and also visited the sewage treatment plant located at Anjana & Bamroli which is operating by Surat Municipal Corporation in the month of March 2022 to for practical approach and to understand treatment system as well as maintenance & cost. Due to certain restriction of technical team on STP, they had not given actual operation & maintenance cost in written/show, they had only discussed with us about operation and maintenance.

Due to COVID-19 pandemic, we could not visit the wastewater treatment/recycling plant in Surat during IDP – I (5^{th} Semester) and in the 6^{th} Semester up to February 2022. After getting necessary permission in this (6^{th}) semester (UDP – II) from SMC in the month of March 2022, we have visited the STP plants as mentioned in this report.

In future it can be compare with other cities or more STP by visiting the plant and based on actual comparative study, we can develop pilot plant at laboratory scale and based on it we can suggest cost effective techniques and also same study can be carried out for rural area by septic tank & soak pit system. Financial assist will require completing these type of study & pilot scale projects.

CH:7 REFERENCES

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