CYCLIC ACTIVATED SLUDGE TECHNOLOGY BASED SEWAGE TREATMENT PLANT DESIGN AT NEW DELHI RAILWAY STATION

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE

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MASTER OF TECHNOLOGY

in

ENVIRONMENTAL ENGINEERING

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CANDIDATE'S DECLARATION

I, **TARUN SHOKEEN, 2K18/ENE/13**, student of **MTech (ENVIRONMENT ENGINEERING**), hereby declare that the project Dissertation titled "**CYCLIC ACTIVATED SLUDGE TECHNOLOGY BASED SEWAGE TREATMENT PLANT DESIGN AT NEW DELHI RAILWAY STATION**" which is submitted by me to the Department of Environmental Engineering, Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title or recognition.

Place: Delhi
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CERTIFICATE

I hereby certify that the Project Dissertation titled "**CYCLIC ACTIVATED SLUDGE TECHNOLOGY BASED SEWAGE TREATMENT PLANT DESIGN AT NEW DELHI RAILWAY STATION**" which is submitted by **TARUN SHOKEEN,2K18/ENE/13**, Department of Environmental Engineering, Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, is a record of the project work carried out by the students under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Geeta 10/07/2020

Place: Delhi
Date: 10/07/2020

(DR. GEETA SINGH)
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ABSTRACT

The present study has been undertaken in order to design a sewage treatment plant for NDLS (New Delhi Railway Station) based on the Cyclic activated sludge technology(C-tech).

The large amount of sewage waste generated at NDLS, one of the busiest railway station in India ,is disposed off directly in the Yamuna river due to this the quality of Yamuna river is deteriorating day by day ,to stop this direct disposal of sewage waste into the Yamuna river the study was undertaken to design the sewage treatment plant for NDLS based on Cyclic activated sludge technology which will require relatively less area and will process and treat the sewage water and will dispose the treated sewage water into the Yamuna river according to the Indian standards for wastewater treatment.

***Keywords**:* C-Tech technology, sewage, waste water treatment

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Place: Delhi
Date: 11/07/2020

(TARUN SHOKEEN)

TABLE OF CONTENTS

CANDIDATE DECLARATION	**2**
CERTIFICATE	**3**
ABSTRACT	**4**
ACKNOWLEDGEMENT	**5**
TABLE OF CONTENTS	**6-7**
LIST OF FIGURES	**8**
LIST OF TABLES	**8**

Chapter 1 : Introduction and Objective	**9-11**
1.1 New Delhi railway station	9
1.1.1Waste water generation and management	9
1.1.2 Waste water quality	10
1.2 Waste water recycle and reuse system	10
1.3 Motivation	11
1.4 Objective	11
Chapter 2 : Literature Review	**12**
Chapter 3 : Waste water Treatment description	**13-25**
3.1 Treatment unit description	13
3.1.1 Stilling chamber	13
3.1.2 Fine screen channel	13
3.1.3 Grit chamber	13
3.1.4 C-Tech basins	14
3.2 Features of C-tech system	14
3.3 Treatment process description	17
3.4 Instruments and Control Philosophy	20
3.4.1 Auto-Valve Operation	20
3.4.2 Instruments	21
3.5 Sludge Sump and Pump House	21
3.6 Equipment	22
3.8.1 Return Activated Sludge (RAS) Pump	22
3.8.2 Surplus Activated Sludge (SAS) Pump	22

Chapter 4 : Material and methods **23-39**
4.1 Study Area 23
4.2 Stilling chamber 23
4.3 Fine screens 24
4.4 Grit chambers 25
4.5 Chlorine contact tank 26
4.6 Chlorinator 26
4.6 Mechanical dewatering unit 27

Chapter 5 : Results and discussion **35-36**

Chapter 6 : Recommendations **37**

Photo Gallery **38**

References **39**

Previously Published Research Paper **40**

List of Figures

Fig. 1 : C-Tech Plant Overview

Fig. 2 : Decanter of the C-Tech Process

Fig. 3 : Aeration basin

Fig. 4 : Nitrification and Denitrification

Fig. 5 : Decanting Process

Fig. 6 : Schematic Drawing of a C-Tech Basin

Fig. 7 : Plane of Treatment Plant

Fig. 8 : Stress Distribution on C-Tech Basin

Fig. 9 :Sewer flowing with Sewage Water

Fig.10:Extracted Sewage sample from Manhole

Fig.11:Sewage sample site and sewage pump house

List of Tables

Table 1.1 : Wastewater Quality of Disposed water at station

Table 4.1: Design Basin

Table 4.2: Treatment Sequence

Table 4.3: Basin Sizing

Table 4.4: Basin Sizing as per CPHEEO Manual Value

Table 4.5: Selector (Anoix) Zone

Table 4.6: Oxygen Calculation at peak Flow Condition

Table 4.7: Air Requirement at peak flow conditions

Table 4.8: Sludge Wasting

Table 4.9: Equipment Specification for C-Tech System

Table 5.1: Excavation Cost

Table 5.2: PCC Cost

Table 5.3: RCC Cost

Chapter 1 : Introduction

1.1 : New Delhi Railway Station

The New Delhi Railway Station (NDLS), is one of the busiest and largest railway stations in India. The NDLS handles above 355 trains and 5,10,000 passengers on the daily basis on its 16 platforms.

The NDLS was opened for public in 1926 with a total covered area of 80 hectares.

Being the capital of India, New Delhi railway station faces the huge number of traffic, thereby contributing to the large number of waste generation which is directly being disposed to the river Yamuna.

1.1.1 : Wastewater Generation and Management:

Wastewater is generated from various sources at the station these include wastewater from:

- Over flow in the Coach filling process
- Apron washing and Platform washing
- Service buildings (Offices, waiting rooms, rest rooms and running rooms)
- Water booths
- Toilets
- Restaurants/ Canteens

The overflows from the overhead tanks are also drained along with the wastewater of the station.

Wastewater generated at different locations is estimated, the wastewater is let out through a network of chambers which ultimately joins the main discharge drains. Four major drains receive the wastewater from the NDLS Railway Station:

- Rajdhani complex washing line
- DLT washing line
- Platforms
- Shatabdi Complex

1.1.2 : Wastewater Quality

Wastewater quality monitoring consisted of composite sampling from the main wastewater discharge locations of the station. Three drains which were identified for this exercise are:

Table 1.1 : Wastewater Quality of Disposed water at station

Sample locations	pH	TSS (mg/L)	BOD (mg/L)	COD (mg/L)	O & G (mg/L)	NH_3 (mg/L)
Rajdhani complex washing line drain	7.5	71	49	80	03	35
DLT washing line drain	7.3	576	235	656	06	40
Wastewater drain at platform 16 near parcel area	7.6	294	178	2000	01	48

1.2 : Wastewater recycle/reuse system

As detailed earlier, a significant volume of wastewater is discharged from the station. In light of considerable volume and quality of discharged wastewater, there is a possibility of spillage and indirect contamination of water resources (surface and groundwater) on discharging the wastewater in the environment. It is recommended that a wastewater treatment system should be installed and integrated with the existing water supply system for non-potable water using activities such as coach washing, apron washing, platform washing, toilet flushing, horticulture, etc. This shall further help reduce the freshwater consumption of the station leading to improvement in water use efficiency, hence reducing the pressure on the natural resource

1.3 Motivation

Currently there is no means of treatment of waste water in NDLS. All this untreated wastewater is being dumped directly into the Yamuna which is further adding to the pollution to the almost biologically dead river. Also the potential of reusing and recycling of wastewater can drastically reduce waste water consumption.

I was motivated to design a low cost wastewater treatment plant for NDLS using SBR Technology to reduce pollution in Yamuna and also tap into potential of wastewater reusing and recycling.

1.4 Objective

Following are the objectives of my study:-

1. To design a low cost waste water treatment plant at new Delhi railway station.
2. Estimation of cost of C-tech based SBR system waste water treatment plant.

Chapter 2 : Literature Review

R. Rajamanickam, S. Nagan, 'C. Tech process in municipal sewage treatment plant - A case study'[1]

Water Resources are being degraded from the pollution caused by sewage discharged from cities and town. C-Tech is an advanced technology of sequential batch reactor (SBR) for treatment of sewage. It usually operates in the cycle of batches. Each cycle is generally of 2.6 to 5 hours duration (usually taken as 3 hours for design basis). Many modules are provided for the continuous treatment of wastewater. Removal of organics, N and P reduction is allowed in a single reactor. One cycle operation consists of 3 steps - filling & aeration, settling and decantation. Sludge volume index of the settled sludge in basin is observed to be (SVI) < 120 and excellent settling characteristics. The excess sludge can be used as manure after complete digestion and dewatering. To separate and concentrate the sludge there is no requirement of secondary clarifier system. Two STPs of C-Tech type with capacity of 125 MLD STP at Avaniapuram and 45.7MLD at Sakkimangalam has been constructed by Madurai corporation in Tamil Nadu in 2011. The results of the treated sewage sample were as follows BOD is < 9 mg/L, COD < 25mg/L and TSS is < 8 mg/L. The treated sewage can be used for farming .By observing the performance of cyclic activated sludge process it can be concluded that it is one of the best technologies that can be used for the treatment of sewage water in local bodies.

Bhakti Kulkarni, R.V. Wanjule, H.H. Shinde, 'Performance Assessment of 100 MLD Sewage Treatment Plant Based On C-TECH Technology at Vashi, Navi Mumbai.'[2]

The aim of this study was to do the performance and functional audit of the 100 MLD Sewage Treatment Plant at Vashi, Navi Mumbai which operates on the latest C-tech Technology. Most of the treated effluent is discharged into Vashi creek and the rest of the treated effluent is used for gardening purpose. From the inlets and the outlets of the STP water sample is being collected and various quality parameters such as Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO)etc. Samples were collected for the period of 10 months (march to December). The results obtained were cross checked by the limits prescribed by MPCB.

B Hazard, K Wutscher, T Bullen, 'C-tech – a reduced footprint cyclic activated sludge technology with simultaneous denitrification and nitrification, and biological phosphorous removal in a single treatment step.'[3]

UK waste water treatment industry is facing increasing number of challenges from increasing the pollution levels in the water. Thereby low level of ammonia, phosphorous and total nitrogen are required without adding chemical dosing. C-Tech technology emerges out to be the best technology to overcome the above problems in a single treatment step. The above process can achieve the following effluent values BOD:SS:TN:TP of < 10:10:10:1 mg/l respectively.

Chapter 3 : Waste Water Treatment Description

3.1 Treatment Unit Description

The proposed treatment plant comprises of the following main process units

1. Stilling Chamber
2. Mechanical Fine Screen channels
3. Mechanical Grit chamber
4. C-Tech Basin
5. Sludge Sump & Pump House
6. Sludge Dewatering System

Process design of these units is given below.

3.1.1 Stilling chamber

The stilling chamber is basically a small chamber specially designed to reduce the effluent flow rate. The reduction in the flow rate will results in the rise of the entrapped gases rise to the surface.

3.1.2 Fine screen channels:

The main purpose of fine screens is to reduce the load on the further treatment units by removing approximately twenty to twenty two percent of suspended solids from the sewage, thereby proving it very effective. Perforations size of fine screen ranges from 1.5mm to 3mm.

3.1.3 Grit Removal chamber

The grit chambers are usually placed after the fine screens, to remove the particles of size 0.2mm. Grit chamber is basically designed to remove inorganic materials like sand gravel and silt by using the sedimentation phenomena.

3.1.4 C-Tech

Cyclic activated sludge technology also known as advanced Sequential Batch Reactors is an advanced biological treatment process for the domestic as well as industrial effluents. C-Tech is an very advanced technique that significantly reduces the installation time and also the cost to a very large extend as compared to other process based Sewage Treatment Plants. This also requires relatively very less area as compared to other processes. This technology is not so widely used in India but is growing very popular in countries like America, Asia, Europe and middle east.

Fig. 1 : C-Tech Plant Overview

3.2 Features of C Tech System :

The C-Tech based STP has the following features :-

3.2.1 Biological Selector zone - No bulking, No Foaming, Denitrification, Phosphorus release for Biological Phosphorus removal

The Biological Selector is being installed in the very front of C-tech System which makes this technology different from other technologies. Under anoxic mix conditions raw effluent is allowed to enter the selector zone. Using RAS pumps, return sludge is being recycled into this zone from the aeration basin. The main function of this zone is the natural selection of the floc forming microorganisms to overcome the need of high Biological oxygen Demand and low Dissolved Oxygen condition. This results in the elimination of the major issue of bulking and foaming. Excellent settling characteristics can be ensured through this process. The Sludge Volume Index always remain less than 120 irrespective of the seasons. Denitrification and phosphorus release also takes place due to the development of anerobic conditions in the selector zone.

3.2.2 Dissolved Oxygen Control - Energy Savings

To optimize the power consumption and to enhance the treatment efficiency Dissolved Oxygen level measurement takes place in the C-Tech reactor. DO sensors continuously monitor the DO concentration in the basin. After the measurement of the Dissolved Oxygen in the basin, to maintain the desired Dissolve Oxygen level in the basin, a variable frequency drive automatically alters the rpm of the aeration blower. Through this methodology efficient use of the energy can be done and power savings up to 20 to 30 percent can be observed.

3.2.3 Fully Programmable Logic Controller system Based Intelligent Control – Operational Simplicity

The complete C-Tech plant operation is controlled automatically through a Programmable Logic Controller system, which is a major factor in reducing operating costs. All key functions like, RAS, sludge wasting, aeration intensity, cycle time control, decanting rate etc. are automatically controlled along with data logging, Complete historical records of plant operation are available on touch of a button

3.2.4 Stainless Steel Decanter - Corrosion Resistant and Long life.

The clear supernatant is removed from the basin using a stainless steel Decanter. During decanting there is no inflow to the basin. The moving weir DECANTER IS motor driven and travels slowly from its park’ position to a designated bottom water level. Variable frequency drives are provided to control the rate of movement of the Decanters. After the required level of supernatant is removed

the Decanter is returned to its “park” position through reversal of the drive. The basin is now ready for the next cycle to begin. Stainless steel fabrication ensures resistant to corrosion, long equipment life without any/no maintenance

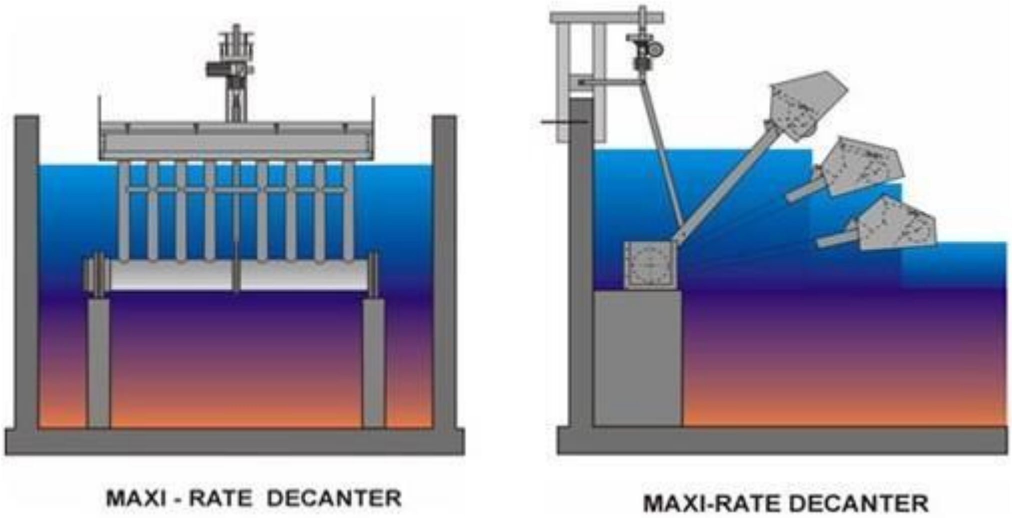

Fig. 2 : DECANTER of the C-TECH Process

3.2.5 Fine Bubble Diffusers for Aeration

Essentially, the aeration system can be thought of as the heart of the C Tech system. The very high quality fine bubble membrane diffusers are used for the process of aeration. The system has highest oxygen transfer efficiency which can yield substantial cost savings and the membrane material is advanced quality PU which promotes extended diffuser life.

Fig 3: Aeration Basin

3.2.6 Surplus Activated Sludge and Return Activated Sludge Pumps for Sludge Wasting.

Submersible RAS and SAS pumps are placed in the C Tech reactor itself. It reduces external pumping space requirements. The pumps are equipped with thermal overload switches to protect the motor.

3.3 Treatment Process Description

The raw sewage after being processed through the grit chamber is being taken to the biological treatment unit to remove phosphorous, organic and nitrogen..

Nitrification, phosphorous removal, BOD reduction denitrification is being processed through cyclic activated sludge technology(C-Tech) which generally operates on extended aeration principle using diffused aeration system of very energy efficient fine bubble membrane which automatically control the uptake rate of oxygen, thereby resulting in power savings of 20 to 30 percent.

The inefficiencies of the continuous processes are being eliminated using the advanced C-tech system which operated on a batch reactor mode. 100 percent treatment is being ensured by this batch reactor thereby also termed as perfect reactor. However, each single reactor is used sequentially for the complete process but to ensure continuous operation two tanks are provided.

This complete biological operation can be divided into numbers of cyclic mode and every basic cycle comprising of :

- Fill-aeration
- Sedimentation
- Decantation

Each cycle is generally of 2.6 to 5 hours duration (usually taken as 3 hours for design basis). The liquid volume increases from low water level to the high water level inside the reactor during the process of fill-aeration. During the fill-aeration process, mixed liquor is being recycled into the selector zone from the aeration zone. The biomass is allowed to sttle under quiescent conditions when the process of aeration ends in the predetermined period. Once the predetermined settling period gets over, using a moving weir electromechanical decanter the treated supernatant is decanted. The cycle is repeated after decanting once the liquid level in the reactor reaches to bottom. During the decanting phase solids are being removed from the reactor.

30 to 40 percent space saving can be done by allowing the operation of fill-aeration, settling and decant consecutively and continuously in the same tank only. To separate and concentrate the sludge there is no requirement of secondary clarifier system.

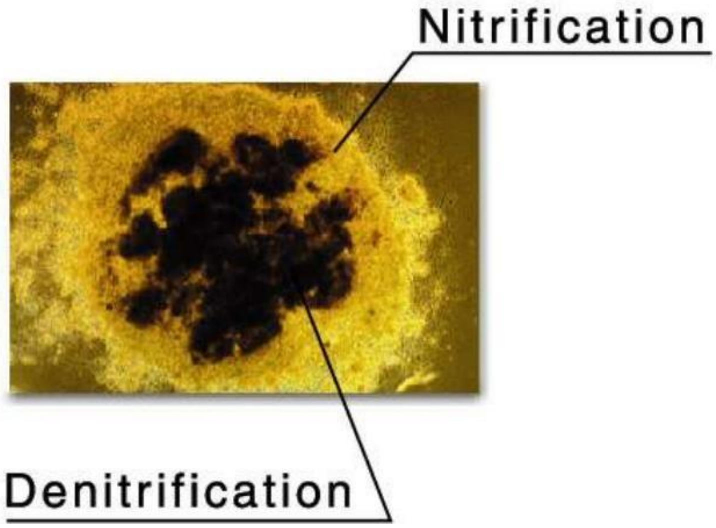

Fig. 4: Nitrification and Denitrification

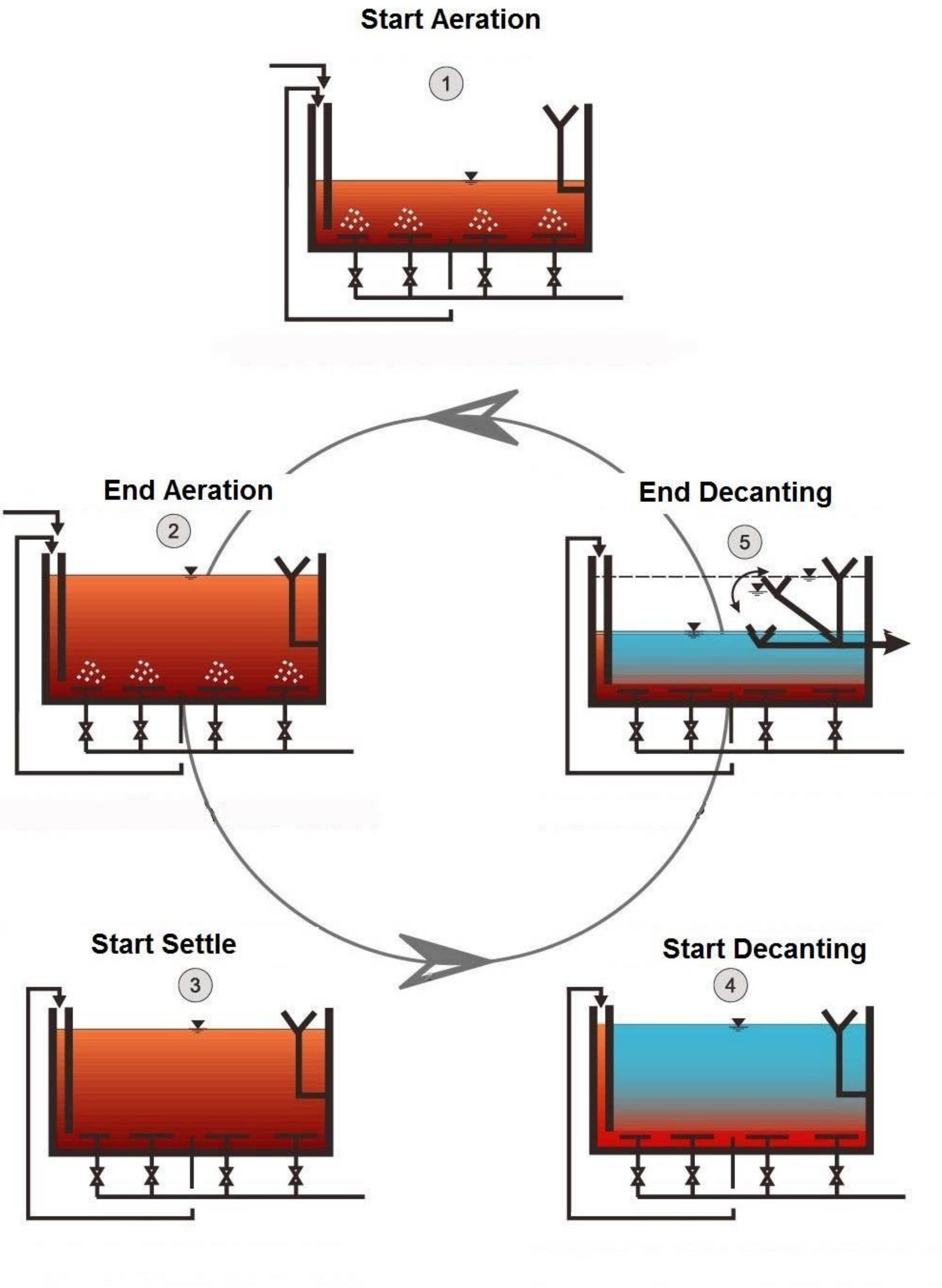

Fig. 5: Decanting Process

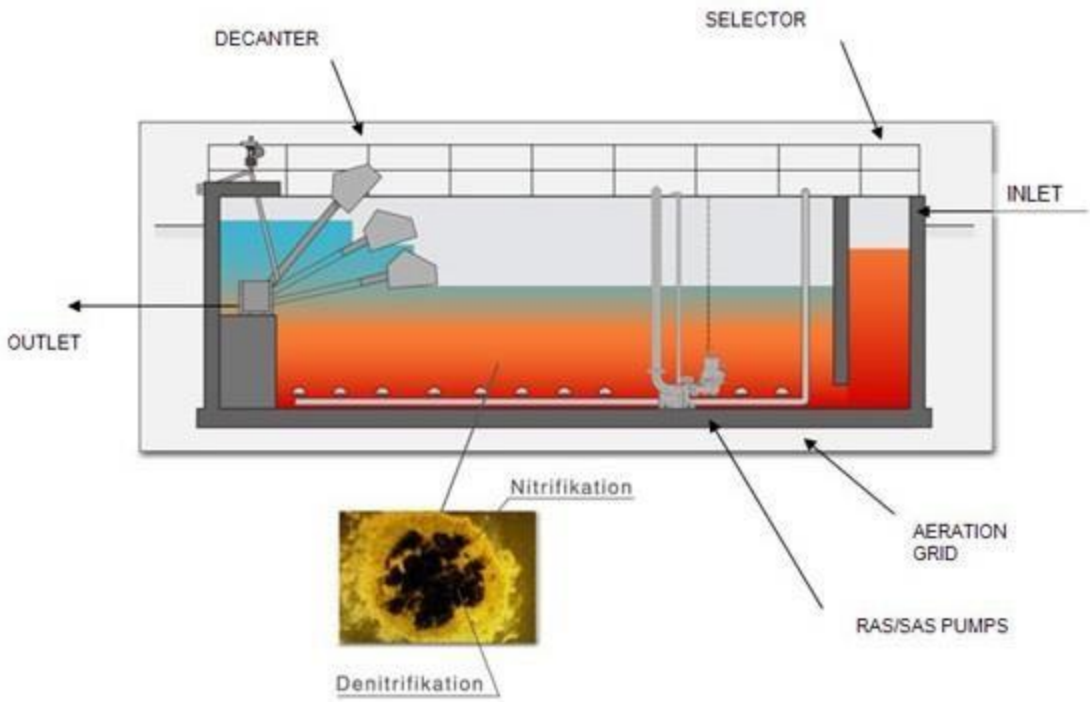

Fig. 6: Schematic Drawing of a C-Tech Basin.

3.4 Instrument and Control Philosophy

The Biological system based on C-Tech Technology will be fully controlled and automatic. Various operations in the basins will be controlled by PLC as follows:

3.4.1 Auto - Valve Operation

a) C-Tech Basin Inlet Gates: Will on/off automatically based on input from PLC to the Gate to allow inflow of wastewater in the selected basin. Based on the pre-decided cycle time, PLC will command one of the inlet Gates to open and receive the influent for a specified time

b) Main Air Header Valves: Will on/off automatically based on input from PLC to the Valve to allow inflow of air in the Aerating basin. Based on the pre decided cycle PLC will command one of the valves to open and supply air to the basin for a specified time. This valve will remain open throughout the entire filling and aeration phase of the basin and will remain closed during other phases of the basin.

c) Selector Air Header Valves: Will on/off automatically based on input from PLC to the Valve to allow inflow of air in selector area of the basins. Based on the pre-decided cycle PLC will command one of the valves to open and supply air to the basin's selector for a specified time. The valve will be under open condition only when main Air Header Valve is open and will be open for the same basin only.

3.4.2 Instruments

a. Level Transmitter: Provides input to PLC about the fill and decanted volume. Also regulates the speed of decanter based on the depth of water to be decanted by controlling the VFD connected to Decanter.

b. DO Analyzer: Analyses the DO level in the tank on continuous basis based on which Air Blower rpm is automatically adjusted through connected VFD with help of PLC to maintain set point DO value in the basin.

c. Decanter Level Positioner: Limits the upward I downward movement of decanter while basin is under decantation.

d. Decanter Level Sensor: Monitors and controls the downward movement of decanter while basin is under decantation.

3.5 Sludge Sump and Pump House

To collect excess sludge generated from the Cyclic Activated Sludge Process, Sludge sump is provided. One common sludge sump is provided for all basins. To assure continuous mixing of contents inside the sludge pump an assembly of coarse bubble air grid made of PVC pipes and air blower is provided.

3.6 Equipment

3.6.1 **Return Activated Sludge (RAS) Pump:** On I off of the pump is regulated by PLC. The pump starts for the basin, which is receiving the influent in the basin and stops only when aeration cycle for the basin ìs completed. The pump does not operate during Settling and Decanting1 phase of the cycle.

3.6.2 **Surplus Activated Sludge (SAS) Pump:** On I off of the pump is regulated by PLC for a specified duration in a treatment cycle, during the decanting phase of the cycle.

Chapter 4 : Material and Methodology

4.1 Study Area

This study includes the design of sewage treatment plant of 17.78 MLD capacity based on the C-tech technology at the New Delhi Railway Station. In this study design of all the units involved in C-tech based STP was carried out and also did the cost estimation to find the overall cost of the project.

4.2 Stilling chamber

Stilling chamber is being designed considering an average flow rate of 8.89 MLD and a peak factor of 2.00. Adequate RCC access platform with railing and staircase as per requirement shall be provided.

Average flow	=	8.89 MLD
Peak factor	=	2.00
Design Flow	=	17.78 MLD
Number of Units	=	1
Detention period	=	30 sec
Min Free board	=	0.5 m

No. of units	=	1
Designed for	=	peak flow
	=	2 x 8890 m3/day
	=	17780 m3/day
	=	0.206 m3/s
Hydraulic retention time	=	30 sec
Volume of tank	=	.206 x 30
	=	6.18 m3
Side water depth	=	3 m
(assuming L is twice the width)		
Width	=	1.1 m
Length	=	2m
Dimension of stilling chamber	=	2 x 1.1 x 3 m

4.3 Fine screens

Each screen channel shall be designed for the peak flow capacity. The clear opening of 2 mm shall be considered for mechanical screens. The bars uses in the mechanical screens shall be of 2 mm thickness of stainless steel SS 304 flats. Chute arrangement and the conveyor belt is to be provided. To regulate the flow the gates are being provided at the upstream as well as the downstream sides.

Average flow : 8.87 MLD

Peak factor : 2.00

Design Flow: 17.78 MLD

No. of Units : 2

Mechanical Approach Velocity at Average Flow(m/sec) : 0.31

Average flow velocity through Screen (m/sec) : 0.5

Peak flow velocity through screen (m/sec) : 1.4

Min Free board : 0.6m

Total working screens = 2 Nos.

Total Standby Screens = 1 Nos.

Designed for = Peak flow = 0.206 m3/s

Average flow = 8890 m3/day = 0.103 m3/s

No. of mechanical screens = 2

(Let cross-section of fine screen be 0.75 m depth x 0.7 m width x 4 m)

Velocity in channel at average flow = average flow/cross-section area of screen channel

= 0.103/ (0.75 x 0.7) = approx 2 m/sec

Head loss across screens = 0.728 $(v^2 - u^2)$

v(velocity though screen at peak flow) = peak flow though channel/clear area of opening

= 0.111 m/s

u(velocity in approach channel at peak flow)= Peak flow though channel/c.section are of channel = 0.0446 m/s

Head loss across screen at peak flow = 0.050 m

Velocity through screen at 50% clogged condition at peak flow = 1.35 m/s

Head loss across screen at 50% clogged condition at peak flow = .158 m

4.4 Grit Chamber

Two mechanical grit chamber (detritus) are provided after fine screen units. At the entrance of the chamber Gates shall be provided. Platforms of RCC with railing shall be provided at the upper level to assure the easy operation of gates.

Average Flow : 8.89 MLD

Peak Factor : 2.00

Design peak Flow : 17.78 MLD

No of units : 2

Specific gravity of grit = 2.5

Freeboard = 0.3m

Number of working units = 2

Number of standby unit = 1

No. of units to be provided = 2

Mechanical Size of grit particle = 0.15mm

Designed flow = 17780 m3/day

Design flow for each grit chamber= 17780/2 =8890 m3/day

Considering overflow rate as = 1000 m3/m2/day

Area of grit chamber required = 8890/1000 =8.89 m2

Take size of square detritus tank as 3 m x 3 m

Detention time in grit chamber = 60 secs

Volume of tanks = 0.103 x 60 = 6.18 m3

Depth required = 6.18/(3x3) = 0.69

Grit storage depth = 0.3 m

Total depth provided = 1 m

(dimension of grit chamber 3 x 3 x 1)

4.5 Chlorine Contact Tank

No. of units = 1 NOS.

Average flow =8890 m3/day =370.5 m3/hr

Decanting flow = 370.5 m3/hr

Hydraulic retention time = 20 min

Volume of tank = flow x HRT = (370/60) x 20 = 123.5 m3

Side water depth = 2 m

Assuming length is twice the width

Length of tank= 11.2 m

Width of tank = 5.6 m

Volume provided = 125.44 m3

Provide free depth = .3 m

Total depth of chlorine contact tank = 2.3 m

Provide chlorine contact size of 11.2 m x 5.6 m x 2.3 m

4.6 Chlorinator

Average flow = 370.5 m3/hr

Design chlorine dosage = 2 ppm

Quantity of chlorine = flow x dosage = 370.5 x 2/1000 = 0.741 kg/hr

No. of standby chlorinators = 1

Total no. of chlorinators = 2

Chlorinator capacity provided = 0.8 kg/hr

4.7 Mechanical dewatering unit

Hundred percent trouble free operation during the entire time is being ensured through the mechanical dewatering units.

Through open body truck the dewatered sludge can be disposed as it can be transported through truck.

Number of Units : 4 Nos. (3 Working+ 1Standby)

Operating Hours : 18 hrs per day maximum

Poly Dosing Rate : 1.5kg/l

Table 4.1: Design Basin

S.No.	Design Basis	Value	Unit
1	Inlet Flow	8890	m^3/day
2	Peak Factor	2	-
3	Inlet BOD	170	mg/L
4	Outlet BOD	8	mg/L
5	Inlet COD	280	mg/L
6	Outlet COD	90	mg/L
7	Inlet TSS	300	mg/L
8	Outlet TSS	9	mg/L
9	Inlet TKN	45	mg/L
10	Outlet TKN	6	mg/L
11	Outlet Ammonia Nitrogen	2	mg/L

Table 4.2: Treatment Sequence

S.No.	Design Consideration	Value	Unit
A	Volume of Sewage Treated	8890	m^3/day
B	Fill and aeration space	1.5	Hours
C	Settling phase	0.50	Hours
D	Decanting phase	1.00	Hours
E	Total cycle time(B+C+D)	3.5	Hours
F	No. of cycles per day per basin	8	No.
G	Aeration time per day per basin	12	Hours
H	No. of basins receiving flow simultaneously	3	No.
I	No. of basins aerating simultaneously	3	No.
J	No. of basing decanting simultaneously	2	No.
K	Flow rate	370.5	$m^3/hour$
L	Flow rate to each basin	12.5	$m^3/hour$

Table 4.3: Basin sizing

As per CPHEEO- MLSS is 2000-4000mg/L

S.No.	Design consideration	values	unit
A	Volume of sewage treated	8890	m^3/day
B	BOD applied	170	mg/L
C	MLSS	2000	mg/L

Table 4.4: Basin Sizing As per CPHEEO manual value

As per CPHEEO- 1. MLVSS is 0.75-0.80 of MLSS

2. F/M(Food/Mass) is 0.2-0.4

S.No.	Design consideration	values	unit
D	MLVSS	1500	mg/l
E	F/M	0.25	-
F	Total Vol. of Aeration Basin{(A*B)/(D*E)}	4030.2	m^3
G	Number of Basins Provided	6	Nos.
H	Vol. Required per Basin(F/G)	671.7	m^3
I	Side Water Depth of the C-Tech Basin	4	m
J	Length of C-Tech Basins	25	m
K	Width of C-Tech Basin{H/(I*J)}	6.72	m
L	Provide width of C-Tech Basin as	6.8	m
M	Vol. Provided per C-Tech Basin(I*J*L)	680	m^3
N	Total Volume Offered(G*M)	4080	m^3
O	Freeboard Provided in C-Tech Basin	0.5	m
P	Total Depth of C-Tech Basin(I+O)	4.5	m
Q	Hydraulic Retention Time{(N/A)*24}	12	Hours
R	Providing Recirculation Ratio	20%	feed flow per basin
S	Feed Flow to each Basin	124	$m^3/hour$
T	Recirculation Pump Flow Required(S*R%)	24.7	$m^3/hour$
U	Recirculation Pump Flow Provided	25	$m^3/hour$

Table 4.5: Selector (Anoxic) Zone

S.No.	Design Consideration	Values	unit
A	Flow rate through each Basin	150	$m^3/hour$
B	Retention time in selector zone	55	Min.
C	Volume Required{(A*B)/60}	125	m^3
D	Number of selector compartments/basin	7	Nos.
E	Side depth of selector compartment	4	m
F	Length of selector compartment	11	m
G	Width of selector compartment{C/(E*F)}	2.8	Metre
H	Width of selector compartment provided	3	Metre
I	Volume offered in selector zone(E*F*H)	134	m^3

Table 4.6: Oxygen calculation at peak flow condition

1. $f = \frac{BOD_5}{BOD_u} = 0.68$
2. 4.56Kg O2 is required for 1Kg of Ammonical Nitrogen(NH3-N)
3. Recommended Dissolved Oxygen(D.O.) is 1-2mg/L
4. Oxygen Required under standard conditions (SOR) :

$$SOR = AOR + [((\beta C'_{sw} - C) + C_{sw}) \times 1.024^{(T-20)} \times \alpha]$$

Where, T : Temperature in C-Tech Basin

C_{sw} : solubility of Oxygen at 20°C

C'_{sw} : Solubility of Oxygen in tap water at field temperature

C : Design Dissolved Oxygen Concentration in aeration basin

α : Oxygen transfer correction factor

Β : Salinity surface tension factor

S.No.	Design Consideration	Value	Unit
A	Volume of sewage treated	8890	m^3/day
B	Theoretical Kg of O_2 Required per Kg BOD	1.2	-
C	Inlet BOD_5	170	mg/L
D	Outlet BOD_5	8	mg/L
E	BOD_5 Removed(C-D)	162	mg/L
F	Kg of BOD Removed in a Day(A*E)	1440.2	Kg/day
G	Kg of O_2 Required for BOD load(B*F)	1728.24	Kg/day
H	Inlet Total Kjeldhal Nitrogen	45	mg/L
I	Outlet Ammoniacal nitrogen	2	mg/L
J	Nitrogen assimilated during BOD removal	9	mg/L
K	Outlet nitrate nitrogen	3	mg/L
L	$NH_3 - N$ removed in a day(H-I-J)	34	mg/L
M	Kg O_2 required per Kg of $NH_3 - N$	4.6	-
N	Kg of $NH_3 - N$ removed in day(A*L)	302.26	Kg/day
O	Kg O_2 required for $NH_3 - N$ removal(M*N)	1390.39	Kg/day
P	Kg O_2 released per Kg of Nitrate-Nitrogen During Denitrification	2.86	-
Q	Kg of Nitrate-Nitrogen generated (assuming 75% Nitrification){A*L*75%}	226.7	Kg/day
R	Kg of Nitrate-Nitrogen in treated sewage(A*K)	26.7	Kg/day

S	Quantity of Nitrogen i.e., Denitrified(Q-R)	200	Kg/day
T	Kg O_2 released during Denitrification(P*S)	570	Kg/day
U	Total Kg O_2 required per day(G+O-T)	2546	Kg/day

Table 4.7: Air Requirement at peak flow conditions

S.No.	Design Consideration	values	unit
A	Total actual oxygen required per day (AOR)	2546	Kg/day
B	Oxygen required under standard conditions(SOR)	5334.74	Kg/day
C	No. of basins Provided	6	-
D	Standard oxygen required at field conditions per basin(B/C)	890	Kg/day/basin
E	Top water level (TWL) in C-Tech basin	4	m
F	Bottom water level (BWL) in C-Tech basin	2.5	m
G	Aeration depth in the basin{(E+F)/2}	3.25	m
H	Height at which diffusors kept	0.25	m
I	Effective aeration depth(G-H)	3	m
J	SOTE for the above effective aeration depth	24.02	%
K	By weight fraction of oxygen in the air	23.18	%
L	Specific gravity of Air at standard condition	1.293	-
M	air req. at field condition per basin{D/(J*K*L)}	12270.5	Nm^3/day/basin
N	Hours of aeration time/basin/day	12	Hour/day/basin
O	Air required/hour/basin(M/N)	1022.54	Nm^3/hour/basin
P	Number of operating blowers/basin	2	Nos.
Q	Capacity of blowers required(O/P)	511.27	Nm^3/hour
R	Capacity of blowers offered	515	Nm^3/hour
S	Number of basins/set of blowers	1	Nos.
T	Number of basins	6	Nos.
U	Number of operating blowers{p*(R/S)}	6	Nos.
V	Number of standby blowers	3	Nos.

Table 4.8: Sludge Wasting

S.No.	Design Consideration	Value	Unit
A	Excess sludge generated per Kg of BOD	0.765	Kg/Kg BOD
B	Kg of BOD removed in Day	1511.3	Kg/day
C	Excess sludge generated/day(A*B)	1156.4	Kg/day
D	Sludge solids consistency	0.80	%
E	Specific gravity of sludge	1.05	-
F	Total vol. of sludge wasted{C/(D% *E*1000)}	137.64	m^3/day
G	Number of basins	3	Nos.
H	Sludge wasted per basin(F/G)	45.88	$m^3/day/$basin
I	Number of cycles/day/basin	6	Cycle/day/basin
J	Sludge wasted/cycle/basin(H/I)	7.65	$m^3/cycle$
K	Pump running time per cycle	15	Minutes
L	Pumps capacity required{(J*60)/K}	30.59	$m^3/hour$
M	Pump capacity offered	35	$m^3/hour$

Table 4.9: Equipment Specification for C-Tech System

S.No.	Description	Specification	Nos.
1	Inlet Gate to C-Tech Basin	Auto Gate	6
2	Air Blowers	4550 Nm^3/h @0.62Kg/cm^2	6W+3S
3	VFD for Air Blower	Suitable	3
4	Diffusor assembly	Suitable (fixed type)	1 Lot.
5	Decanters with positioner and Drive	Suitable	6
6	VFG for auto rate control of Decanters	Suitable	6
7	RAS Pumps	105 m^3/h @0.5 Kg/cm^2	3
8	SAS Pumps	35 m^3/h @1 Kg/cm^2	3
9	Piping and walls	-	1 Lot.
10	Main Air Header Wall	Auto Butterfly	3
11	Selector Air Header Wall	Auto Butterfly	3
12	Selector Down Comers wall	Manual ball	21
13	SAS Pump Discharge	Auto KGV	3
14	Instrumentation and Controls		
A	PLC and Control Panel	-	1
B	DO Transmitter	Fixed type	3
C	Level Transmitter	Hydrostatic Type	3
D	Pressure Gauge	Bourdon Type	8

Chapter 5: Results and discussion

The following results are summarized in the table below.

- The total cost of the project come out to be Rs.12004321
- The total cost per MLD comes out to be Rs.1350317.8
- The total area required for this plant comes out to be 200 m^2.

5.1 Project Cost Estimation

The rates per m^3 were taken from Delhi Scheduled Rates 2016(DSR) for the calculation of overall cost of the project.

Table 5.1: Excavation Cost

S.No.	Components	No. of Units	Volume(m^3)	Cost (₹/m^3)	Cost Of The Component (₹)
1	Grit Chamber	2	33.7	160	5392
2	C-Tech Basin	6	5609	160	897440
3	Chlorine contact tank	2	380.5	160	60880
4	Stilling basin	2	30	160	4800
5	Fine screen channel	3	18.84	160	3014

Table 5.2: PCC Cost

S.No.	Components	No. of Units	Area (m^2)	Cost (₹/m^2)	Cost of The Component(₹)
1	Fine Screen Channel	3	18	4000	7200
2	Stilling Basin	2	8.85	4000	35400
3	Grit Chamber	2	26	4000	10400
4	C-tech basin	6	1136.64	4000	4546560
5	chlorine contact tank	2	146.32	4000	585280

Table 5.3: RCC Cost

S.No.	Components	No. of Units	Volume (m^3)	Cost (₹/m^3)	Cost Of The Component(₹)
1	Stilling Basin	2	16	5500	88000
2	Fine Screen Channel	3	12.54	5500	68970
3	Grit Chamber	2	15.7	5500	86350
4	C-Tech Basin	6	1019.025	5500	5604635

Total Cost = Rs.12004321.00
Cost Per MLD = Rs.1350317.32

Chapter 6 : Recommendations

Based on the complete sewage treatment design and the cost analysis I would like to provide following recommendations:-

- Cyclic activated sludge technology based sewage treatment plant is a very good alternative for the treatment of waste water at every railway stations in our country.
- C-Tech technology requires relatively less area and low cost as compared to other treatment processes.
- The quality of our river Yamuna can be enhanced to a great extent.
- I propose to Government of India to have this kind of small scale latest technology based sewage treatment plant at every railway station across India.
- The Coordinates of land of two hundred meter square required for the build up of this Sewage Treatment Plant are 35.6458^{o}N,75.2689^{o}E.
- The aesthetic view of the station as well as the railway station can be enhanced to a great extent.

Photo Gallery

Fig. 9:Sewer flowing with Sewage Water   Fig.10:Extracted Sewage sample from Manhole

Fig.11:Sewage sample site and sewage pump house

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