A

Dissertation Report On

Design and Development of Low Cost Domestic (hostel)Wastewater Treatment Plant

Submitted

In partial fulfilment of the requirements for the degree of

Master of Technology

In

Civil-Construction Management

by

Mr. Harshad Mahipati Bhosale

(Roll no. 1827011)

Under the supervision of

Dr. Y. M. Patil

(Professor,RIT Islampur)

Department of Civil Engineering

K.E. Society's

Rajarambapu Institute of Technology, Rajaramnagar

An Autonomous Institute, Affiliated to Shivaji University,Kolhapur

2019-2020

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CERTIFICATE

This is certify that, **Mr.Harshad Mahipati Bhosale (Roll No-1827011)** has successfully completed the dissertation work and submitted dissertation report on "Design and Development of Low Cost Domestic (hostel)Wastewater Treatment Plant" for the partial fulfillment of the requirement for the degree of Master of Technology in Civil-Construction Management from Department of Civil Engineering, as per rules and regulations of Rajarambapu Institute of Technology,Rajaramnagar.

Date:

Place: Rajaramnagar

Dr. Y. M. Patil

Supervisor

Name	Prof. D.S.Patil
External Examiner	Head of program
Dr.P.D.Kumbhar	Prof.Dr.S.S.Gawade
Head of Department	PG Convener

DECLARATION

I declare that this report reflects my thoughts about the subject in my own words. I have sufficiently cited and referenced the original sources, referred or considered in this work. I have not misrepresented or fabricated or falsified any idea/data/fact/source in this my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute.

Place:RIT, Rajaramnagar. Name of Student: Harshad Bhosale

Date: Roll no.1827011

ACKNOWLEDGEMENTS

I would like to express a deep sense of gratitude towards my guide Dr. Y. M. Patil Department of civil Engineering,RIT Islampur for providing this opportunity ,Valuable guidance and inspiration throughout the project work.

I am thankful to Civil engineering depertment and my parent Institute RIT,Islampur for providing support.I am grateful towards all teaching and non teaching staff of my college.

Place:RIT, Rajaramnagar. Name of Student: Harshad Bhosale

Date: Roll no.1827011

ABSTRACT

Excessive use of natural water resources due to rapid urbanization has necessitated search for alternative sources of water for non-potable purposes. The potential sources which can be explored include harvested rainwater, reclaimed water, and sea water. Reclaimed water from every institute is an appropriate choice as it provides scope for water conservation, pollution prevention and decentralized treatment. In developing countries like India, reclamation of domestic for non-potable use is essential due to non-existence of sewerage system in most of the towns/cities and groundwater pollution due to disposal of untreated sewage. Water is essential commodity of society. The water availability in RIT during summer season is limited and the wastewater disposal system in RIT is not methodical, it is directly discharged into open land therefore it is need to search suitable natural treatment systems of domestic wastewater treatment for sustainable development for tropical developing country like India.

The designed low-cost treatment system consists primary treatment (Sedimentation), Secondary treatment (Advanced Septic tank) and Tertiary treatment (Constructed Wetland). The estimated cost of proposed treatment system is Rs. 27, 67,674/-. The operation and maintenance cost of system is Rs. 82,940/-.

The design and development of lab scale model is done and operation and experimental setup is given in the present study.The efficiency of model comes around 90%.

The different PPP(Public Private Partnership) models are proposed for wastewater treatment plant. Financial viability of the proposed alternative is assessed with respect to different models that are being popularly implemented in India. Construction of constructed wetland system is financially viable at HAM (Hybrid Annuity Model) which can attract potential contractors to execute the project.

Keywords - Wastewater, Constructed wetland, Public Private Partnership

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ABBREVIATIONS

BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
TSS	Total Suspended Solids
TDS	Total Dissolved Solids
MBR	Membrane Bioreactor
UASBR	Up Flow anaerobic Sludge Blanket Reactor
SSFCW	Subsurface Flow Constructed Wetland
RBC	Rotating Biological Contactor
NPV	Net Present Value
PPP	Public Private Partnership
BOT	Built Operate Transfer
HAM	Hybrid Annuity Model
EPC	Engineering Procurement and Construction

Chapter 1

INTRODUCTION

1.1 General

Water is a scarce and finite resource which is often taken for granted. In the 20th century, population has increased resulting in pressure on the already scarce water resources. Excessive use of natural water resources due to rapid urbanization has necessitated search for alternative sources of water for non-potable purposes. The potential sources which can be explored include harvested rainwater, reclaimed water, and seawater [1].

1.2 Relevance

Wastewater is water whose physical, chemical or biological properties have been changed as a result of the introduction of certain substances which render it unsafe for some purposes such as drinking. The day to day activities of man is mainly water dependent and therefore discharge 'waste' into water. It is known that much of water supplied ends up as wastewater which makes its treatment very important. The untreated wastewater creates various types of diseases in environment. A research conducted in 2007 found that discharge of untreated sewage is a single major cause of surface and groundwater pollution in India. In India, there is big gap between domestic wastewater generation and treatment [2]. In these fields, the wastewater produced usually percolates in the soil or evaporates. Uncollected waste accumulates in urban regions causing unhygienic circumstances and releasing surface and groundwater leaching pollutants. Usually traditional wastewater treatment plant produced in these fields involves procedures such as primary sedimentation, aeration, secondary treatment, and chlorination. This form of treatment plants requires high initial investment. In addition, their maintenance costs are high and huge land area is required for treatment plants. The plant's skilled labours are needed for functioning and adequate maintenance. The treatment plants in general are expensive and the results are not up to the mark. Treatment of waste water by traditional method is very costly and hence neglected by most of the public bodies [2]. The main objective of this study is to develop cost effective treatment technology for sewage treatment.

1.3 Outline of Project Report

The dissertation report is divided into following chapters. These chapter describes the different work conducted for study.

This phase II dissertation report is divided into 5 chapters which describe the different investigations conducted in this study.

Chapter 1: In first chapter some introduction and general information about water scarcity and usefulness of reuse of wastewater is given.

Chapter 2: This chapter includes literature review including review of previous studies carried out by the some of the researchers. In this chapter motivation of study and objectives of project work is given.

Chapter 3: This chapter includes the methodology adopted and research progress of the project work carried out.

Chapter 4: This chapter includes information of theoretical concepts about sewage treatment plant and Conventional wastewater treatment plant and low cost wastewater treatment plant is given.

Chapter 5: This chapter includes design, drawings and estimation of low cost wastewater treatment systems.

Chapter 7-In this chapter discussion

Chapter 8-: In this chapter conclusion of project work is given along with scope for further research.

1.4 Closure

In first chapter some introduction and general information about water scarcity and usefulness of reuse of wastewater is given. This chapter describes the need of wastewater reuse for agricultural reuse.

Chapter 2

LITERATURE REVIEW

2.1 General

The research mainly focuses on finding out best alternative systems for treatment of wastewater which gives feasibility for small population. The proposed research includes the development of cost effective alternatives for project execution. Also Numerous research papers were selected to study the best system for contaminants removal.. From the research, objective function of model, input parameters used in research were studied. Some research was also performed on suggesting best alternative for wastewater treatment using various modifications.

2.2 Review of Previous Studies

2.2.1 Solano et al. (2003), "Constructed Wetlands as a Sustainable Solution for Wastewater Treatment in Small Villages"

This research has addressed the concept Wastewater treatment problem in small villages; treatment performance of a pilot scale subsurface-flow constructed wetland (SFW) was evaluated for removal efficiency of biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS) from raw municipal wastewater. In the wetland two different hydraulic application rates (150 and 75mm/day) and two macrophytes, were assayed. For the highest percentages of removal were obtained in those beds with the lowest HAR (75mm/day) and with the longest retention time (3days). No significant differences were observed between two macrophytes. In the seasonal variation, the summer season gives better results than other. Future study should be done on varying the retention time in the bed, in order to improve the efficiency of the system [3].

2.2.2 Vipat et al., (2008) "Efficiency of root zone technology for treatment of domestic wastewater : field case study of pilot project in Bhopal .(MP),India."

The paper under reference therefore is an attempt to evaluate the performance efficiency of field scale horizontal subsurface flow constructed wetland demonstration unit was constructed at ekant park, Bhopal. Wastewater at nalla passing through was 70,000 liters/day. The unit contains of pretreatment (settling tank-35m3) followed by root zone bed (700 sq.m) with gravels, reed plants and inlet-outland arrangement for subsurface flow. The system performances were recorded monthly for 18 months. The results clearly indicated that the removal efficiency of 88.4% for turbidity, 79% for TSS, 70.7% for total solids, 77.8% for COD, 65.7% for BOD. Results established that the removal efficiency of the system studied ranged from 65% to 90% for various pollutants [4].

2.2.3 Gholikandi et al. (2009) "Treatment of domestic wastewater in a pilot-scale HSFCW in West Iran."

This research work has addressed the two low cost wastewater treatments namely duckweed and reed beds for treating domestic wastewater. The pilot plant was tested with six different BOD, COD, TN, TP, TSS and TDS loadings. The test results showed the artificial reed bed with subsurface flow capable of removing TSS by 92%, BOD by 89% and COD by 78%. The reed bed effluents were discharged into duckweed lagoon and the removal ratios of the above parameters were once again studied. The results showed reductions of 20% in BOD, 10% in COD, 24% in TSS, 8% in TN and 29% in TP. Based on these studies, the use of artificial reed beds for treating household wastewater in small communities is a sound technical and economical solution [5].

2.2.4 Kouki et al. (2009),"Performances of a constructed wetland treating domestic wastewater during a macrophytes life cycle"

In this study, the performance of a combined subsurface vertical and horizontal flow constructed wetlands system, designed for rural domestic wastewaters treatment and with theoretical hydraulic retention time of 2 and 3.6 days, respectively, was investigated. Several water quality parameters including pH, BOD5, COD, TSS, TKN and TP, and faecal bacteria's number in both raw and treated wastewaters were monitored during a macrophytes lifecycle. The result shows average effluent pH, BOD5, TSS and faecal bacteria were in agreement with the standards, but COD, nitrogen and phosphorus residual loads were still above the values required by the quality criteria [6].

2.2.5 Pawaskar (2012)"Application of modified root zone treatment system for wastewater treatment within nallah area"

This research examined the efficiency and techno economic feasibility of RZTS (Root zone treatment system) along with its modification. Another goal of the research was to work out the effectiveness of modified RZTS and trickling bed model with BOD, COD and TSS removal. The modification suggested and evaluated was Upper 1.5 m depth bed will be designed as trickling bed, act as aerobic treatment and Lower 0.5 m depth bed will be acting as constructed wetland (RZTS), as anaerobic treatment. Based on experimental results and its analysis modified constructed wetland gives average BOD and COD removal efficiency of 79.45% , average TSS removal efficiency of 83.07% For Total 1.5m combined bed depth [7].

2.2.6 Viller (2012) "Vertical subsurface wetlands for wastewater purification"

This study has suggested concept of 'vertical subsurface flow wetland' in order to reduce the pollutants in the factory wastewater and the treatment system was designed to be placed after the already existing treatments in the company. The design prefers area necessary, for effective BOD reduction in wastewater treatment, of the vertical subsurface wetland is the 20 m2. The vertical subsurface wetland after a primary treatment reduces the value of main pollutant in the wastewater and it presents a stable behavior in the reduction of the main pollutants after the first six weeks of operation [8].

2.2.7 Lu et al. (2015) "Study on method of domestic wastewater treatment through new-type multi-layer artificial wetland"

This paper introduces a new-type multi-layer artificial wetland for treatment of domestic sewage, and analyzes the removing effects of CODcr, BOD5, NH3-N, TN and TP in this approach. The results indicate that when hydraulic loading reaches approximately 0.44 m3/(m2/ d) and hydraulic retaining duration reaches 3 days, the effect of removing CODcr , BOD5, NH3-N, TN and TP from the wetland is relatively good, and the average removing rate achieves 90.6%, 87.9%, 66.7%, 63.4% and 92.6% respectively. The planting density, temperature variation and influent contaminant concentration have relatively great correlation with efficiency of wetland treatment [9].

2.2.8 Patil and Munavalli (2016) "Performance evaluation of an Integrated On-site Greywater Treatment System in a tropical region"

The study was done in Integrated On-site Greywater Treatment System (IOGTS) with primary (settling/filtration), secondary (constructed wetland) and tertiary (adsorption) treatment was used to treat greywater from hostel. The performance evaluation of IOGTS was carried out for a study period of one year. The quality parameters used to assess feasibility of disposal for land application were COD, TKN, suspended solids, and pathogens. The effect of hydraulic loading rate (HLR), Hydraulic Retention Time (HRT) and Organic Loading Rate (OLR) on performance of the system was also studied. Overall performance of IOGTS for COD, TKN and pathogen removal was observed to be 70%, 70% and 85% respectively [1].

2.2.9 Shinde et al., (2017) "Low cost sewage treatment by root zone technology"

In this paper, a significant issue in Indian cities is the treatment of sewage and disposal of treated sewage. Construction of treatment equipment requires enormous capital investment; it is very expensive to operate the conventional treatment plant. Sewage treatment is the most overlooked element in our nation because of these variables. It leads to river pollution and groundwater resources as well. Studies have been performed to discover suitability for sewage treatment of root zone technology. The cost-effective solution produced in small cities and isolated institutions for sewage treatment. Results of the pilot plant reactor research show that root zone technology is a cost-effective solution for sewage treatment in small cities and isolated countries [2].

2.2.10 Munavalli et al., (2018).“Effect of media and vegetation in constructed wetland for domestic wastewater treatment”

Constructed wetland (CW) has been used in decentralized domestic wastewater as a physical and biological therapy. CW’s performance is greatly influenced by media assistance and vegetation type. Four laboratory-scale treatment systems with distinct media and vegetation combinations have been created in this context. For Hydraulic Retention Time (HRT) of 3 to 24 h and idle time of 1 to 2 h, the CW systems were operated in batch and Fill-Drain-Idle-Fill (FDIF) modes. The system feed was settled wastewater (gray water and black water) from the hostel at the university premises (Walchand College of Engg., Sangli). The performance of system was evaluated for organic matter (measured in terms COD) removal. Results shows Increase in Hydraulic Retention Time beyond 6 h does not contribute significantly to COD removal, Vegetation plays significant role compared to medium in Constructed wetland systems for COD removal. FDIF mode of operation enhances COD removal [10].

2.2.11 GarciaAvila et al. (2019).“Performance of Phragmites Australis and Cyperus Papyrus in the treatment of municipal wastewater by vertical flow subsurface constructed wetlands”

This research paper has the purpose to compare the purification capacity of domestic wastewater using two species of plants sown in subsurface constructed wetlands with vertical flow built on a small scale that received municipal wastewater with primary treatment. The species used were Phragmites Australis and Cyperus Papyrus. Study gives the Cyperus Papyrus presented a greater capacity of pollutants removal as biochemical oxygen demand (80.69%), chemical oxygen demand (69.8%), ammoniacal nitrogen (69.69%), total phosphorus (50%), total coliforms (98.08%) and fecal coliforms (95.61%) [11].

2.3 Research Gap

The literature review on domestic wastewater treatment shows that there are systems which can treat domestic wastewater potentially so that it can be recycled. The treatment option use by various researchers includes physical, chemical and biological systems. The physical treatment consists of screening and sand filters. Chlorination and photo catalytic oxidation were chemical treatment. The systems viz. Membrane Bioreactor (MBR), Up Flow anaerobic Sludge Blanket Reactor (UASBR), Rotating Biological Contactor (RBC) and constructed wetland has been used as biological options. It can seen from the above discussion and literature review that there is plenty of scope to assess the performance of various combinations of low-cost physical and biological processes for domestic wastewater treatment. Also feasibility of PPP model for wastewater treatment is going to be prepared.

2.4 Objectives

Following are the objectives of proposed work -

1. To design and develop domestic wastewater treatment system incorporating preliminary treatment, various combination of physical and biological treatment process.
2. To design and development of lab scale model of wastewater treatment.
3. To check cost-benefit analysis of domestic wastewater treatment system.
4. To propose feasibility analysis of PPP model for wastewater treatment plant for RIT campus.

2.5 Closure

In this chapter different methods used to treat wastewater with different techniques is studied. Also the research gives knowledge regarding characteristics and treatment process of wastewater, along with this, project gap and objectives are derived.

Chapter 3

RESEARCH METHODOLOGY

3.1 General

From the review of literatures, research gap has been identified which is used to derive objectives and problem statement of the dissertation work.

3.2 Problem Statement

Water is essential commodity of society. The water availability in RIT during summer season is limited and the wastewater disposal system in RIT is not methodical, it is directly discharged into open land therefore it is need to design and develop wastewater treatment plant for RIT campus. The present study will address design of wastewater treatment plant for RIT campus. Also suggest feasible PPP model for the proposed wastewater treatment plant.

Figure 3.1: Wastewater Management Practice in RIT Campus

3.3 Proposed Methodology

The procedure used in the project is divided into four steps. First step is to identify problem and collect the data for research work. The data collection include details of study area,water usage,wastewater characteristics, population and mainly the low cost treatment systems. Problem identification is done and move to second step is to decide suitable treatment system which is low cost and highly efficient. Here the design consists of primary treatment (Sedimentation), Secondary treatment (Advanced Septic tank) and Tertiary treatment (Constructed Wetland). also there estimation of each system component. The design of lab scale model and there operation and experimental setup is carried out. Third step is to check the cost benefit analysis of system and payback period from net present value. The different public private partnership models are checked for financial viability of system in RIT campus. In forth step find out the results and draw the conclusion and diagrammatic presentation of methodology adopted for research work is shown following Fig.3.2.

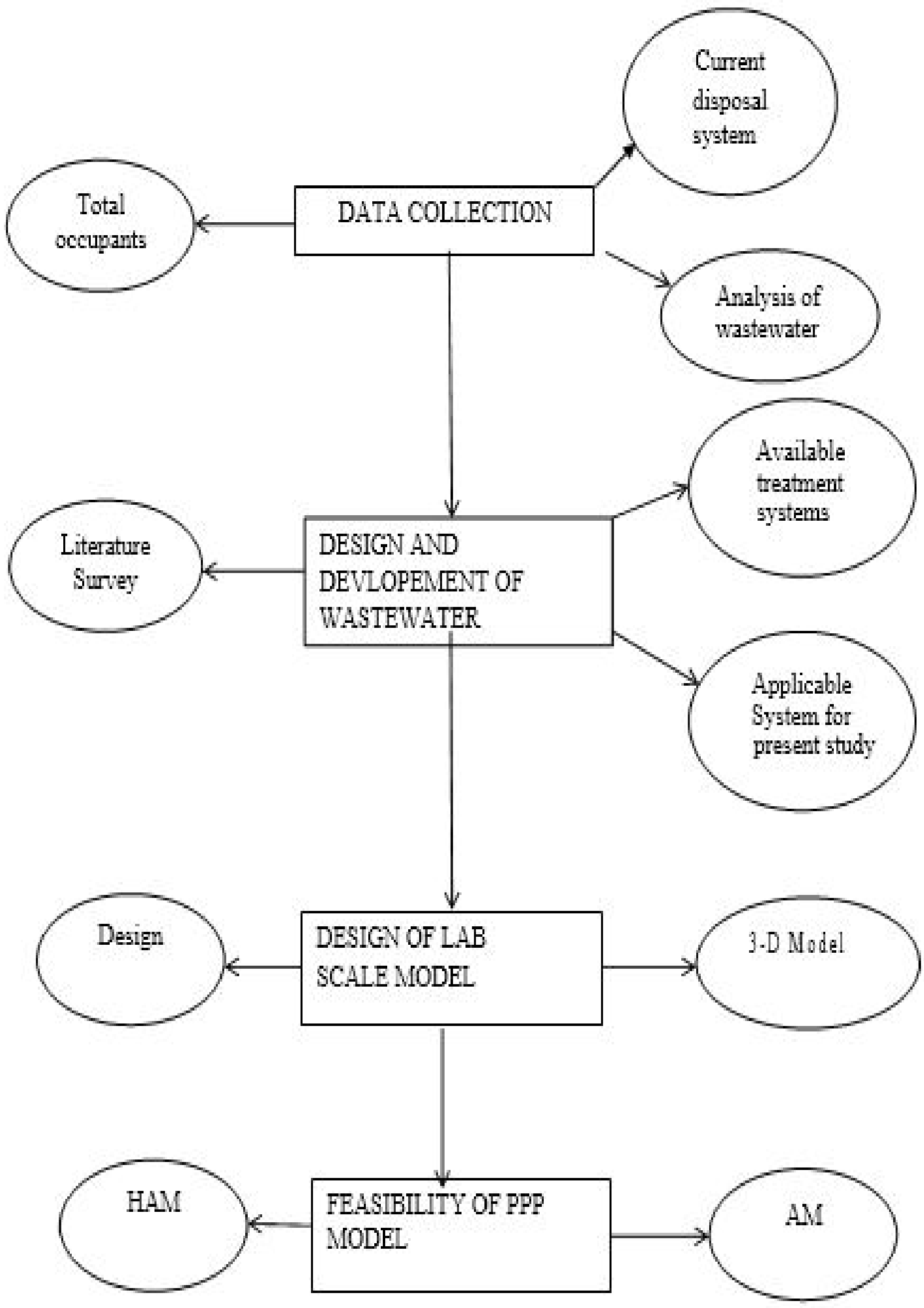

Figure 3.2: Methodology adopted in project work

3.4 Closure

The gap has been identified that combination of different physical, biological treatments with there design and development is not prepared and also feasible Public private Partnership (PPP) Model was not prepared.

Chapter 4

THEORETICAL CONCEPTS OF PROPOSED WASTEWATER SYSTEM

4.1 General

This chapter includes the information of treatments in conventional plant and in the low cost treatment plant. The chapter explains in detail about systems required for removal of contaminates in wastewater. One of the low-cost options of wastewater treatment technology based on natural processes of purification is SSFCW and VFCW. Micro-organisms that naturally live in saturated media and on the roots of wetland plants consume organic matter and nutrient. The operation and processes in these physical and biological systems is complex and requires better theoretical description. A sound knowledge on pollutant dynamics of SSFCW is required for proper design, achieving good removal efficiency for organic matter and nutrient. The oxygen transfer in support media by root of vegetation and presence of aerobic/anaerobic zones needs to be understood properly.

4.2 Conventional Wastewater Treatment Process

The conventional wastewater treatment process consists of a series of physical, chemical and biological processes. Typically, treatment involves three stages, called primary, secondary and tertiary treatment.

4.2.1 Primary Treatment

Primary treatment is used to separate and remove the inorganic materials and suspended solids that would clog or damage the pipes. Primary treatment consists of screening, grit removal, and primary sedimentation. Screening and grit removal may also be called "preliminary treatment." Large debris, such as plastics, rags, branches, and cans are removed by the screens, while smaller coarse solids, such as sand and gravel, are settled by a grit chamber system. Then wastewater is moved into a quiescent basin, with a temporarily retention; the heavy solids settle to the bottom while the lighter solids, grease and oil float to the surface. The settled and floating pollutants are removed by sedimentation and skimming, with the remaining liquid then discharged to undergo secondary treatment. Typically, about 50% of total suspended solids (TSS) and 30% to 40% of BOD are removed in the primary treatment stage.

4.2.2 Secondary Treatment

Secondary treatment removes dissolved and suspended biological matter. Typically, up to 90% of the organic matter in the wastewater can be removed through secondary treatment by a biological treatment process. The two most common conventional methods used to achieve secondary treatment are attached growth processes and suspended growth processes. In attached growth (or fixed-film) processes, the bacteria, algae and microorganisms grow on a surface and form a biomass. Attached growth process units include trickling filters, and rotating biological contactors. In suspended growth processes, the microbial growth is suspended in an aerated water mixture. The most common of this type of process is called "activated sludge." This process grows a biomass of aerobic bacteria and other microorganisms that will breakdown the organic waste.

4.2.3 Tertiary Treatment

Tertiary treatment is sometimes defined as advanced treatment; it produces a higher-quality effluent than do primary and secondary treatment in order to allow discharge into a highly sensitive or fragile ecosystem. The purpose of tertiary treatment is to provide a final treatment stage to raise the effluent quality to the desired level. This advanced treatment can be accomplished by a variety of methods such as coagulation sedimentation, filtration, reverse osmosis, and extending secondary biological treatment to further stabilize oxygen-demanding substances or remove nutrients. As wastewater is purified to higher and higher degrees through such advanced treatment processes, the treated effluent can then be safely and appropriately reused.

4.2.4 Disinfection

Before the treated wastewater is discharged, a disinfection process is sometimes required. Water systems add disinfectants to kill pathogenic microorganisms. The purpose of disinfection in the treatment of wastewater is to substantially reduce the number of microorganisms in the water to be discharged back into the environment, and it is almost always the final step in the treatment process regardless of the level or type of treatment used. Common methods of disinfection include chlorine, and ultraviolet light. The treated water can be discharged into a stream, river, lagoon, or wetlands, or it can be used for landscape irrigation. If it is sufficiently clean, it can also be used for groundwater recharge or agricultural purposes.

4.2.5 Advantages and Disadvantages of Conventional Treatment System

Advantages of Conventional Treatment System

Conventional sewage treatment system requires relatively less land area and allows better control of the wastewater treatment process. The treatment facilities are usually operated under a well-controlled environment. Thus, the efficiency is less sensitive to the environment. This technique could produce a more consistent quality of effluent

Disadvantages of Conventional Treatment System

The main disadvantage of conventional wastewater treatments is their high cost of construction and maintenance. Also, the operation and monitor of mechanical systems requires specialized personnel. Generally, the complexity and cost of wastewater treatment technologies increase with the quality of the effluent produced.

4.3 Low Cost Wastewater Treatment System

In the low cost treatment, systems as primary are included to increases efficiency of the wetland system.

4.3.1 Sedimentation cum Settling Tank

Sedimentation tank, also known as settling tank is part of a treatment of wastewater. As it flows slowly through the tank, a sedimentation tank allows suspended particles to settle out of wastewater, thus providing some degree of purification. A layer of accumulated solids is formed at the bottom of the tank, called sludge, and is removed periodically. There are many sedimentation basin shapes including rectangular, circular, and square. Rectangular basins are commonly found in large-scale water treatment plants. Rectangular tanks are popular as they tend to have predictable performance ,cost effectiveness due to lower construction cost , lower maintenance ,minimal short circuiting. Treatment quality depends on the nature of influent and temperature, but can basically BOD removal rate for sedimentation tank is 20%.

4.3.2 Advanced Septic Tank

Wastewater enters in advanced septic tank, allowing settling of solids and floating scum. The settled solids are digested anaerobically, reducing solid volume. The liquid component flows through the dividing wall into the, where further settlement takes place. The excess liquid, now in a relatively clear condition, then drains from the outlet for further processes. Detention time is 12 to 64hrs for to separate out the liquid with solid. In design the area requirement is calculated as 1 m2 / m3 / day.

4.3.3 Constructed Wetland

Constructed wetlands are systems designed to use natural plants, soil, and species to handle wastewater. The layout of the constructed wetland must be adjusted accordingly depending on the type of wastewater. Constructed wetlands were used to handle sewage both centralized and on-site. Primary treatment for large amounts of suspended solids or soluble organic matter (measured as BOD and COD) is recommended. Constructed wetlands also act as a bio filter and/or can remove a range of pollutants (such as organic matter, nutrients, pathogens, heavy metals) from the wastewater. The planted vegetation plays an important role in contaminant removal. The filter bed, consisting usually of sand and gravel, has an equally important role to play. A constructed wetland is an engineered sequence of water bodies designed to filter and treat waterborne pollutants found in sewage. Constructed wetlands are used for wastewater treatment or for grey water treatment. They can be used after a septic tank for primary treatment (or other types of systems) in order to separate the solids from the liquid effluent. Vegetation in a wetland provides a substrate (roots, stems, and leaves) upon which microorganisms can grow as they break down organic materials. The microorganisms and natural chemical processes are responsible for approximately 90 percent of pollutant removal and waste breakdown. Constructed subsurface flow wetlands are meant as secondary treatment systems which means that the effluent needs to first pass a primary treatment which effectively removes solids.

4.3.4 Advantages and Disadvantages of Low Cost Wastewater Treatment System

Advantages of Low Cost Wastewater Treatment System

Wetlands can be less expensive to build than other treatment options. Operation and maintenance expenses (energy and supplies) are low. Operation and maintenance require only periodic, rather than continuous, on-site labor. Wetlands are able to tolerate fluctuations in flow. They facilitate water reuse and recycling.

Disadvantages of Low Cost Wastewater Treatment System

The only disadvantage is requires more land as compare to conventional treatment system.

4.3.5 Types of Constructed Wetlands

Constructed wetlands are manmade engineered systems that are designed and constructed by utilizing natural processes including wetlands soils, vegetation and microbial assemblies. The design is based on natural wetland systems and benefits from all processes in natural wetlands for pollutant treatment but in a more controlled environment. Constructed wetlands can be classified based on Vertical

Subsurface Flow Constructed Wetland, Horizontal Subsurface Flow Constructed Wetland, Free Water Surface Constructed Wetland.

Vertical Subsurface Flow Constructed Wetland (VSSF-CW)

The wastewater is feed to wetland through distribution pipe, which is lined near to the root of plants.VSSF-CWs were not as quickly spread as horizontal subsurface flow constructed wetlands due to requirements of high operation and maintenance cost for batch pumping of wastewater on wetland surface. Wastewater is fetched in batches and allowed to trickle down through filter media until the system is fed with the next batch.

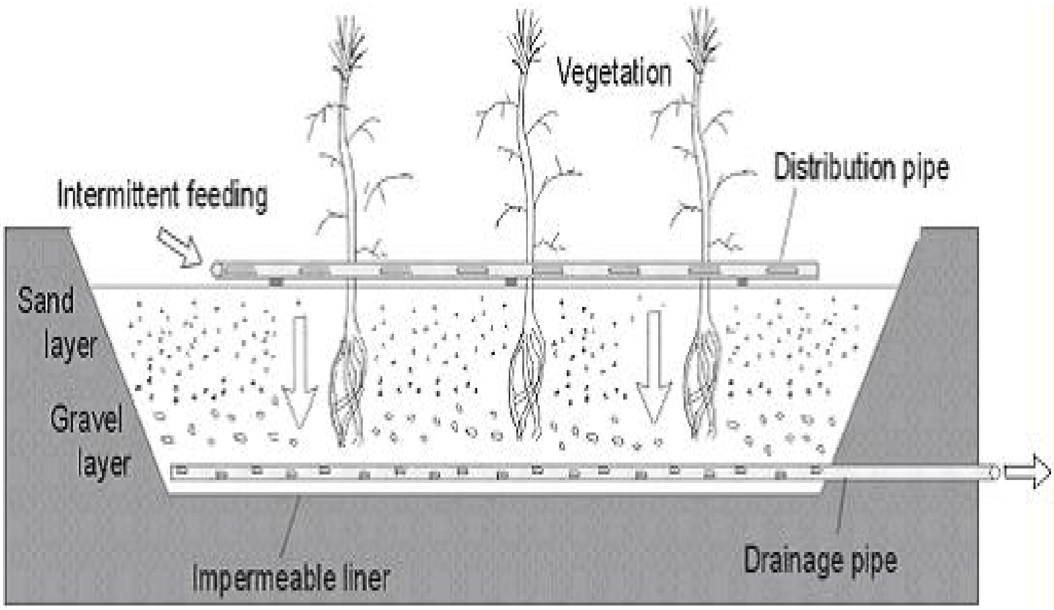

Figure 4.1: Vertical Subsurface Flow Constructed Wetland

Free Water Surface Constructed Wetland

Free water surface constructed wetlands consist of shallow sealed basin with emergent vegetation with water depth of 20-40 cm. Dense emergent plants cover the maximum surface of FWS-CW, usually more than 50%. In these systems plants provide temporal storage of nutrients because with their decay all nutrients are released back to water. Due to dense cover of plants and free water surface flow the contaminants were removed by only anaerobic way, which is not good.

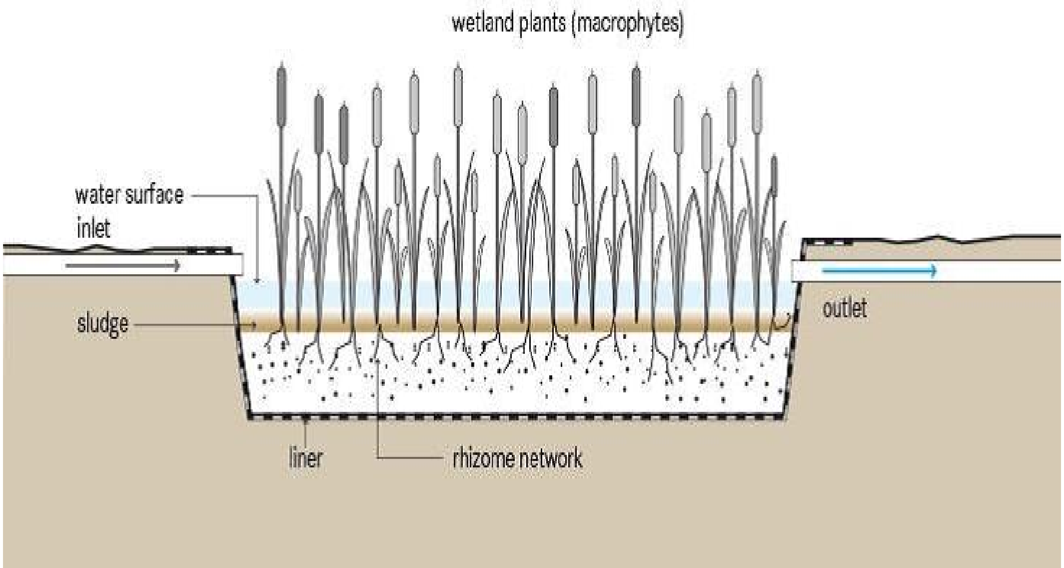

Figure 4.2: Free Water Surface Constructed Wetland

Sub-surface flow constructed wetland

Constructed wetland (CW) is artificial water tight channel filled with/without support media and planted with emergent vegetation. The wastewater is flowing through CW move with free surface, subsurface and vertical flow. The combination of any of them is referred as hybrid CW. SSFCW is a basin filled with support medium and vegetated with emergent plants. SSFCW can also be referred as root-zone system.Figure No. 4.3shows schematic section of a SSFCW and its components.

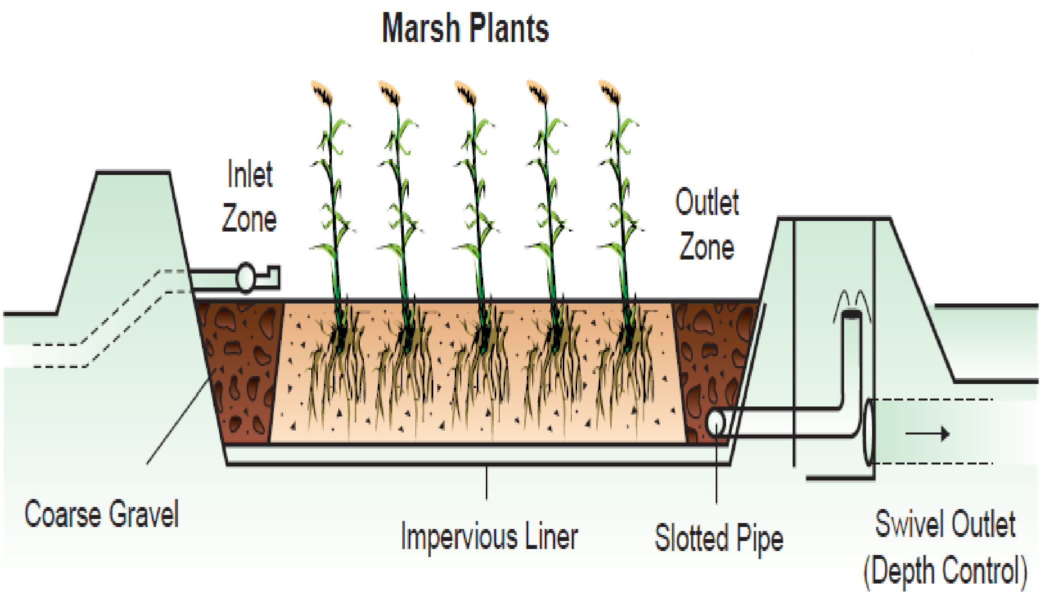

Figure 4.3: Typical Section of SSFCW

Selection of Type of Constructed Wetland

Subsurface flow constructed wetlands are known as fixed film bioreactors in which organic matter is degraded by chemical, physical and biological processes. In the VSSF-CW, the path of wastewater created is less and having minimum contact with the plant roots and base of plants and in the SSFCW the path is ideal means create the maximum removal efficiency of waste contaminants. Due to the presence of strong reducing conditions in SSFCW, these systems considered as anaerobic systems. The SSFCW are good for wastewater removal efficiency.

4.4 Components of Low Cost Wastewater Treatment System (SSFCW)

4.4.1 Inlet and outlet structure

Inlet structures distribute flow into SSFCW and control the flow path through wetland. The inlet structure must be designed to minimize the potential for short-circuiting and clogging in the media and maximize even flow distribution. Inlet structures at SSFCW include surface and subsurface manifolds such as a perforated pipe, open trenches perpendicular to the direction of the flow etc. In general, perforated or slotted manifolds are used for the inlets. Wherever possible, the inlet manifold should be installed in an exposed position to allow access by the operator for flow adjustment and maintenance. The typical inlet structures for SSFCW are shown in Figure no. 4.4

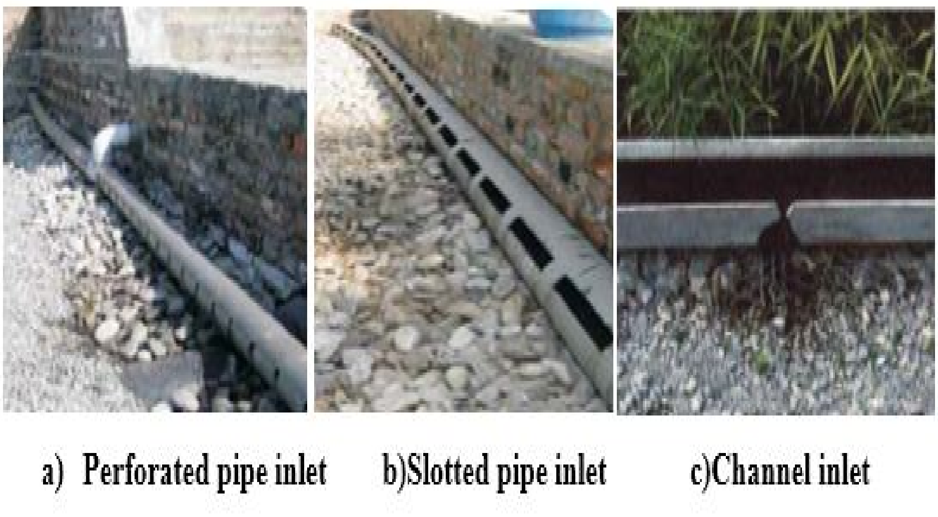

Figure 4.4: Typical Inlet Structures for SSFCW

The functions of outlet structure are to minimize the potential for short-circuits, maximize even flow collection and allow operator to vary the operating water level and drain the bed. Typical outlet structures used in SSFCW are shown in Figure no. 4.5

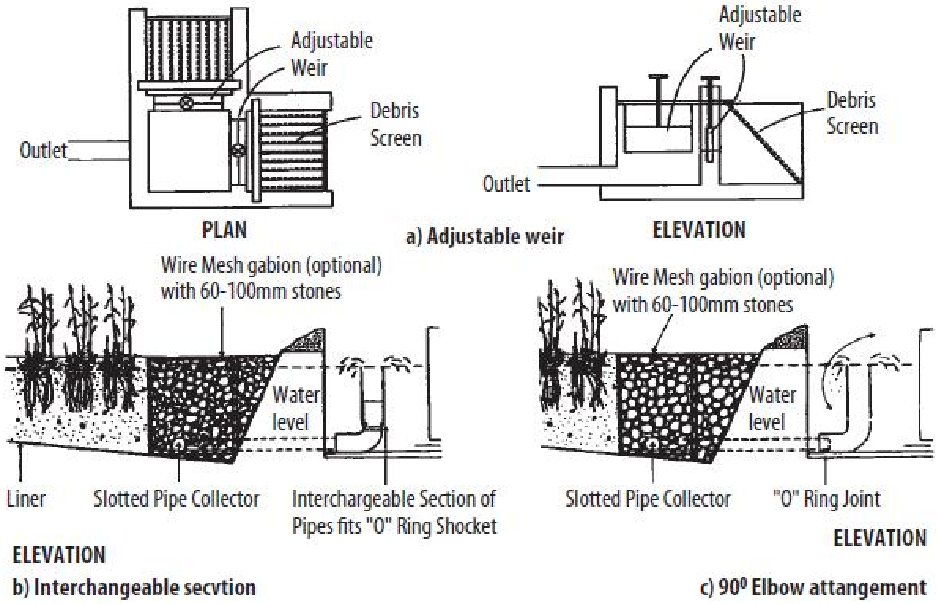

Figure 4.5: Typical Outlet Structures for SSFCW

4.4.2 Support media

Support media is an important component of SSFCW. The functions of support media are rooting material for vegetation, help to evenly distribute/collect flow at the inlet/outlet, provide surface area for microbial growth, filter and trap particles and anchorage for vegetations. In SSFCW systems, beds can be filled with 5-10 mm washed gravel except at the inlet and outlets where 50-200 mm rock will be used in gabions [12]. The most often used support media are stone grit, gravel, sand, laterite, bauxite, shale, burnt oil shale, limestone, zeolite, light expanded clay, fly-ash, blast furnace slag, charcoal, inert wood chips, plastic and rubber. The porosity of supporting media bed varies from 0.30-0.5% depending upon the media content. Generally stone grit is used as supporting media in SSFCW.

4.4.3 Vegetation

Vegetation plays vital role in SSFCW. They maintain the temperature, decrease wind speed and avoid re-suspension of nutrient and sludge, supply surface for periphyton and bacteria. It also helps in providing the required conditions for various biological and physicochemical processes within a SSFCW for effective treatment of wastewater. The most commonly used plants are Phragmites australis (Common reed), Typha latifolia, bulrush,Colocasia esculenta (Taro), Canna indica, Helicona and Typha angustifolia. The common requirements of plants for appropriate use in SSFCW for wastewater treatment systems includes types of plants - native or exotic, level of tolerance to nutrient load, stage of plant growth, density, spacing of plants, season of their germination, growth, harvesting, oxygen supply to roots, type of microbial growth on root surface, maximum root surface area for microbial community, withstand wetland condition and evapotranspiration.

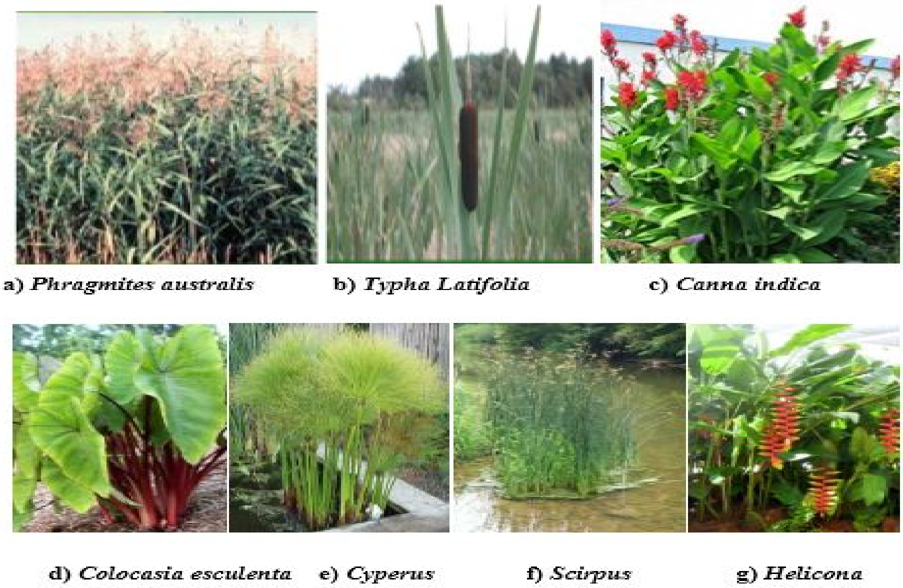

Figure 4.6: Commonly used vegetation in SSFCW

4.4.4 Liner

The main function of liner is to prevent groundwater pollution and loss of water from infiltration below the wetland site. Many wetlands have been constructed onsite where soil has high permeability. In these cases some types of liner or barrier will likely be required to minimize infiltration. Some examples of wetland liner material include imported clay fill, bentonite, soil liner, chemical treatment of existing soil, asphalt and synthetic material, liners such as poly vinyl chloride (PVC) or high density polythene plastic (HDPE), and concrete liner. Mostly in India concrete, clay, brick and geo-textile, HDPE, low density polythene plastic (LDPE) lining is used for constructed wetland.

4.4.5 Basin

The basin is water tight shallow tank constructed for SSFCW. Generally bed of basin may be rectangular in plan (about 5:1 in length: width ratio) and may be inclined at1-3% slope. It is shallow bed about 0.6-0.8 m deep filled with supporting media (less than 15mm in size) and planted with vegetation tolerant of saturated condition. Configuration of SSFCW (Fig. 2.5) is modification for allowing homogeneous flow of wastewater throughout aerobic-anoxic pockets of media, thus accelerating biological removal routes of nutrients and organics.

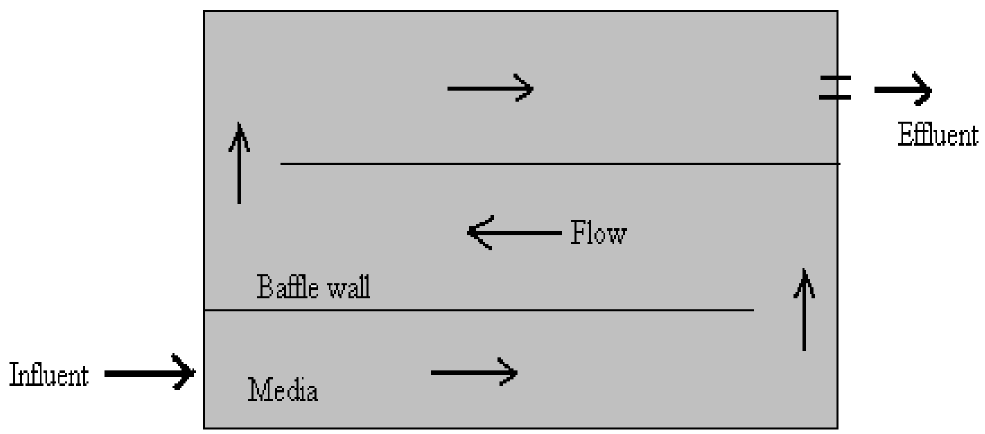

Figure 4.7: Baffled Horizontal Flow SSFCW

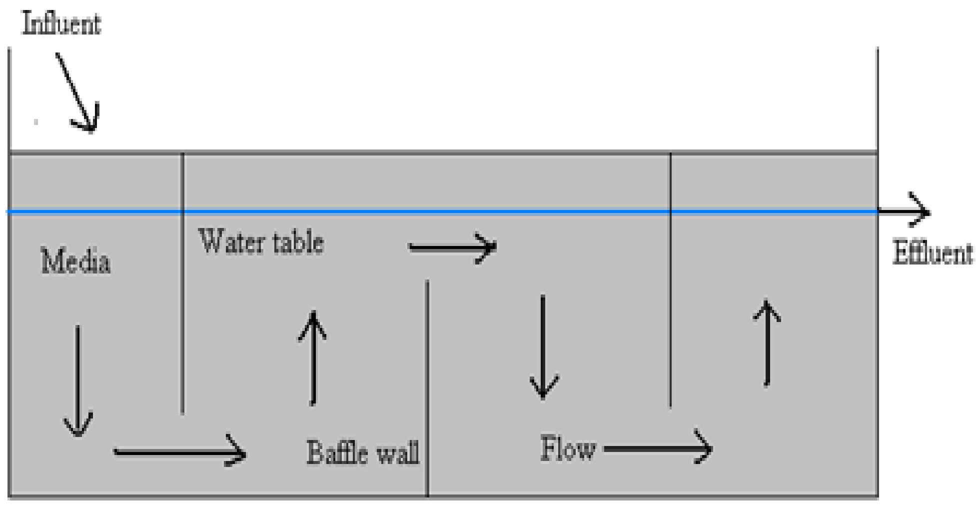

Figure 4.8: Baffled up-down flow SSFCW

4.5 Pollutant Removal Mechanism in SSFCW

SSFCW reduce many contaminants; including suspended solids, organic matter (BOD5, COD), nutrient, and pathogens.

4.5.1 Suspended solid

The principal mechanisms of TSS removal in SSFCW system is filtration in the granular bed. Due to the relatively low velocity and high surface area of the bed, this mechanism is effective. These processes are enhanced by the adhesion forces between solids, which tend to form bigger particles.SSFCW systems act like gravel filter and thereby they provide opportunities for TSS separations by gravity sedimentation, physical capture, and adsorption on biomass film attached to gravel and root system.In SSFCWs, most of the TSS is removed at near the inlet structure and its concentration decreases exponentially along the bed. In general, nearly all the TSS, removal takes place on the 1/3-1/4 of the total length of the bed.

4.5.2 Organic matter

Wastewater organic matter contains both biodegradable and non-biodegradable forms. Each of these two forms is further divided into particulate and dissolved organics. In SSFCW reactor particulates (biodegradable/non-biodegradable) are generally removed by physical process such as filtration and sedimentation. The biodegradable particulates are subjected to metabolism (i.e. adsorption on bio-cells, hydrolysis etc.) after being trapped by physical processes. On the other hand, biodegradable dissolved organics generally penetrate through bio-cells, where such contents are subjected to biological metabolism. Non-biodegradable dissolved organic content usually escape all treatment barriers, leaving the SSFCW reactor without being treated. In SSFCW reactor, organics are biologically degraded via aerobic, anaerobic, attached growth and facultative routes. In the top layer of SSFCW systems, aerobic degradation can occur near the water surface and around the roots. For removal of soluble organics, attached and suspended microbial growth around the root is responsible. The oxygen required for aerobic degradation is supplied directly from the atmosphere by diffusion or oxygen leakage from the macrophyte roots into the rhizo-sphere as shown in Fig.2.6. In aerobic degradation (of organic compounds), aerobic chemo-heterotrophs oxidize organic compounds in the presence of oxygen and produce CO2, NH3, and other stable chemical compounds. Uptake of organic matter by the macrophytes is negligible as compared to biological degradation. But the oxygen released by the roots is not enough to remove completely the organic matter. Hence, the predominant metabolic pathways are mostly anaerobic.

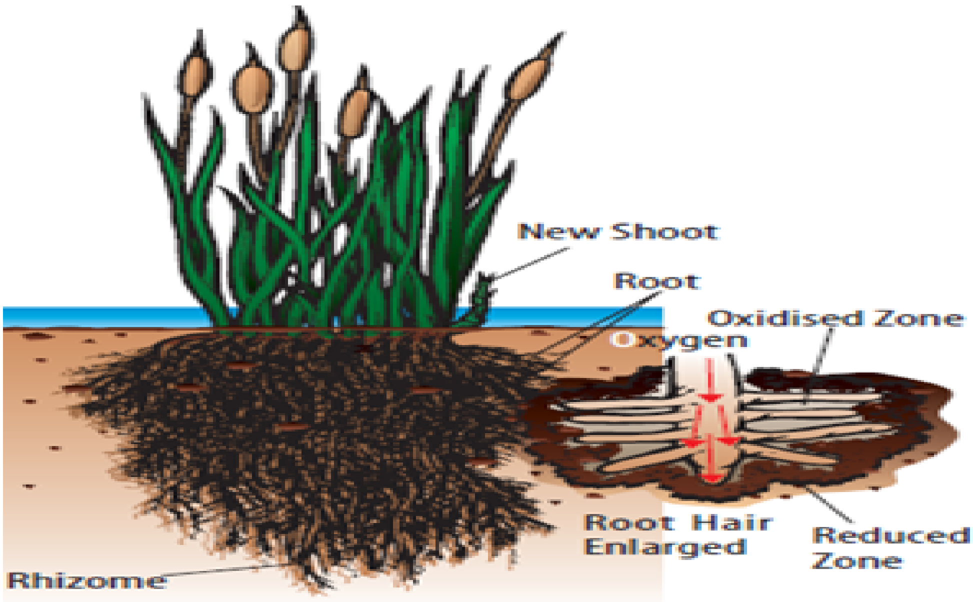

Figure 4.9: Mechanism of Oxygen Transfer from Roots

Anaerobic action is accomplished in the absence of oxygen through four sequential steps, such as (a) hydrolysis, (b) acidification, (c) acetogenesis, and (d) methanogenesis.

4.5.3 Nitrogen

In wastewater nitrogen exists as organic and inorganic nitrogen. Ammonia and nitrate are the most important inorganic forms of nitrogen in wetlands. The ionized form of ammonia (NH4+) is predominant in most wetland systems because of moderate pH and temperature. Common nitrogen removal routes (Fig.2.7) in SSFCW include ammonification, nitrification, denitrification, partial nitrification-denitrification, plant uptake, biomass assimilation, and adsorption.

Uptake by plants

Plants are one of the most important components of SSFCW, as they provide attachment sites and supply oxygen via roots inside wetland media, thereby accelerating the growth of biofilms. Oxygen supply from the roots of the most commonly employed wetland plant species (i.e. Canna indica). In addition, such root network also provides organic C (via secretion and decomposition) to support Nitrogen uptake by plants is dependent on configurations, influent wastewater characteristics, input loadings, and environmental parameters.

Media adsorption

Adsorption of ammonia by media is controlled by cation exchange properties of the supporting media components and NH4+ions of the bulk wastewater. In this study stone grit is used as supporting media in SSFCW. Nitrogen by media adsorption is not possible.

4.5.4 Phosphorus

Phosphorus in wastewater is mainly available as ortho phosphate, polyphosphate and organic phosphate. Orthophosphates (i.e. PO43-, HPO42- H2PO4-, H3PO4) can be degraded biologically; polyphosphates often undergo hydrolysis process. Organic phosphates are commonly found in industrial wastewater. Removal of phosphates can be achieved via (a) chemical precipitation and (b) biological metabolism. However, this section focuses on chemical removal of phosphorus and biological removal of phosphorous that is commonly observed in SSFCW. There are three main factors that lead to low P-removal rates. First, microbial phosphorus removal is only a temporary sink. Second, as in the case of nitrogen, plant uptake tends to have a relatively small effect on removal. Third, most substrates used as granular media have low P-sorption and P-complexation capacities: in the case of gravel, from the start of the operating period; in the case of sandy media, after a limited period of time due to the depletion of sorption sites and complexing agents. Detailed descriptions of these three mechanisms are given below.

Bacteriological removal

Unlike denitrification, in which nitrite and nitrate are mainly converted into harmless nitrogen gas that escapes from the wetland, microbial P-removal exhibits no similar sink. Bacteria can only take up and store P, which is a partly reversible removal mechanism. The continuous cycle of growth, die-off and decay releases most of the initially assimilated phosphorus and only some refractory fractions become a permanent sink for P. Consequently, once the CW start-up phase has been completed, net microbial P-removal is generally very low.

Plant uptake

Plant uptake occurs within dissolved inorganic phosphorus. Dissolved organic phosphate, insoluble inorganics and organic phosphate may be transformed to a soluble inorganic form. This transformation may take place in the water column by suspended microbes and biofilms on the plants. Plant uptake is rapid and following plant death; phosphorus may be quickly recycled to the water column or deposited in the sediments. Uptake by macrophytes occurs in the sediment pore water by the plant root system. The absence of vegetation reduces removal capability.

4.5.5 Pathogen

Pathogens are disease-causing organisms. SSFCW are very effective at removing pathogens, typically reducing pathogen number by up to five orders of magnitude from wetland inflows (Reed et al., 1995).The processes that may remove pathogens in wetlands include natural die-off, sedimentation, filtration, ultra-violet light ionization, unfavorable water chemistry, temperature effects, predication by other organisms and pH.

4.6 Data Collected For Sewage Treatment Plant

4.6.1 Details of Study Area

The criteria behind the selection of RIT, Rajaramnagar were two-fold. In, RIT there is a need for a wastewater treatment system for certain locations in the campus and RIT is the parent institute of the research scholar. The need of a wastewater treatment system was coupled also with a possibility of constant monitoring and systematic result assessment at the site for which the expenses would be borne by the institute.

RIT, Rajaramnagar was started in 1983, located in Sakharale village near Islampur city. The latitude and longitude of study site is 17^{o}4N and 74^{o}5E respectively. The total area of RIT campus is 17 hectares, consists of educational and administrative buildings, library and hostel buildings for boys, girls and staff. The campus is sub-divided into two basic sections, namely Administrative and Educational Section; and Hostel Section separated by MIDC Water Treatment Plant road. Total population in the campus is 3047 as per the office records of the year 2010.

The topographical condition of RIT campus is having natural slope from North to South direction. The highest reduced level 101.75 m is in educational building area and lower most point is located towards the hostel campus area. The natural drainage pattern and generated sewage from educational and hostel building site is partially collected with combined sewerage system separately for hostel area and educational building. In general, the drainage system in the campus does not have any suitable disposal point due to absolute absence of any type of sewerage systems from the local municipal corporation.

The larger volume of wastewater generated from hostel area had resulted in cesspools within the campus area. The non availability of wastewater treatment and disposal facility were causing severe nuisance in terms of odor, aesthetics and possible pathogenic epidemics. Hence, the institute felt the need of developing a wastewater treatment system and thereby fulfill its dream of developing green campus. Keeping in view these requirements of the institute, it was decided to take up this research project for development of a better solution to the problem that was being faced by the institute. According to the discussions had with the college administration and the management officials, the Hostel Section was selected for carrying out this research work. The entire hostel campus comprises of total 6 hostels (4-boys' and 2-girls' hostels) with a three storied staff quarter building.

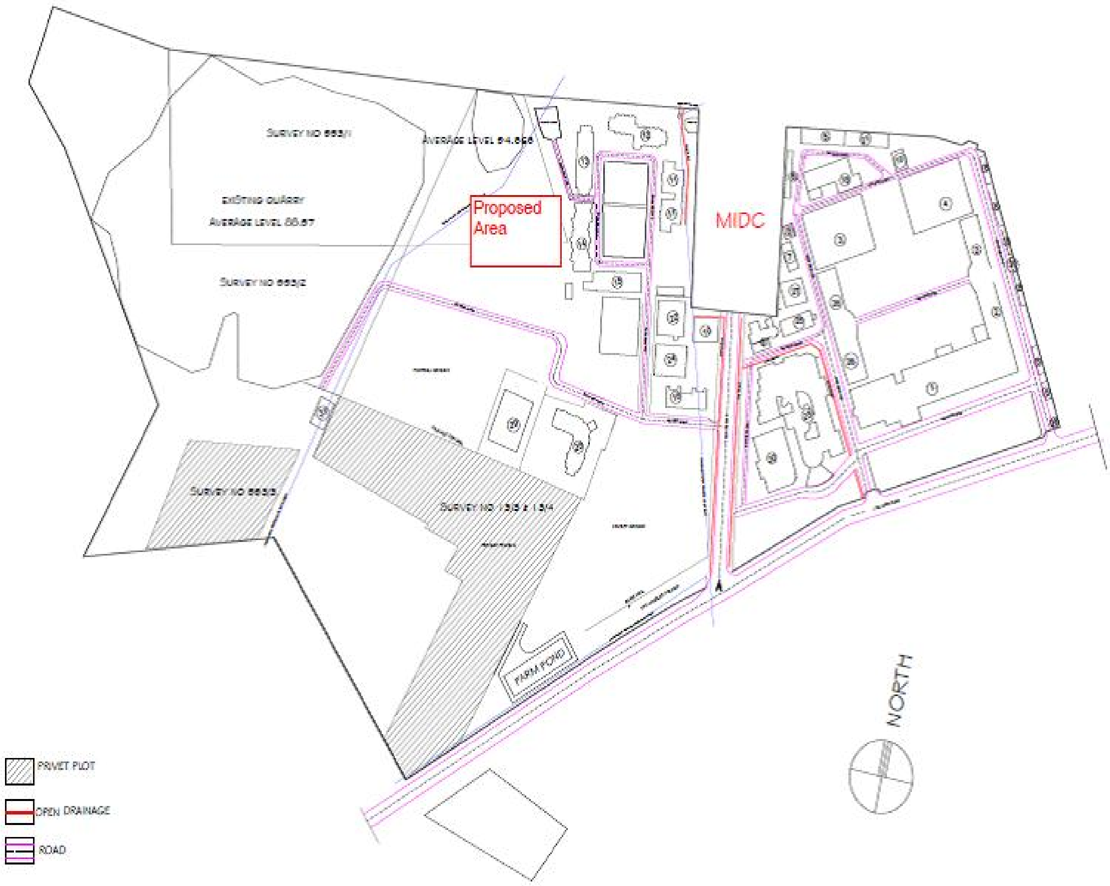

Figure 4.10: Proposed Layout in RIT Campus

4.6.2 Water Usage

Wastewater quantity mainly depends upon the water used in hostel campus. According to data collection, the MIDC provides the water for hostel campus daily. The water meter readings are taken at the hostel campus are obtained. Maximum limit of water usage is up to 65 units (1 unit – 1000lit) of water, above this limit the extra charges are added to bill. As per the water usage, the maximum reading of 271 units is used in month of September 2019. The average reading of year 2017, 2018 is 156 units and year 2019 up to October is 145 units. In the year 2019 strength of RIT hostel is given in Table no. 4.1

From collected data of water usage in RIT hostel the average monthly usage readings are calculated and graph is created for year 2017, 2018, 2019.

Table 4.1: RIT Hostel Students Count

RIT HOSTEL STUDENTS ADMISSION 2019		
Name of Hostel	Intake	Actual Admission
Boys		
A Hostel	150	150
B Hostel	157	157
C Hostel	181	175
D Hostel	186	186
Total	674	668
Girls		
E Hostel	102	91
F Hostel	95	90
G Hostel	59	49
H Hostel	192	183
Total	448	412
Total Boys & Girls	**1122**	**1080**

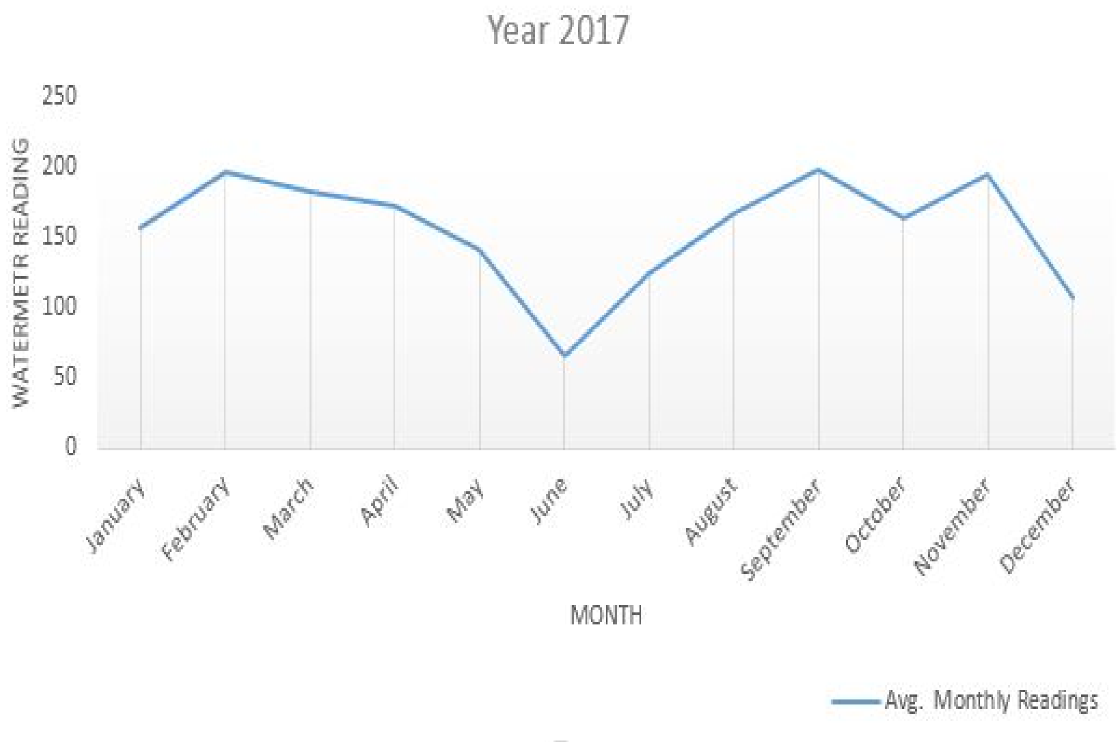

Figure 4.11: Monthly Water Usage at RIT Hostel Campus 2017

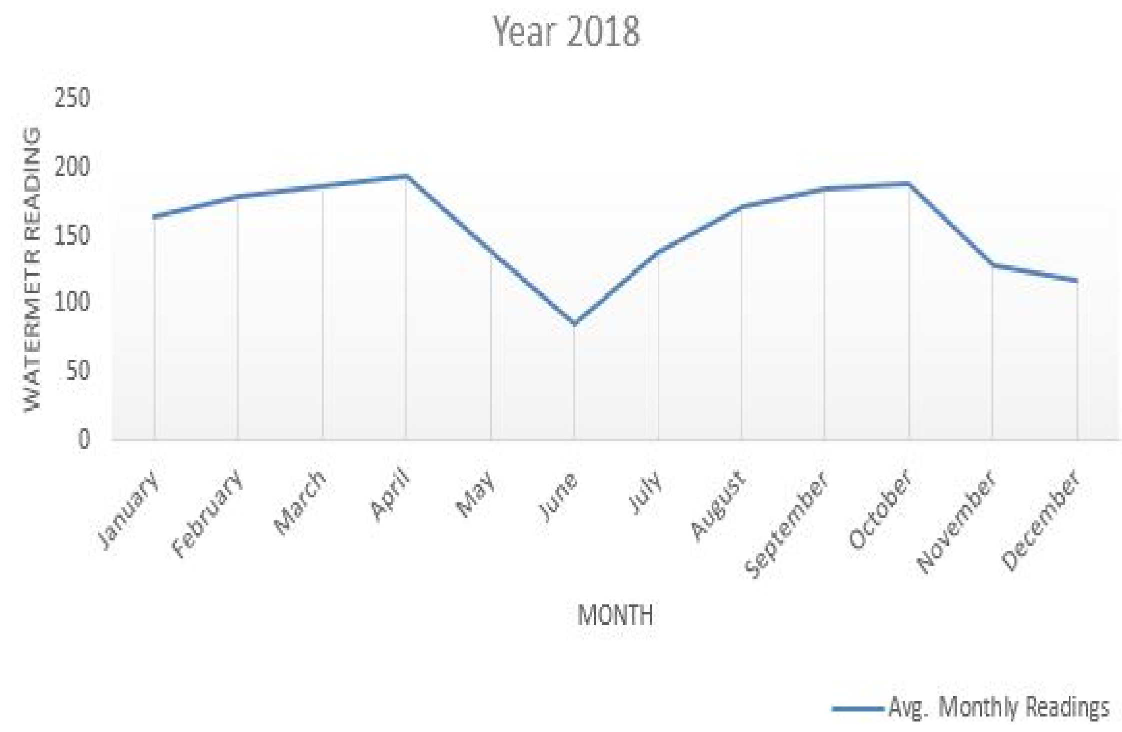

Figure 4.12: Monthly Water Usage at RIT Hostel Campus 2018

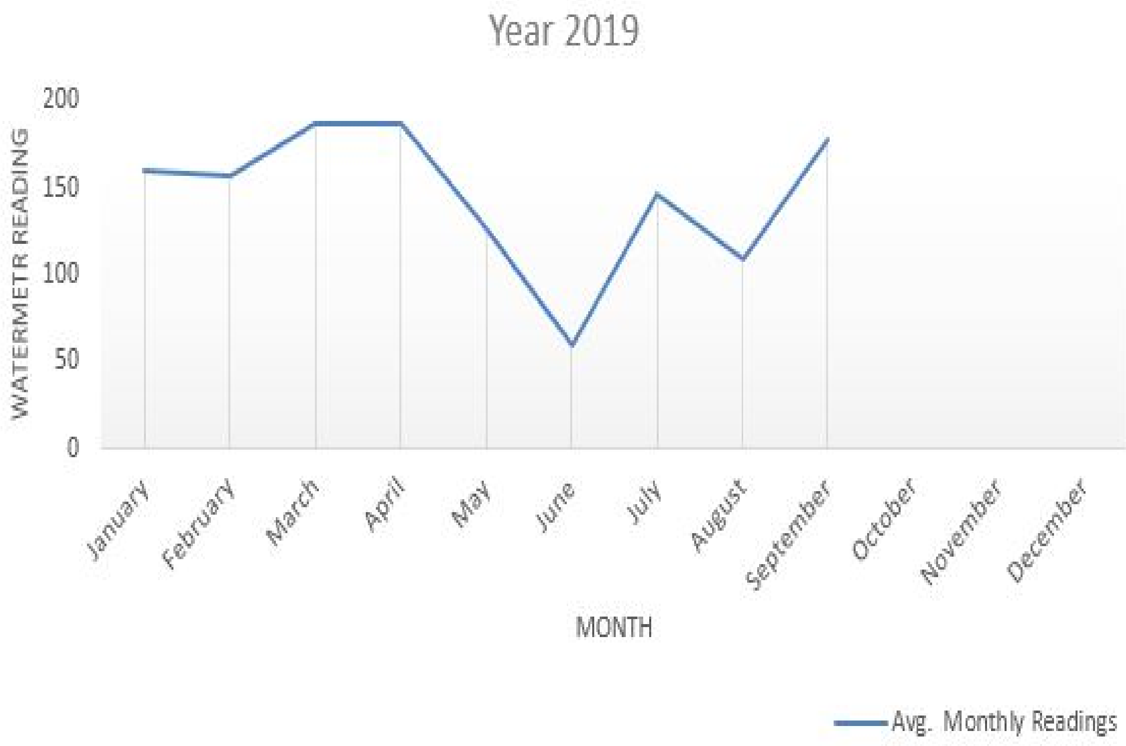

Figure 4.13: Monthly Water Usage at RIT Hostel Campus 2019

As per Figure no. 4.11,4.12,4.13 the water usage fluctuations can easily understand, in May, June, July month the water usage is low compare to other months because in those months the collage is having holiday so in hostel there is no students. From the above data of water usage, the quantity of wastewater generate daily is calculated by 80% of water usage. Maximum watermeter reading = 271 units Wastewater quantity = 271 x 80% = 216.8 units Taking the peak quantity as 220 units, and designing the units

4.6.3 Sanitary conditions in hostel campus

Water Consumption

a. Water Sources: The only source of water for RIT is the MIDC Water Treatment Plant situated around 500 m from the actual campus of RIT.
b. Water Demand: Based on the data provided by the RIT administration for the water consumption for the Hostel campus, the maximum volume of water required per day was observed to be 271m3/day. The actual per capita consumption for the total hostel campus is estimated to be 220 LPCD

Plumbing system details

All hostel buildings have two pipe plumbing system to collect and transport bathroom wastewater (wastewater) and toilet wastewater (black water) separately. The black water was directed to septic tanks, while the wastewater was disposed as it is. This arrangement was separate for each building and the disposal was therefore scattered. This led to a need for a decentralized treatment unit for each building.

Wastewater Generation

As observed through various practical studies and actual surveys, the average domestic wastewater generation is 80% of the total water consumption. In the present context, this volume was observed to be to the tune of 271 m3/day for the total hostel campus. Actual on-site wastewater estimation was done by carrying out field survey.

4.6.4 Wastewater Characterization

Wastewater characterization was performed by identifying impactful concentrations through sampling and analysis of wastewater. The type of wastewater identified for treatment using experimental constructed wetland was domestic wastewater from wastewater nallahs near the parking area of RIT campus. The concentrations of contaminants in the water to be treated are important for the process of sampling and analysis and for predicting the output of the wetland in the face of unidentified potential variations. The results showed variations in the season. Wastewater from a college campus is different in terms of both quantity and quality from any other form of wastewater. The volume of flow in weekends and holidays is significantly reduced. Although there is a significant variation in the quantity of the campus wastewater, this study does not look at the effect of this variation. Only the quality will be analyzed. the characteristics are given in Table no. 4.2

Table 4.2: Characteristics of Domestic wastewater at RIT Hostel

Characteristics of Domestic wastewater	
Description	Domestic wastewater
pH	7 to 12
BOD	190 mg/l
COD	258 mg/l
TSS	257 mg/l
TDS	223 mg/l

4.6.5 Treatment Goals

A detailed knowledge of regulations is required before designing a developed wetlands. The treated water to be released into reservoirs called primary groundwater users, surface water, irrigation water and reuse for gardens. Before the treated water is released into these receivers, the required quality of the treated water specification must be met which are given in Table no. 4.3. Hence proper design requires a clear statement of required water quality, leaving the constructed wetlands. A central pollution control board permit is required for point water/wastewater discharges into India's water bodies. A central pollution control board permit specifies discharge standards of the water. A constructed wetland was designed to treat wastewater components. The system's intake and outflow is measured. By comparing the parameters with the permit values, the treatment efficiency of the built wetlands system can be evaluated from these results.

Table 4.3: CPCB Permit Limit

CPCB PERMIT LIMIT	
Description	Permit Limit
pH	5.5 to 9
BOD	40 mg/l
COD	25.3 mg/l
TSS	35 mg/l
TDS	120 mg/l

4.7 Closure

The chapter explains about input parameters used in conventional treatment plant and low cost wastewater treatment plant and also gives selectivity for perfect type of wetland system.

Chapter 5

DESIGN OF LOW COST WASTEWATER SYSTEM

Treatment plant design must be imposed within a limited and controlled environment favorable to biological and physiochemical processes, helpful in eliminating contaminants so that the treated water can be reused for farming. Along with the designing, construction and long term treatment process of wastewater other factors such as less energy consumption, operation and management and cost effectiveness should also be considered. Constructed wetlands are considered particularly effective in developing countries for their low construction, management and operational cost. In this chapter the design of systems according to general standards, limitations, assumptions are considered from different books, research papers.

As per design flow and wastewater characteristics in present study schematic process diagram for proposed field scale wastewater treatment plant is prepared. The schematic process diagram for proposed field scale wastewater treatment plant was as shown in Figure No. 5.1

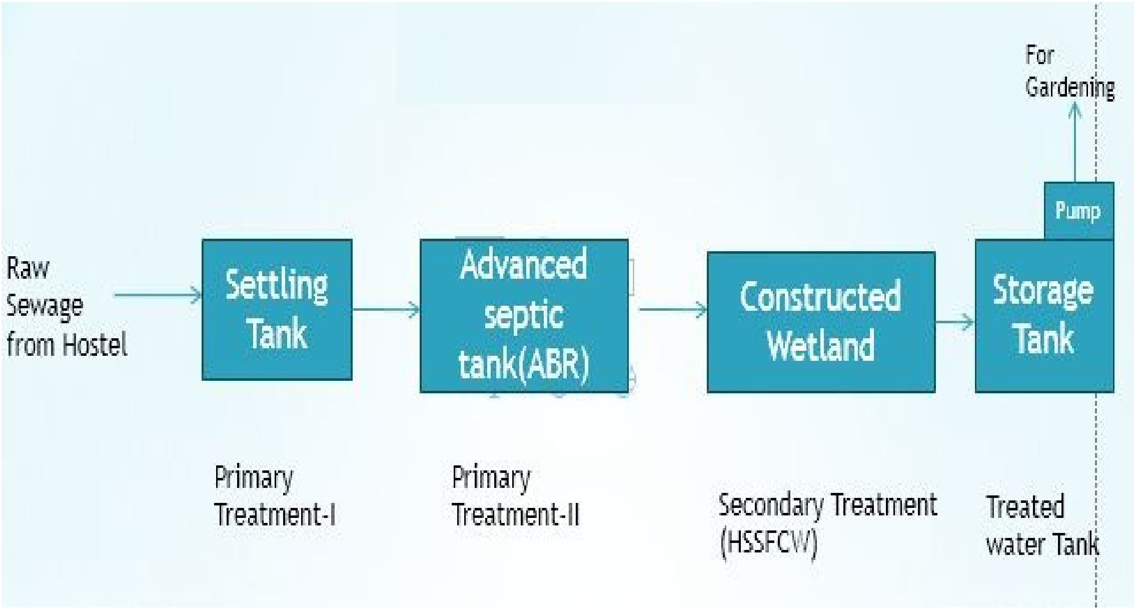

Figure 5.1: Schematic Process Flow Diagram of Proposed On-site Wastewater Treatment System

The proposed field scale wastewater treatment plant consisted of pre-treatment, secondary/biological CW treatment and tertiary treatment processes. It consists of three stage treatment viz.pre/primary [settling tank, advance septic tank, biological (SSFCW) and storage tank.

5.1 Design of Sedimentation Tank

QP= 220 cum/day

BOD at inlet of sedimentation tank = 400 mg/lit

Detention time= 4 hrs.

Volume = (220 x 4)/24 = 41.90 cum

Assume D= 1.5m

Area= 27.93 cum

L= 2B

2B sqm = 27.93

B = 3.73m = 4m

L = 7.47m = 8m

Size of sedimentation tank = 8m X 4m X 2m (Including freeboard)

Assuming 20% BOD removal efficiency from sedimentation tank.

BOD at outlet of sedimentation tank = 320 mg/lit

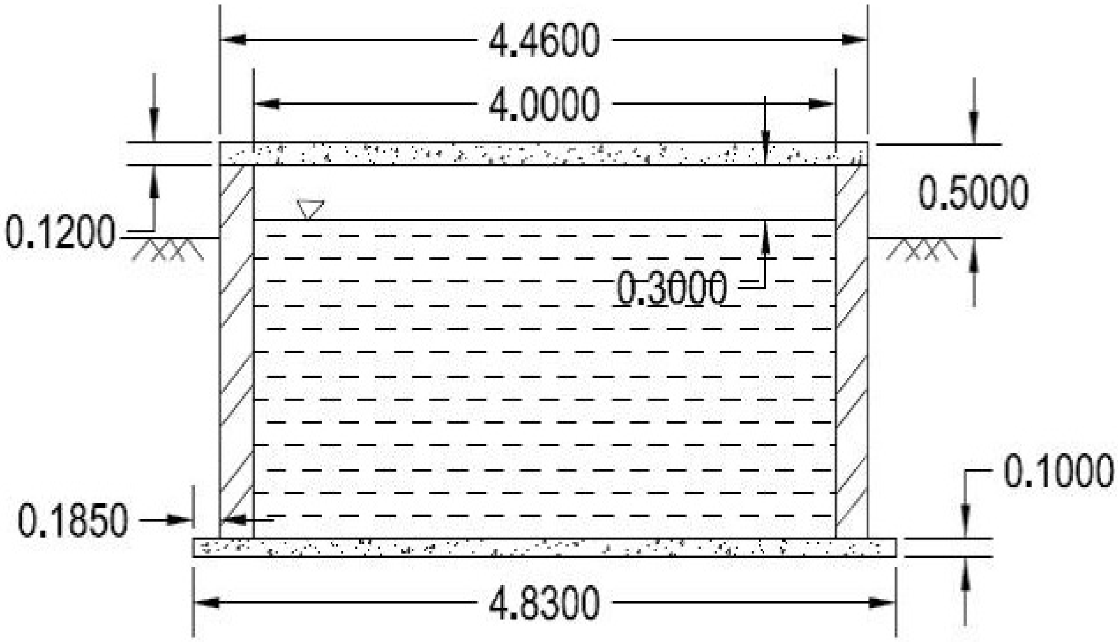

Figure 5.2: Sedimentation Tank c/s

5.2 Design of Advanced Septic Tank

Q = 220 cum

Guide lines

A = 1 sqm /cum/day

Area = 220x1 sqm /cum/day = 220 sqm

L = 1.5B

1.5B sqm = 220

B = 12 m

L = 18 m

Size of advanced septic tank = 12m X 18m X 3m

Assuming 30% BOD removal efficiency from advanced septic tank.

BOD at outlet of advance septic tank = 224 mg/lit

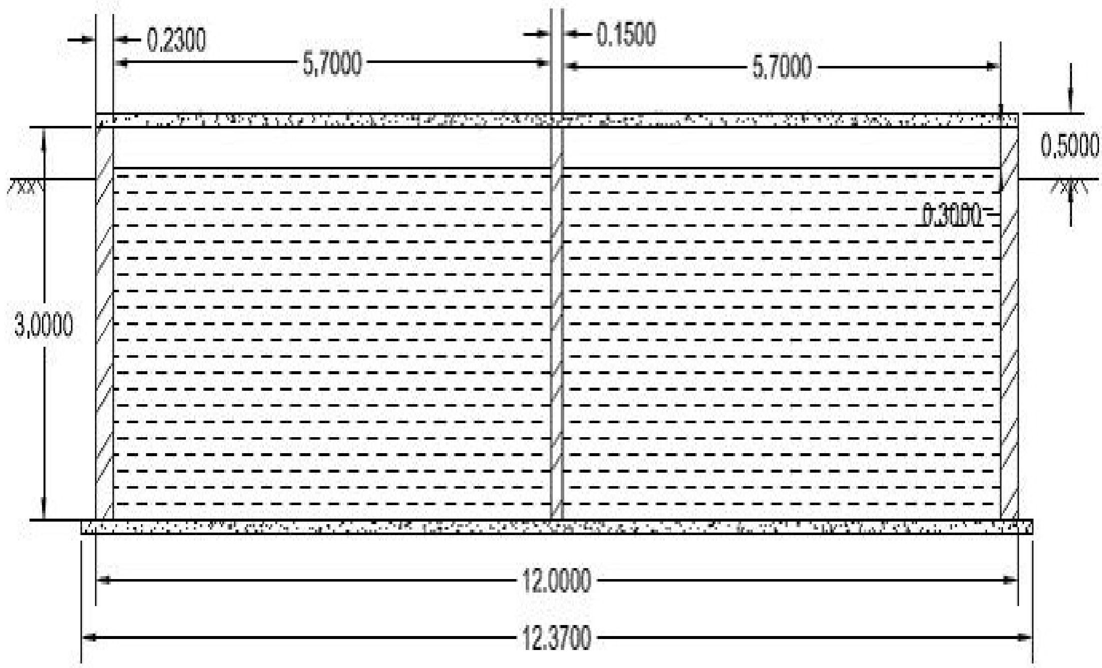

Figure 5.3: Advanced Septic Tank c/s

5.3 Design of Construction Wetland

Q =220 cum/day

BOD = 200 mg./lit

Organic Loading = 220x200/1000 = 44 kg/day

Organic Loading rate (OLR) = 400 kg/hect./day

Area= OL/OLR = (44 kg/day) x 10000/(400kg/hect./day)

= 1100m sqm

Assume, L = 2B

2B sqm = 1100

B = 23 m

L = 46 m

Size of construction wetland = 23m X 46m

Assuming 90% BOD removal efficiency from construction wetland.

BOD at outlet of construction wetland = 22.4 mg/lit

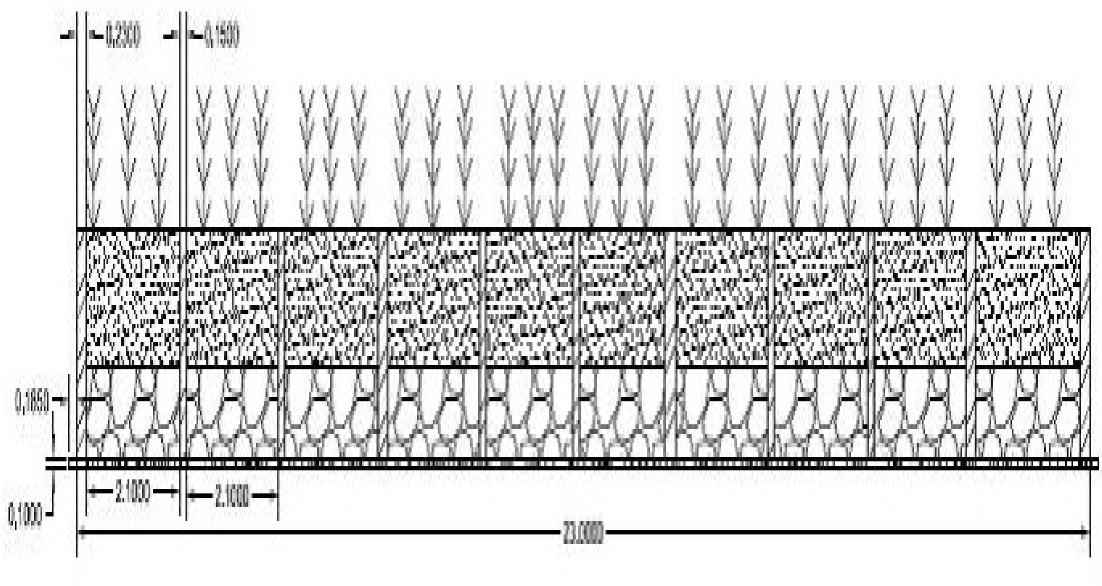

Figure 5.4: Construction Wetland c/s

5.4 Design of Storage Tank

Q =220 cum/day

Detention time= 4 hrs.

Volume = (220 x 4)/24 = 41.90 cum

Assume D= 1.5m

Area= 27.93 sqm

L= 2B

2B sqm = 27.93

B = 3.73m = 4m

L = 7.47m = 8m

Size of storage tank = 8m X 4m X 2m

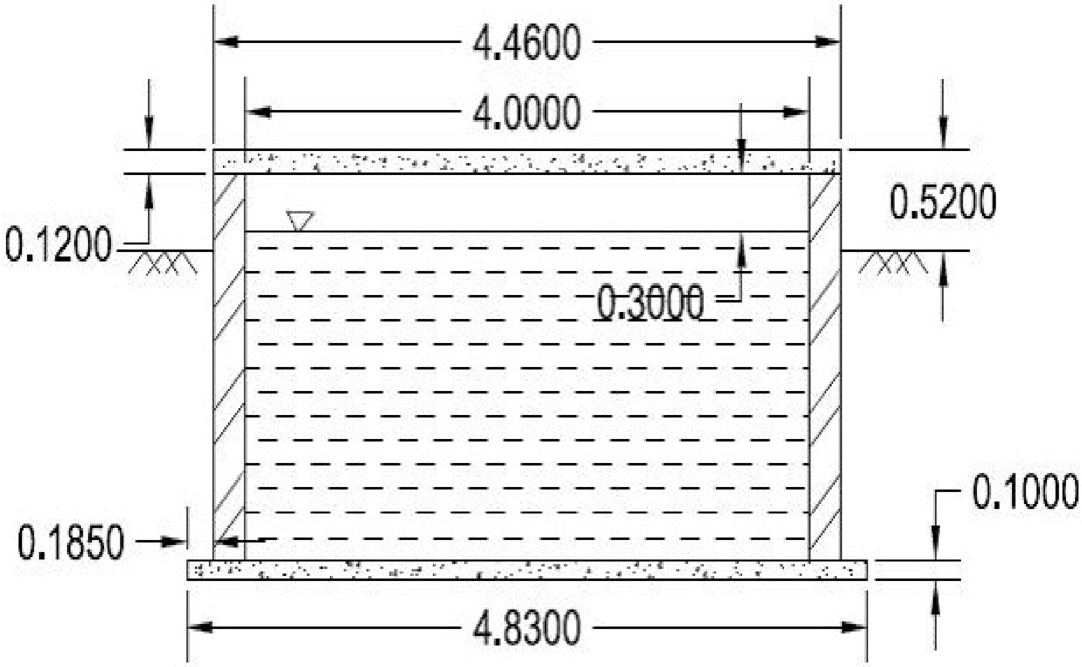

Figure 5.5: Storage Tank c/s

5.5 Configuration of Sewage Treatment Plant

From the above designed data of all treatment systems the dimensions of all systems are in the Table No. 5.1. The layout of treatment system is given in Figure No.5.6.

Table 5.1: Dimensions of All Systems

Sr.no.	UNIT NAME	LENGTH (m)	BREADTH(m)	HEIGHT(m)
1	SEDIMENTATION TANK	8	4	2
2	ADVANCED SEPTIC TANK	18	12	3
3	CONSTRUCTED WETLAND	46	23	1.8
4	STORAGE TANK	8	4	2
5	Total area required for system	61.00	30.00	
		1830 sq. m.		

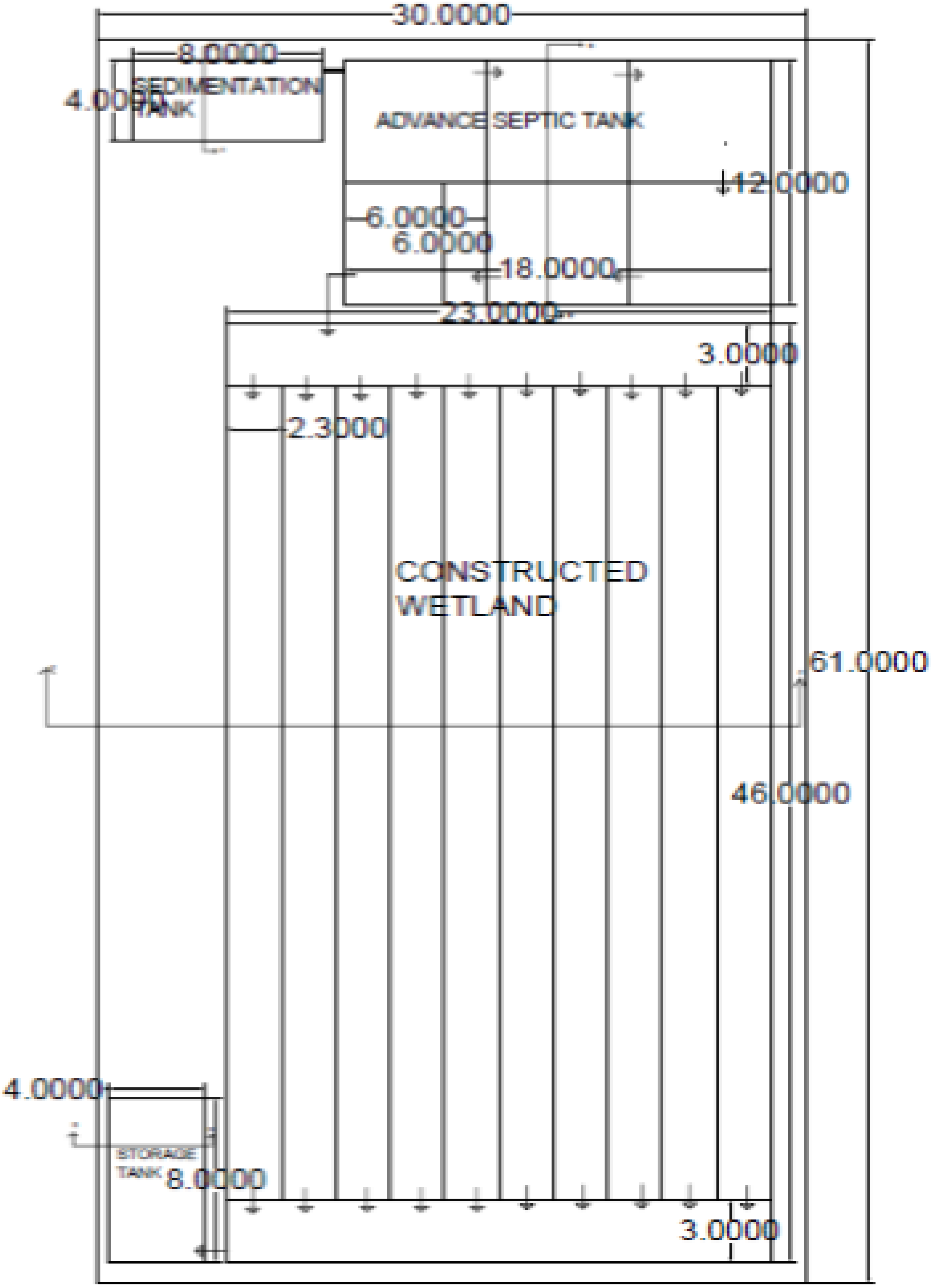

Figure 5.6: Layout of Treatment System

Table 5.2: Measurement Sheet for Sedimentation Tank

Sr. No.	**Discription of Item**	**NO**	**Length (L) m**	**Breadth (B) m**	**Depth/ Height (D/H) m**	**Quantity**	**Total Quantity**
1	EXCAVATION	1	9.13	5.13	1.5	70.25535	
2	PCC	1	9.13	5.13	0.1	4.68369	
3	FOOTING BELOW COLUMN	4	0.6	0.6	0.2	0.288	
4	RCC COLUMNS	4	0.23	0.3	2	0.552	
5	BBM	2	8.46	0.23	2	7.7832	
		2	4	0.23	2	3.68	
	DEDUCTION OF COLUMN	4	0.23	0.3	2	0.552	10.9112
6	RCC SLAB AT TOP	1	8.46	4	0.12	4.0608	
7	PLASTERING WITH WATERPROOFING	2	8		2	16	
	EXTERNAL	2	4		2	8	
	INTERNAL	2	8		0.62	4.96	
		2	4		0.62	2.48	
	BOTTOM PLASTERING	1	8	4		32	63.44

Table 5.3: Measurement Sheet for Advance Septic Tank

Sr. No.	**Discription of Item**	**NO**	**Length (L) m**	**Breadth (B) m**	**Depth/ Height (D/H) m**	**Quantity**	**Total Quantity**
1	EXCAVATION	1	18.67	12.67	3	709.6467	
2	PCC	1	18.67	12.37	0.1	23.09479	
3	FOOTING BELOW COLUMN	12	0.6	0.6	0.2	0.864	
4	RCC COLUMNS	12	0.23	0.3	3	2.484	
5	BBM	3	18	0.23	3	37.26	
		4	12	0.23	3	33.12	
	DEDUCTION OF COLUMNS	12	0.23	0.3	3	2.484	67.896
6	RCC SLAB AT TOP	1	18	12	0.12	25.92	
7	PLASTERING WITH WATERPROOFING						
	INTRENAL	6	22.16		3	398.88	
	EXTERNAL	2	18		0.5	9	
		2	12		0.5	6	
	BOTTOM	6	5.54	5.54		184.1496	598.0296

Table 5.4: Measurement Sheet for Constructed Wetland

Sr. No.	**Discription of Item**	**NO**	**Length (L) m**	**Breadth (B) m**	**Depth/ Height (D/H) m**	**Quantity**	**Total Quantity**
1	EXCAVATION	1	23.67	46.67	2	2209.3578	
2	FOOTING BELOW COLUMN	4	0.6	0.6	0.2	0.288	
3	RCC COLUMN	2	0.23	0.3	1	0.138	
		2	0.23	0.3	1.8	0.2484	
4	BBM	10	46	0.23	0.9	95.22	
		10	46	0.23	0.45	47.61	
		2	23	0.23	0.9	9.522	
		2	23	0.23	1.8	19.044	171.396
5	CA FILLING	10	40	2	0.7	560	

Table 5.5: Measurement Sheet for Storage Tank

Sr. No.	**Discription of Item**	**NO**	**Length (L) m**	**Breadth (B) m**	**Depth/ Height (D/H) m**	**Quantity**	**Total Quantity**
1	EXCAVATION	1	9.13	5.13	1.5	70.25535	
2	PCC	1	9.13	5.13	0.1	4.68369	
3	FOOTING BELOW COLUMN	4	0.6	0.6	0.2	0.288	
4	RCC COLUMNS	4	0.23	0.3	2	0.552	
5	BBM	2	8.46	0.23	2	7.7832	
		2	4	0.23	2	3.68	
	DEDUCTION OF COLUMN	4	0.23	0.3	2	0.552	10.9112
6	RCC SLAB AT TOP	1	8.46	4	0.12	4.0608	
7	PLASTERING WITH WATERPROOFING	2	8		2	16	
	EXTERNAL	2	4		2	8	
	INTERNAL	2	8		0.62	4.96	
		2	4		0.62	2.48	
	BOTTOM PLASTERING	1	8	4		32	63.44

Table 5.6: Abstract Sheet for Low Cost Wastewater Treatment

Sr.no.	**Description**	**Unit of Measurment**	**Quantity**	**Rate**	**Unit/Rate**	**Amount**
1	Excavation	Cu. M.	3059.5	90	Per Cu. M.	275355
2	Footing	Cu. M.	0.864	9800	Per Cu. M.	8467.2
3	PCC	Cu. M.	32.09	4900	Per Cu. M.	157241
4	BBM Partition	Cu. M.	261.11	4500	Per Cu. M.	1174995
5	C.A. Filling (20MM)	Cu. M.	560	725	Per Cu. M.	406000
6	RCC Slab Cover	Cu. M.	34.04	9700	Per Cu. M.	330188
7	RCC Column	Cu. M.	1.24	9700	Per Cu. M.	12028
8	Plastering With Water Proofing	Sq. M.	724	350	Per Sq. M.	253400
9	Plumbing	LUM.				150000
					TOTAL =	2767674

Chapter 6

LABORATORY SCALE CONSTRUCTED WETLAND SYSTEM

Recycle and reuse are the best options to deal with water scarcity. An attempt is made to reuse wastewater after giving low cost effective treatment with the help of constructed wetland. Constructed wetland is an emerging technology in which combined action of plants activity and the adsorption properties of material like soil, sand and gravel particles on the organic pollutants applied for wastewater treatment. It is required to develop a combined treatment system for wastewater with constructed wetland as secondary treatment laboratory scale setup with controlled experimentation.

The present study addresses design and development of Constructed wetland which consists of physical and biological systems of treatment so that suspended solids, organics, and nutrients can be removed. The combination of biological system with physical filtration is considered to be the most economical and feasible solution for wastewater recycling. The up flow sand gravel filter, Constructed wetland with Canna indica vegetation in laterite soil are used to enhance its performance as biological treatment.

6.1 Materials And Methods

6.1.1 Diluted Wastewater

It was required to use diluted wastewater for constructed wetland. The BOD5 of raw wastewater was in the range of 140-160mg/L. The surface area of constructed wetland unit was lesser. In order to maintain appropriate OLR in the range 30-300 kg BOD5/ha.d the raw wastewater was diluted to reduce BOD5 15-50 mg/L. The dilution was carried out with tap water using routine dilution procedure.

6.1.2 Experimental Set-up

A laboratory scale vegetated constructed wetland model was designed and developed for average rate of 150 L/d. The developed treatment facility for vegetated constructed wetland has pre-treatment and secondary/biological treatment processes.

In the lab scale model systems of actual designed model are same but less in size. The model is having 2 circular 200 liters tank used as sedimentation tank and storage tank. Rectangular 2 tanks of 300 liters of size 1.3mX0.6mX0.4m used as advance septic tank and storage tank. The provision of settling cum equalization tank enables settling of suspended solids and normalizes the quality wastewater. Sedimentation tank is placed at high position on stand and other setup is below it, because of this the free flow is maintained in model setup. Advance septic tank is having 3 compartments joining each other.

In the constructed wetland The bottom (first) layer was filled with 25-50 mm unisized laterite gravel (depth 0.15 m), second layer 12.5-25 mm laterite gravel (depth 0.15m), third layer 6-12 mm laterite gravel (depth 0.15 m) and topmost layer laterite soil (depth 0.15m). The total vertical depth of flow filter was 0.6 m with a free board of 0.20 m. Canna indica was planted in vegetated constructed wetland0.30 m deep support laterite soil and gravel medium of size 6mm-10 mm.The flow regulation valves were provided at outlet of tank for maintaining required HRT.The layout is given in Figure no.6.1 and Figure no.6.2

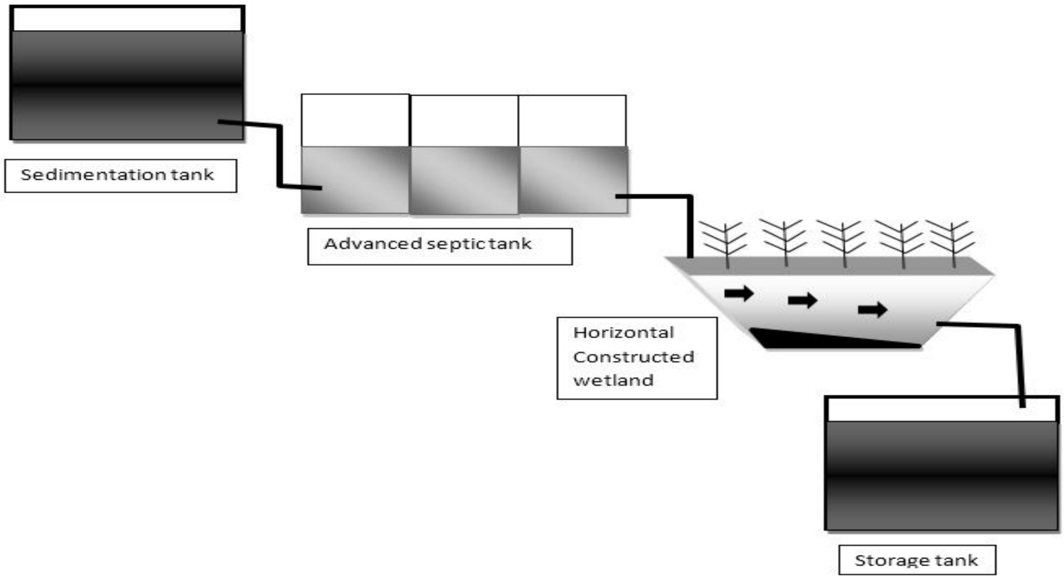

Figure 6.1: Laboratory Scale Constructed Wetland System

Figure 6.2: Laboratory Scale 3D Constructed Wetland System

6.2 Operation of the System

The different units in the treatment system were arranged to maintain the gravity flow. Up flow and down flow was maintained in sedimentation tank/equalization tank, advanced septic tank and in constructed wetland. The operation of the system was in sequential batch mode. The operational steps are as follows:

1. The wastewater was taken from modified hostel plumbing system and diluted by using BOD free tap water.

2. The control valve of equalization tank is opened to allow the flow into the system.
3. The flow from outlet of equalization tank equally distributed into the compartments of advanced septic tank by control valves.
4. The drip system was used to supply treated wastewater in constructed wetland from uniformly to the secondary biological system, which operates in flow mode. The effluent from constructed wetland retained by control valve for desired HRT and collected in storage tank.
5. Steps 1 through 4 were repeated for each batch.

Table 6.1: Efficiency of Various Units of Laboratory Scale Model

Component	Removal (%)			
	Sedimentation Tank	Advanced Septic Tank	Constructed wetland	Overall
Turbidity	55	60	79	90
BOD5 @20°C	21	50-60	60-80	63
TKN	17	30-50	40-64	61
Phosphorus	16.86	30-50	35-68	59

The expected efficiencies for various components of lab Scale model of integrated domestic wastewater model form literature is as given in Table No. 6.1. The overall efficiency of system is more than 90%.

Chapter 7

FINANCIAL ANALYSIS

7.1 General

This chapter gives input parameters required for financial analysis and revenue calculation. Here suitable concessionary model are proposed, by using decision making parameter of risks in PPP.

7.2 Financial Analysis of Sewage Treatment Project

Financial analysis shows the viability, stability and profitability of project. It is decision making parameter for investment of private sectors into the infrastructure development. It is consider while designing, construction, operation and maintenance of any project.

In India, the highway projects are either using one of the models such as BOT (toll), BOT (annuity) and EPC (Engineering, procurement and construction).Also the new version of model is introduced which is HAM (Hybrid annuity model) among all of this there is necessary of selection of appropriate concessionaire model for successful completion of project. This Concessionaire models plays a very important role in evaluation of projects for making project financing decisions by both the lenders and equity investors. In project finance, the funding agencies look into the expected future cash flows in relation to the amount of the initial investment while making the investment decision. On the other hand, financial model is used by lenders to know the level of cover for their loans and the timeliness of project debt service payments.

7.3 Decision Making Parameters

7.3.1 Net present value (NPV)

NPV is used for capital budgeting and planning for the investment to analyse the profitability of the project.Net present value (NPV) is the sum of the all positives as well as negative cash flows over the life of the project. Hence the project is accept which is having positive NPV and reject the project which is having negative NPV.Here the inflation rate considered as 4% over the concession period.

Table 7.1: Net Present Value of Project

Years	**Cash outflow**	**Cash Inflow**	**Total Cash Flow**	**NPV**	**Cumulative NPV**
	in lakh	**in lakh**	**in lakh**	**in lakhs**	**in lakhs**
0	-27.89		-27.89	-27.89	-27.89
1	-0.83	5.94	5.11	4.78	-23.11
2	-0.86	6.17	5.31	4.97	-18.14
3	-0.89	6.41	5.52	5.16	-12.98
4	-0.92	6.69	5.77	5.4	-7.58
5	-0.95	6.95	6	5.63	-1.95
6	-0.99	7.2	6.21	5.61	3.66
7	-0.83	7.48	6.65	6.22	9.88
8	-1.02	7.77	6.75	6.33	16.21

7.3.2 Cost-Benefit Analysis

As per the design is given in last chapter the total capital cost including construction of all units of constructed wetland system and costs in the initial estimation include following cases

1.Engineering Services and Design

2.Product Providence Including: Mechanical equipment's and installations – electrical equipment's and installations – instrumentation equipment's and installations – spare parts.This costs are shown in Figure No.7.2

3.One -year utilization Personnel costs - chemical materials consumption – electricity consumption – sampling and experiments – other costs. This costs are shown in Figure No.7.3

Table 7.2: Cost Related to Project

	Costs		
	Engineering Services	Product Providence	Utilization
Constructed Wetland System	27,67,674	22,000	82,940/year
	Total Cost	28,72,614	

Table 7.3: Recurring Costs

Sr. No.	Component	Cost (Rs.)
1.	Man-power (Annual operation and maintenance of system contract was given. As per contract Rs 6,000=00/month is O and M cost.)	48,000.00
2.	Energy Charges (2HP motor and working hours=4hour/d) 1.492 x 4 = 5.968 kWh 5.968 x365= 2178 kWh 2178 Units x Rs 4.1/Unit (As per MSEB rate for Residential Building)	8,940.00
3.	Annual operation and maintenance Cleaning of CW each 3 months (for 1 month= 4,000)	16,000.00
3.	Media replacement charges per year	10,000.00
Total Cost (Rs.)		82,940.00

According to the fact that plan period is considered fifteen years and the amount of input sewage to the sewage treatment plant and consequently, the amount of productive wastewater, the incomes of the plan are determined as follows and the general results are outlined. Selling treated wastewater for 15rs for each cubic meter.

Benefit = Annual water cost – O and M Cost

= 4,95,000 – 82,940

= 4,12,060

Cost-Benefit Analysis (CBA) is a relatively simple and common technique for decision making concerning an attempt and making a change. As its name implies, the value of the obtained incomes of an attempt are merely added and are subtracted from the relevant costs. Costs are incurred altogether or it might be incurred gradually, but benefits are reaped after a period. We have expressed and brought

this time factor with the calculation of a period of income return in our analysis. Analyze the results of the study show that benefits arising from the construction of wastewater treatment brought back the initial investments. The approaches used for cost-benefit analysis includes calculation of annual cost and comparison of cost of water (municipal and recycled wastewater)
Annual capital cost-

$$\frac{A}{P} = \frac{i(1+i)^n}{(1+i)^n - 1}$$

Where A= annuity, P = present worth, i = rate of interest and n = number of years.
In the present study
a) If i = 9.5%, For P = 27, 89,974.00, n =8 years, A=?

$$\frac{A}{27,89,974} = \frac{0.095(1+0.095)^8}{(1+0.095)^8 - 1}$$

Therefore A= Rs 5,13,427.00/year.
Annual recurring cost= Rs 82,940.00/year
Total annual cost = Rs 5,96,367.00/year
The rate of treated wastewater =

$$\frac{5,96,367}{220000X365} = \text{Rs. } 0.0074/\text{L}$$

Thus, cost of treated wastewater is Rs 0.0074.00/L. This is for first five years.
b) If i = 0 %, (Capital investment is done by Trust/Society)
For P = 27, 89,974.00, n =8 years, A=?

$$\text{A} = \frac{P}{n} = \frac{27,89,674}{8}$$

Therefore A= Rs 3,48,709.00/year
Annual recurring cost= Rs82,940.00/year
Total annual cost = Rs 4,31,649.00/year
The rate of treated wastewater =

$$\frac{4,31,649}{220000X365} = \text{Rs. } 0.0053/\text{L}$$

As per information from maintenance department of RIT, Rajaramnagar water supply is from Maharashtra Industrial Development Corporation (MIDC) Islampur. The rate of MIDC water is Rs 15.00/1000 L i.e., 0.015/L.
Thus, for first five years system treated wastewater cost was less than MIDC treated water. This will be compensated in the form of development of RIT green campus. In draught-prone region, this system is economically feasible.

If the project has BCR greater than 1.0 then the project is acceptable. If the BCR is less than 1.0 then project is non-beneficial, this is simple to use. All cost and benefit estimates must be converted to a common equivalent monetary unit (PW, AW, or FW) at the discount rate (interest rate).

$$\frac{A}{27,89,974} = \frac{0.095(1+0.095)^8}{(1+0.095)^8 - 1}$$

Therefore A= Rs 5,13,427.00/year.
Initial investment = 27,89,647/- (Converting to Annual worth = 5,13,427)
Water taken from MIDC = Rs. 15 X 220 Cum X 365 Days = 12,04,500
Water taken from Proposed treatment system = Rs. 7.4 X 220 Cum X 365 Days = 5,94,220
Annual maintenance = 82,940/year
Annual Benefit = 5,94,220 - 82,940
=5,27,340/-
Benefit Cost=Total Benefit (B)/ Total Cost (C)
= 5,27,340/ 5,13,427
= 1.02
As the project has BCR greater than 1.0 then the project is acceptable.

7.3.3 Payback Period

The payback period states about amount of time it takes to recover the cost of an investment. Payback period is the length of time an investment reaches a break-even point. The profitability of project is directly related to its payback period. Short payback period represent more attractive investment. Calculating the payback period is useful in financial and capital budgeting, but there is one problem related to payback period calculation, it ignores the time value of money. The payback period is calculated by dividing the amount of the investment by the annual cash flow. From the Table No.7.1 of net present value of project the payback period is 6 years.

7.4 Public Private Partnership(PPP)Models

PPP or the Public Private Partnership involves a contract between a public sector authority and a private party, in which the private party provides a public service or project and assumes substantial financial, technical and operational risk in the project. Sewage treatment plant (STP) projects are currently being granted on the basis of Engineering Procurement and Construction (EPC) and have a limited role for the EPC contractor in O & M of assets. In certain cases, the assets so generated are of relatively low quality, inadequately maintained and do not meet the criteria of the Emission Control Boards for the treatment of effluents. In order to ensure optimal utilization of deployed funds and proper development and maintenance of assets, it is beneficial to explore the option of PPP contracts where Private Sector Participants long-term commitment will be assured by continued implementation of their own resources.

Sewerage and sanitation services require a massive investment in capital, high operating costs, and maintenance of infrastructure and significant human resources; thus, this service is becoming increasingly costly. In recent years, public-private partnerships in sewerage facilities are on the rise. Local governments now are more aware of the benefits of privatization, and private companies are eager to enter the market. There is a need for a Public Private Partnership (PPP) because of it provides much needed expertise, operational competency and managerial efficiency of the private sector, improved operation and management, it brings in new and cost effective technology.

Treatment for Reuse-

In collages with large number of population and scarcity of water, sewage treatment projects for reuse can be developed. This type of project can be developed with the private sector on PPP basis. The private sector partner will implement the project, treatment plant, conveyance system and bill and collect on behalf of the collage authority from the end consumer industries. The collage authority will pay annuity to the private sector partner on take or pay basis. Under the PPP structure, the private sector partner who invests in the project assets and recovers it over a project life cycle of say 10–20 years, is likely to ensure better management of project assets and delivery of committed service level parameters during the project term. There are several business models of PPP as described below,

BOOT (Build-Own-Operate-Transfer) contract

BOO (Build-Own-Operate)

BOT (Build-Operate-Transfer)

BTO (Build-Transfer-Operate)

By studying all this PPP models, the best suited model for sewage treatment systems is BOT. Under a BOT model there are following types -

7.4.1 BOT (Build-Operate-Transfer) Toll model

Key features of toll Model-

1. Bid Parameter: Total cost of project = Engineering services and design + Product providence

= 27,67,674 + 22,000

= 27,89,674

2. Revenue collection and O and M payments: There is no payment to the private player as he earns his money invested from tolls.

3. Secured cash flows in form of annuity payments: No Annuity payment is made by RIT collage to private player.

4. Risk Allocation: Private partner bears all the risks.

5. Sharing of Capital cost: There is no sharing of capital. After 10 years the owner is RIT collage.

7.4.2 Build Operate and Transfer (BOT) Annuity Model

Under BOT annuity, a developer builds a highway, operates it for a specified duration and transfers it back to the government. The government starts payment to the developer after the launch of commercial operation of the project. Payment will be made on a six-month basis.

Key features of Annuity Model (AM)-

1. Bid Parameter: Total cost of project = Engineering services and design + Product providence

= 27,67,674 + 22,000

= 27,89,674

2. Revenue collection and O&M payments: Revenue as water given to RIT campus of quantity whichever may come at the end of year, and O&M payment will be made to the private player.

3. Secured cash flows in form of annuity payments: Annuity payment is made by RIT collage to private player for water usage in every year for 10 years.

4. Risk Allocation: Private partner bears the construction and maintenance risks as in BOT (Toll) projects and also all the revenue risk as well as the inflation risk.

5. Sharing of Capital cost: There is no sharing of capital. After 10 years the owner is RIT collage.

7.4.3 Hybrid Annuity Model (HAM)

HAM has emerged as a mix of the previous models – BOT-Annuity and BOT Toll Model. In financial terminology hybrid annuity means that the collage authority makes payment in a fixed amount for a considerable period and then in a variable amount in the remaining period. Hybrid Annuity Model (HAM) has been introduced by the Government to revive PPP (Public Private Partnership) in highway construction in India.

Hybrid annuity means the first 40% payment is made as fixed amount in five equal installments whereas the remaining 60% is paid as variable annuity amount after the completion of the project depending upon the value of assets created. As the collage pays only 40%, during the construction stage, the private contractor should find money for the remaining amount. Here, he has to raise the remaining 60% in the form of equity or loans. There is no direct revenue right for the private contractor. Under HAM, revenue collection would be the responsibility of the collage authority.

Advantages of HAM:

Advantage of HAM is that it gives enough liquidity to the private contractor and the financial risk is shared by the collage authority.

While the private partner continues to bear the construction and maintenance risks as in the case of BOT (toll) model, he is required only to partly bear the financing risk.

Key features of Hybrid Annuity Model (HAM)-

1. Bid Parameter: Total cost of project = Engineering services and design + Product providence

= 27,67,674 + 22,000

= 27,89,674

2. Revenue collection and O&M payments: Revenue as reuse of water in RIT campus of quantity 220 cum, and O&M payment will be made to the private player.

O& M payment = 82,940

Revenue made = 5,27,340

3. Secured cash flows in form of annuity payments: Annuity payment is made by RIT collage for 10 years

4. Risk Allocation: Private partner bears the construction and maintenance risks as in BOT (Toll) projects. Collage bears all the revenue risk as well as the inflation risk.

5. Sharing of Capital cost: 40% of the bid project cost shall be payable to the Private partner by the authority in five equal installments linked to physical progress of the project Private partner has to initially bear the balance 60% of the project cost through a combination of debt and equity.

40% of the bid project cost = 27,89,674 X 40% = 11,15,869

60% of the project cost = 27,89,674 X 60% = 16,73,804

Cost per year to pay –

60% of the project cost = 27,89,674 X 60% = 1,67,380 + 82,940 = 2,50,320

Revenue made = 5,27,340 / year

Annuity to private player = 2,50,320

Benefit per year = 2,77,020

Chapter 8

CONCLUSION

8.1 General

The chapter gives the conclusions which are obtained after analysing PPP (Public Private Partnership) models and discussion of the results is carried out. Based on all scenario conclusion procured as in below section-

8.2 Conclusion

The water availability in RIT during summer season is limited and the wastewater disposal system in RIT is not methodical, it is directly discharged into open land therefore it is need to design and develop wastewater treatment plant for RIT campus.

As per requirement of AICTE green campus initiative in the present dissertation work on low cost wastewater treatment syste, was designed for RIT campus. The proposed sewage treatment plant consists of primary treatment (Sedimentation), Secondary treatment (Advanced Septic tank) and Tertiary treatment (Constructed Wetland). As per DSR market rate cost of project is Rs. 27,67,674/-.

The laboratory scale constructed model for domestic wastewater treatment was found to be suitable for RIT campus. The efficiency of lab scale model for various parameters removal is 90%.

As per cost benefit analysis for wastewater treatment system the payback period is 6 years and benefit cost ratio is 1.02 means project is acceptable.

For the development of wastewater treatment system for collage campus by using Public Private Partnership (PPP) model. Detailed financial analysis of these PPP models was carried out.

Financial viability of the proposed alternative is assessed with respect to different models that are being popularly implemented in India. Construction of constructed wetland system is financially viable at HAM (Hybrid Annuity Model) which can attract potential contractors to execute the project.

8.3 Future Scope

In this study, financial viability of the case study carried out.Economical viability for the same project will build confidence amongs decision makers .So economical analysis for the same project can be carried out to get clear picture about the project.

Also the performance evaluation of lab scale model of constructed wetland system can be carried out to get the preliminary results of system.

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LIST OF PUBLICATIONS ON PRESENT WORK

1. Harshad Bhosale, Dr. Y.M.Patil "Study of Public Private Partnership Models for Low Cost Sewage Treatment Plant." International Research Journal of Engineering And Technology.,vol 7, Issue 10, oct 2020 (Published).

2. Harshad Bhosale, Dr. Y.M.Patil "Design of Domestic Wastewater System by Subsurface Flow Constructed Wetlands in RIT Islampur." International Journal on Advanced Science ,Engineering and Information Technology. 2020(Under Review)

Study of Public Private Partnership Models for Low Cost Sewage Treatment Plant

Harshad Bhosale[1], Dr. Y.M.Patil[2]

[1]M.Tech Dept. of Civil Engineering, RIT, Maharashtra, India
[2]Assistant Professor, Dept. of Civil Engineering, RIT, Maharashtra, India

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Abstract - *Water is essential commodity of society. The water availability in RIT during summer season is limited and the wastewater disposal system in RIT is not methodical, it is directly discharged into open land therefore it is need to design and develop wastewater treatment plant for RIT campus. The present study will address design of wastewater treatment plant for RIT campus. Also suggest feasible PPP model for the proposed wastewater treatment plant.*

Key Words: Wastewater, Constructed wetland, Public Private Partnership,

1. INTRODUCTION

Water is a scarce and finite resource which is often taken for granted. In the 20th century, population has increased resulting in pressure on the already scarce water resources. Excessive use of natural water resources due to rapid urbanization has necessitated search for alternative sources of water for non-potable purposes. The potential sources which can be explored include harvested rainwater, reclaimed water, and seawater.

Water is essential commodity of society. The water availability in RIT during summer season is limited and the wastewater disposal system in RIT is not methodical, it is directly discharged into open land therefore it is need to design and develop wastewater treatment plant for RIT campus.

The present study will address design of wastewater treatment plant for RIT campus. Also suggest feasible PPP model for the proposed wastewater treatment plant.

1.1 Study Area

The work, the project setting is in Rajarambapu Institute of technology located at Islampur Village, Sangli District, and Maharashtra, India. Fig shows the layout of the RIT collage with the location of plant area. Wastewater quantity mainly depends upon the water used in hostel campus. According to data collection, the MIDC provides the water for hostel campus daily. The water meter readings are taken at the hostel campus are obtained. Maximum limit of water usage is up to 65 units (1 unit = 1000lit) of water, above this limit the extra charges are added to bill. As per the water usage, the maximum reading of 271 units is used in month of September 2019. The average reading of year 2017, 2018 is 156 units and year 2019 up to October is 145 units.

Maximum water meter reading = 271 units

Wastewater quantity = 271 x 80% = 216.8 units

Taking the peak quantity as 220 units, and designing the units

2. METHODOLOGY

In the methodology as per collected data from the collage hostel of wastewater generation. A treatment system regards to low initial cost and which also gives more benefits from it, is selected as constructed wetlands. From the given data the design of units sedimentation tank, advance septic tank, constructed wetland and storage tank is completed. The details of the each component is in table1

PPP or the Public Private Partnership involves a contract between a public sector authority and a private party, in which the private party provides a public service or project and assumes substantial financial, technical and operational risk in the project. Sewage treatment plant (STP) projects are currently being granted on the basis of Engineering Procurement and Construction (EPC) and have a limited role for the EPC contractor in O & M of assets.

In collages with large number of population and scarcity of water, sewage treatment projects for reuse can be developed. This type of project can be developed with the private sector on PPP basis.

Under the PPP structure, the private sector partner who invests in the project assets and recovers it over a project life cycle of say 10–20 years, is likely to ensure better management of project assets and delivery of committed service level parameters during the project term.

e-ISSN: 2395-0056 p-ISSN: 2395-0072

International Research Journal of Engineering and Technology (IRJET)

(An ISO 9001 : 2008 Certified Journal)

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Harshad Bhosale

In recognition the publication of the manuscript entitled

Study of Public Private Partnership Models for Low Cost Sewage Treatment Plant

published in our Journal Volume 7 Issue 10 Oct 2020

Impact Factor : 7.529

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Design of Domestic Wastewater System by Subsurface Flow Constructed Wetlands in RIT Islampur.

Harshad Bhosale[1*], Dr. Yashwant Patil[2].

[1*] KES Rajarambapu Institute of Technology, Research Scholar of Civil Engineering Department, Islampur Maharashtra India
[2] KES Rajarambapu Institute of Technology, Assistant Professor - Civil Engineering Department, Islampur Maharashtra India

*Corresponding author: harshad.bhosale2659@gmail.com

KEYWORDS: Wastewater Treatment, Constructed Wetland, Horizontal Sub-Surface Constructed Wetland.

Introduction

Water is a scarce and finite resource which is often taken for granted. In the 20th century, population has increased resulting in pressure on the already scarce water resources. Excessive use of natural water resources due to rapid urbanization has necessitated search for alternative sources of water for non-potable purposes. The potential sources which can be explored include harvested rainwater, reclaimed water, and seawater.

Water is essential commodity of society. The water availability in RIT during summer season is limited and the wastewater disposal system in RIT is not methodical, it is directly discharged into open land therefore it is need to design and develop wastewater treatment plant for RIT campus.

The present study will address design of wastewater treatment plant for RIT campus. Also suggest drawings and estimate of work.

Methods

The methodology included data collection in the form of Wastewater Quantity, Wastewater Characterization, and Design of Low cost wastewater treatment system. The data collected from these sources was then analyzed.

The work, the project setting is in Rajarambapu institute of technology located at Islampur City, Sangli District, and Maharashtra, India. Fig shows the layout of the RIT collage with the location of plant area. Wastewater quantity mainly depends upon the water used in hostel campus. According to data collection, the MIDC provides the water for hostel campus daily.

1

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Country	Indonesia - SIR Ranking of Indonesia	17 H Index
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Publisher		
Publication type	Journals	
ISSN	20885334, 24606952	
Coverage	2015-2020	
Scope	International Journal on Advanced Science, Engineering and Information Technology (IJASEIT) is an international peer-reviewed journal dedicated to interchange for the results of high quality research in all aspect of science, engineering and information technology. The journal publishes state-of-art papers in fundamental theory, experiments and simulation, as well as applications, with a systematic proposed method, sufficient review on previous works,	

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RAJARAMBAPU INSTITUTE OF TECHNOLOGY, RAJARAMNAGAR

(An Autonomous Institute, Affiliated to Shivaji University, Kolhapur.)

SYNOPSIS OF M. TECH. DISSERTATION

1. Name of Course	: S. Y. M. Tech. Civil - Construction Management
2. Name of the Student	: Mr. Harshad Mahipati Bhosale
3. PRN of Student	1827011
4. Month of Registration	: July 2019
5. Name of Guide	: Prof. Y. M. Patil
6. Proposed Title	: **"Design and development of low cost domestic (hostel) wastewater treatment plant.."**

7. Synopsis of Proposed Work:

7.1 Introduction and Relevance:

Water is a scarce and finite resource which is often taken for granted. In the 20th century, population has increased resulting in pressure on the already scarce water resources. Excessive use of natural water resources due to rapid urbanization has necessitated search for alternative sources of water for non-potable purposes. The potential sources which can be explored include harvested rainwater, reclaimed water, and seawater (Patil and Munavalli, 2016).

Wastewater is water whose physical, chemical or biological properties have been changed as a result of the introduction of certain substances which render it unsafe for some purposes such as drinking. The day to day activities of man is mainly water dependent and therefore discharge „waste" into water. It is known that much of water supplied ends up as wastewater which makes its treatment very important.

The untreated wastewater creates various types of diseases in environment. A research conducted in 2007 found that discharge of untreated sewage is a single major cause of surface and groundwater pollution in India. In India, there is big gap between domestic wastewater generation and treatment (Shinde et al., 2017).

In these fields, the wastewater produced usually percolates in the soil or evaporates. Uncollected waste accumulates in urban regions causing unhygienic circumstances and releasing surface and groundwater leaching pollutants. Usually traditional wastewater treatment plant produced in these fields involves procedures such as primary sedimentation, aeration, secondary treatment, and chlorination. This form of treatment plants requires high initial investment. In addition, their maintenance costs are high and huge land area is required for treatment plants. The plant's skilled labours are needed for functioning and adequate maintenance. The treatment plants in general are expensive and the results are not up to the mark. Treatment of waste water by traditional method is very costly and hence neglected by most of the public bodies (Shinde et al., 2017). The main objective of this study is to develop cost effective treatment technology for sewage treatment.

7.2 Literature Review:

7.2.1. Solano et al. (2003). "Constructed Wetlands as a Sustainable Solution for Wastewater Treatment in Small Villages."

This research has addressed the concept Wastewater treatment problem in small villages; treatment performance of a pilot scale subsurface-flow constructed wetland (SFW) was evaluated for removal efficiency of biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS) from raw municipal wastewater. In the wetland Two different hydraulic application rates (150 and 75mmday) and two macrophytes, were assayed. For the highest percentages of removal were obtained in those beds with the lowest HAR (75mmday) and with the longest retention time (3days). No significant differences were observed between two macrophytes. In the seasonal variation, the summer season gives better results than other. Future study should be done on varying the retention time in the bed, in order to improve the efficiency of the system.

7.2.2. Vipat et al., (2008). "Efficiency of root zone technology for treatment of domestic wastewater : field case study of pilot project in Bhopal .(MP),India."

The paper under reference therefore is an attempt to evaluate the performance efficiency of field scale horizontal subsurface flow constructed wetland demonstration unit was constructed at ekant park, Bhopal. Wastewater at nalla passing through was 70,000 liters/day. The unit contains of pretreatment (settling tank- $35m^3$) followed by root zone bed (700 sq.m) with gravels, reed plants and inlet-outland arrangement for subsurface flow. The system performances were recorded monthly for 18 months. The results clearly indicated that the removal efficiency of 88.4% for turbidity, 79% for TSS, 70.7% for total solids, 77.8% for COD, 65.7% for BOD. Results established that the removal efficiency of the system studied ranged from 65% to 90% for various pollutants.

7.2.3. Gholikandi et al. (2009). "Treatment of domestic wastewater in a pilot-scale HSFCW in West Iran."

This research work has addressed the two low cost wastewater treatments namely duckweed and reed beds for treating domestic wastewater. The pilot plant was tested with six different BOD, COD, TN, TP, TSS and TDS loadings. The test results showed the artificial reed bed with subsurface flow capable of removing TSS by 92%, BOD by 89% and COD by 78%. The reed bed effluents were discharged into duckweed lagoon and the removal ratios of the above parameters were once again studied. The results showed reductions of 20% in BOD, 10% in COD, 24% in TSS, 8% in TN and 29% in TP. Based on these studies, the use of artificial reed beds for treating household wastewater in small communities is a sound technical and economical solution.

7.2.4. Kouki et al. (2009). "Performances of a constructed wetland treating domestic wastewater during a macrophytes life cycle."

In this study, the performance of a combined subsurface vertical and horizontal flow constructed wetlands system, designed for rural domestic wastewaters treatment and with theoretical hydraulic retention time of 2 d and 3.6 d, respectively, was investigated. Several water quality parameters including pH, BOD5, COD, TSS, TKN and TP, and faecal bacteria"s number in both raw and treated wastewaters were monitored during a macrophytes lifecycle. The result shows average effluent pH, BOD5, TSS and faecal bacteria were in agreement with the standards, but COD, nitrogen and phosphorus residual loads were still above the values required by the quality criteria.

7.2.5. Pawaskar (2012). "Application of modified root zone treatment system for wastewater treatment within nallah area."

This research examined the efficiency and techno economic feasibility of RZTS (Root zone treatment system) along with its modification. Another goal of the research was to work out the effectiveness of modified RZTS and trickling bed model with BOD, COD and TSS removal. The modification suggested and evaluated was Upper 1.5 m depth bed will be designed as trickling bed, act as aerobic treatment and Lower 0.5 m depth bed will be acting as constructed wetland (RZTS), as anaerobic treatment. Based on experimental results and its analysis modified constructed wetland gives average BOD and COD removal efficiency of 79.45% , average TSS removal efficiency of 83.07% For Total 1.5m combined bed depth.

7.2.6. Viller (2012). "Vertical subsurface wetlands for wastewater purification."

This study has suggested concept of „vertical subsurface flow wetland' in order to reduce the pollutants in the factory wastewater and the treatment system was designed to be placed after the already existing treatments in the company. The design prefers area necessary, for effective BOD reduction in wastewater treatment, of the vertical subsurface wetland is the 20 m2. The vertical subsurface wetland after a primary treatment reduces the value of main pollutant in the wastewater and it presents a stable behavior in the reduction of the main pollutants after the first six weeks of operation.

7.2.7. Lu et al. (2015). "Study on method of domestic wastewater treatment through new-type multi-layer artificial wetland."

This paper introduces a new-type multi-layer artificial wetland for treatment of domestic sewage, and analyzes the removing effects of CODcr, BOD_5, NH_3-N, TN and TP in this approach. The results indicate that when hydraulic loading reaches approximately 0.44 m3/(m2 d) and hydraulic retaining duration reaches 3 days, the effect of removing CODcr , BOD5, NH3-N, TN and TP from the wetland is relatively good, and the average removing rate achieves 90.6%, 87.9%, 66.7%, 63.4 and 92.6% respectively. The planting density, temperature variation and influent contaminant concentration have relatively great correlation with efficiency of wetland treatment.

7.2.8. Patil & Munavalli (2016). "Performance evaluation of an Integrated On-site GreywaterTreatment System in a tropical region."

The study was done in Integrated On-site Greywater Treatment System (IOGTS) with primary (settling/filtration), secondary (constructed wetland) and tertiary (adsorption) treatment was used to treat greywater from hostel. The performance evaluation of IOGTS was carried out for a study period of one year. The quality parameters used to assess feasibility of disposal for land application were COD, TKN, suspended solids, and pathogens.

The effect of hydraulic loading rate (HLR), Hydraulic Retention Time (HRT) and Organic Loading Rate (OLR) on performance of the system was also studied. Overall performance of IOGTS for COD, TKN and pathogen removal was observed to be 70%, 70% and 85% respectively.

7.2.9. Shinde et al., (2017). "Low cost sewage treatment by root zone technology."

In this paper, a significant issue in Indian cities is the treatment of sewage and disposal of treated sewage. Construction of treatment equipment requires enormous capital investment; it is very expensive to operate the conventional treatment plant. Sewage treatment is the most overlooked element in our nation because of these variables. It leads to river pollution and groundwater resources as well. Studies have been performed to discover suitability for sewage treatment of root zone technology. The cost-effective solution produced in small cities and isolated institutions for sewage treatment. Results of the pilot plant reactor research show that root zone technology is a cost-effective solution for sewage treatment in small cities and isolated countries.

7.2.10. Munavalli et al., (2018). "Effect of media and vegetation in constructed wetland for domestic wastewater treatment."

Constructed wetland (CW) has been used in decentralized domestic wastewater as a physical and biological therapy. CW's performance is greatly influenced by media assistance and vegetation type. Four laboratory-scale treatment systems with distinct media and vegetation combinations have been created in this context. For Hydraulic Retention Time (HRT) of 3 to 24 h and idle time of 1 to 2 h, the CW systems were operated in batch and fill-drain-idle-fill modes. The system feed was settled wastewater (gray water and black water) from the hostel at the university premises (Walchand College of Engg., Sangli). The performance of system was evaluated for organic matter (measured in terms COD) removal. Results shows Increase in Hydraulic Retention Time beyond 6 h does not contribute significantly to COD removal, Vegetation plays significant role compared to medium in Constructed wetland systems for COD removal. FDIF mode of operation enhances COD removal.

7.2.11. García-_Avila et al. (2019). "Performance of Phragmites Australis and Cyperus Papyrus in the treatment of municipal wastewater by vertical flow subsurface constructed wetlands."

This research paper has the purpose to compare the purification capacity of domestic wastewater using two species of plants sown in subsurface constructed wetlands with vertical flow built on a small scale that received municipal wastewater with primary treatment. The species used were Phragmites Australis and Cyperus Papyrus. Study gives the Cyperus Papyrus presented a greater capacity of pollutants removal as biochemical oxygen demand (80.69%), chemical oxygen demand (69.87%), ammoniacal nitrogen (69.69%), total phosphorus (50%), total coliforms (98.08%) and fecal coliforms (95.61%).

7.3 Research Gap:

The literature review on domestic wastewater treatment shows that there are systems which can treat domestic wastewater potentially so that it can be recycled. The treatment option use by various researchers includes physical, chemical and biological systems. The physical treatment consists of screening and sand filters. Chlorination and photo catalytic oxidation were chemical treatment. The systems viz. Membrane Bioreactor (MBR), Up Flow Anaerobic Sludge Blanket Reactor (UASBR), Rotating Biological Contactor (RBC) and constructed wetland has been used as biological options.

It can seen from the above discussion and literature review that there is plenty of scope to assess the performance of various combinations of low-cost physical and biological processes for domestic wastewater treatment. Also feasibility of PPP model for wastewater treatment is going to be prepared.

7.4 Problem Statement:

Water is essential commodity of society. The water availability in RIT during summer season is limited and the wastewater disposal system in RIT is not methodical, it is directly discharged into open land therefore it is need to design and develop wastewater treatment plant for RIT campus.

The present study will address design of wastewater treatment plant for RIT campus. Also suggest feasible PPP model for the proposed wastewater treatment plant.

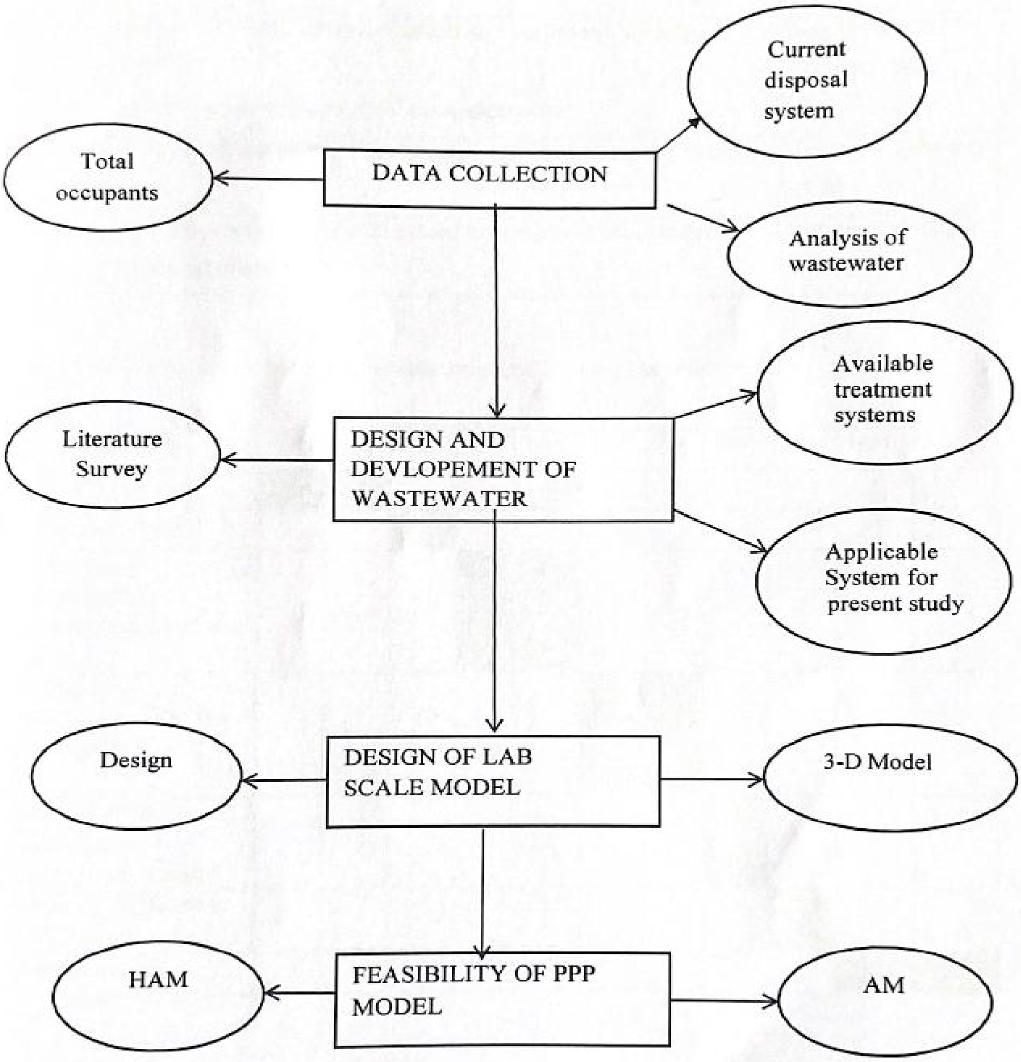
7.5 Proposed Objectives:

Following are the objectives of the proposed project work,

1. To design and develop of domestic wastewater treatment system incorporating preliminary treatment, various combination of physical and biological treatment process.
2. To design and development of lab scale model of wastewater treatment.
3. To check cost-benefit analysis of domestic wastewater treatment system.
4. To propose feasibility analysis of PPP model for proposed wastewater treatment plant for RIT campus.

7.6 Proposed Methodology:

To meet the objectives of dissertation work following methodology has been proposed,



7.7 **Plan of Proposed Work:**

Phase	Details	Completion date
1.	Data collection regarding existing disposal system of wastewater	July- September 2019
2.	Design and development of domestic wastewater treatment system. Design and development of lab scale model.	September 2019– January 2020
3.	Cost-benefit analysis of domestic wastewater treatment system.	January- February 2020
4.	Feasibility analysis of PPP model for proposed wastewater treatment plant	February – March 2020

Following table shows the expected time required to complete phase work,

Details	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	April	May
Literature review	■	■									
Data collection			■								
Design and development of wastewater treatment plant.				■	■						
Design and Development of lab scale model.						■	■				
Cost benefits analysis of wastewater system.								■			
Developing feasible PPP model.									■		
Report writing.										■	■

8. Facilities Available:

The following facilities to carry out dissertation work are available at Rajarambapu Institute of Technology, Rajaramnagar.

1. College central library for references journals and books.
2. Digital library for literature survey on national and international journals.
3. Departmental computer lab for Structural software.
4. Departmental lab for experimental study.

9. Expected Date for Completion of Work: - May 2020.

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Date- 01/02/2024
Place – RIT, Rajaramnagar

Mr. Harshad Mahipati Bhosale
Roll No. 1827011
S.Y.M.Tech.

Dr. Y. M. Patil
Project Guide
RIT, Rajaramnagar

DPGC member
RIT, Rajaramnagar

DPGC member
RIT, Rajaramnagar

Prof. D. S. Patil
HOP, Const. Mag.
RIT, Rajaramnagar

Dr. P. D. Kumbhar
HOD, Civil Engg. Dept
RIT, Rajaramnagar

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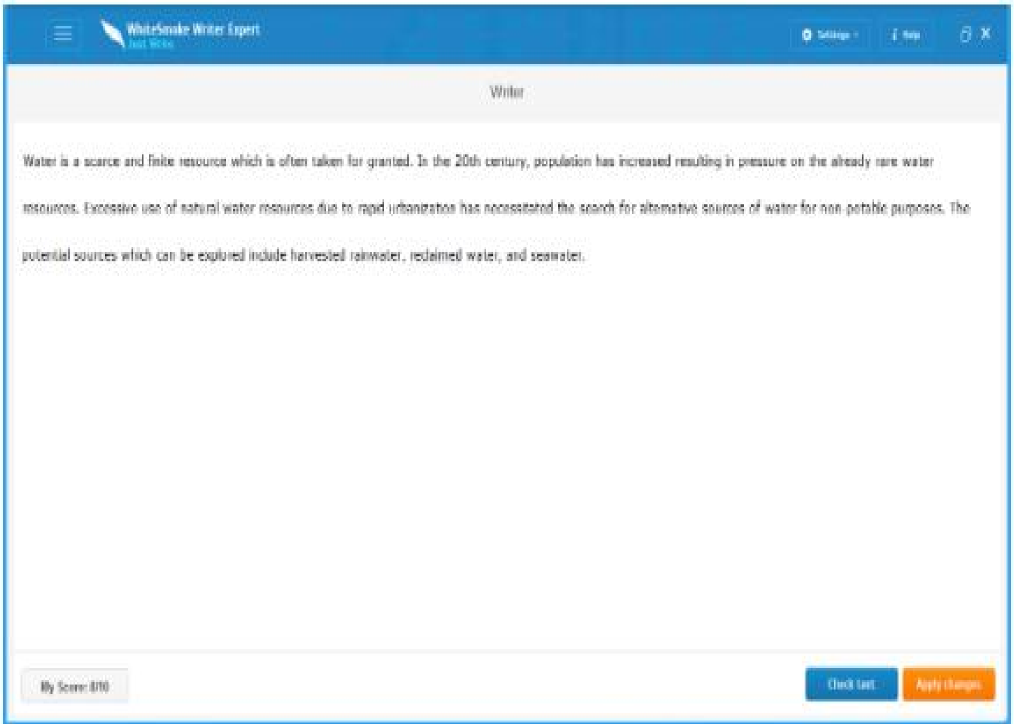
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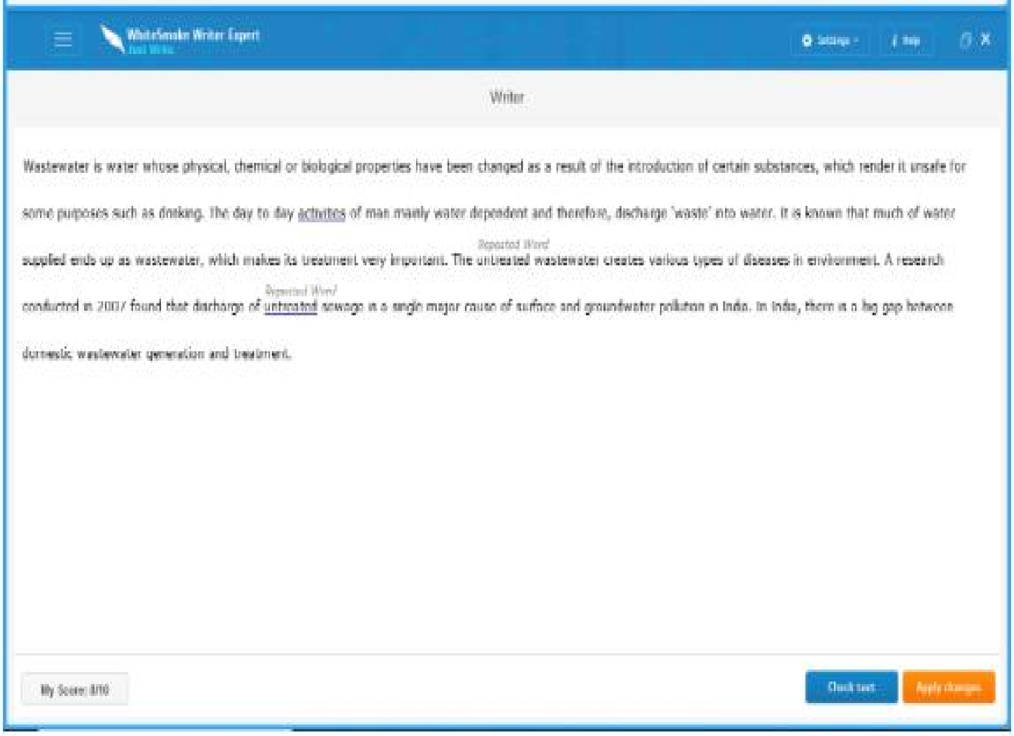
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VITAE (CV)

Name of the student: Mr. Harshad Mahipati Bhosale

Roll Number: 1827011

Permanent address: A/P Warananagar,Tal-Panhala,Dis-Kolhapur, Maharashtra, India.

Email address: harshad.bhosale2659@gmail.com

Contact number: 9881112659

Date of birth: 19/09/1996

Mr. Harshad Mahipati Bhosale, obtained B. E. in Civil Engineering from Shivaji University in 2018. He is studying M. Tech. in Civil-Construction Management in Rajarambapu Institute of Technology, Rajaramnagar. His Master's thesis is related to "Design and Development of Low Cost Domestic (hostel)Wastewater Treatment Plant" under supervision of Dr. Y. M. Patil. His research interests are in the field Environmental Engineering. He has one International paper and one under review International journal publication to her credit till date.