Performance Evaluation of Lal-Pani Sewage Treatment Plant(STP), Shimla

Project Report Submitted in partial fulfilment of the requirements for the

award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

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To

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT SOLAN – 173 234 ,HIMACHAL PRADESH, INDIA

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CERTIFICATE

This is to certify that the work which is being presented in the project title **"Performance Evaluation of Lal-Pani Sewage Treatment Plant(STP), Shimla"** in partial fulfillment of the requirements for the award of the degree of Bachelor of technology and submitted in Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Amul Mishra** and **Vinayak Kumar** during a period from August 2015 to June 2016 under the supervision of **Dr. Veeresh Gali** Associate Professor, Civil Engineering Department, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of my knowledge.

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ABSTRACT

The present study has been undertaken to evaluate the performance of 19.35 MLD Sewage Treatment Plant (STP) located at Lalpani, Shimla. Performance of this plant is an essential parameter to be monitored as the treated effluent is discharged into River Kalapani. The Performance Evaluation will also help for the better understanding of design and operating difficulties (aeration, blowers, etc.) in Sewage Treatment Plant. Sewage samples were collected from different treatment units i.e. Inlet screen, outlet Grit Chamber ,outlet Clarifier etc and analysed for the major waste-water quality parameters, such as pH, Biological Oxygen Demand (BOD), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS). Actual efficiency of the 19.35 MLD STP will be evaluated by collecting samples from different treatment units for the period of 8 months (October to May). The conclusions of these evaluations may determine required recommendations and focus on modification requirements for the STP and will also determine whether the effluent discharged into the water body are under limits. The conclusions drawn from this study will outline the need for continuous monitoring and performance analysis by removal efficiencies of each and every unit of STP.

ACKNOWLEDGEMENT

We wish to express our earnest gratitude to our esteemed mentor **Dr. Veeresh Gali** , for providing us invaluable guidance and suggestions, which inspired us to take up such a challenge. He not only cleared all our doubts but also generated a high level of interest in the subject. We are truly grateful to him. The prospect of working in a group with a high level of accountability fostered a spirit of teamwork and created a feeling of oneness which thus, expanded our range of vision, motivated us to perform to the best of our ability and create a report of the highest quality. To do the best quality work, with utmost sincerity and precision has been our constant endeavour. We extent our deep appreciation and thanks to the authors of various books which we referred in order do this project.

Thanking You

Amul Mishra (121607)

Vinayak Kumar (121653)

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Chapter – 1

INTRODUCTION

1.1 Description of SHIMLA

Shimla is the capital of the beautiful state of Himachal Pradesh and is located to the north of Chandigarh . The name was derived from the name “Shymala” .it predominantly covers an area of 35 sq. Km .

1.2 Climate

The winter temperature in Shimla varies from 18ºC to -4ºC and in summer from 32ºC to 6ºC. The city receives the monsoon during the months of July to September with annual average rainfall of about 150mm.

1.3 Demographics

Asper provisional data of 2011 census Shimla urban agglomeration had a population of 171,817.

1.4 Sewerage system

Presently, there are two authorities responsible for the sewerage system in Shimla. Irrigation and Public Health (I&PH) department is responsible for planning, construction, operation & maintenance of trunk sewer lines (in periphery areas) and sewage treatment plants, while MC Shimla maintains domestic and commercial connections from household to trunk sewer lines (branches and laterals), billing and addressing peoples‟ grievances. However the proposal for handing over entire responsibility of sewerage system along with STPs to MC Shimla is under process.

1.5 Sewage Generation

The estimated population of Shimla as on today is 2.16 lakhs including permanent and floating population. The estimated sewage generation for 2010 is 27.75 MLD and is projected to be 40.40 MLD for 2025 and 57.99 MLD for 2040. The sewage generation as estimated in the DPR as mentioned is based on the total water demand, which includes the unaccounted losses (20-25%) and fire fighting (5%) reserve. However in practice, the conveyance losses and water reserve for firefighting do not contribute to sewage generation.

1.6 Zone Wise Details

1.6.1 North Disposal zone

North Disposal has a present population of 29,275 persons. An STP having Extended Aeration process of 5.80 mld has already been set up which is sufficient for projected population upto 2025 except Bharari (North Disposal sub-zone – II) area having present population about 1350 persons (as per 2010 estimation) which cannot be met with the existing network due to population situated on lower side than the existing network. As per the current population in Bharari, the total sewage generation is about 0.15 mld (based on 135 lpcd water supply).

Estimating sewage generation of 150 Kld in Bharari region as a whole, 3 individual decentralised treatment plants can be installed in this region, each treating approximately 50 Kld of domestic sewage. DEWATS can be incorporated as an extension of the already existing septic tanks providing primary treatment of the sewage.

1.6.2 Dhalli Zone

Dhalli zone presently has a population of 6553 persons. The projected population for the year 2025 will be 10,361 persons. Sewage treatment plant of Extended Aeration process of 0.76 mld has already been set-up which is sufficient to meet the requirement for the designed year 2025 but some residential areas (Dhalli sub zone – II) i.e. Hipa area, Lower / upper area of Sanjouli by-pass etc. having an estimated present population of 1050 persons (2010) cannot be met with the existing sewerage network of Dhalli because the elevation of above areas do not permit to meet the sewer connections with the existing network by gravity. The sewage generation in this region is around 0.12 mld (based on water supply of 135 lpcd).Estimated sewage generation in this zone is 120 Kld. To treat this quantity of sewage, 4 rootzone treatment systems/SBT (Soil biotechnolgy) units can be installed, each having a capacity of 30 Kld as an extension of the primary treatment-providing septic tanks already in use in the region.

1.6.3 Sanjauli Malyana Zone

Some areas of Sanjouli Malyana (sub-zone – II) zone i.e. lower *Pantheghati*, Mehli, IAS colony & village Sargeen etc. having a present population of 1100 persons (as per 2010 estimation) cannot be met with the existing sewerage network due to topography of the area. The sewage generation of this region is 0.12 mld (based on 135 lpcd). Furthermore, the effluent of the STP treating the wastewater generated from the sewered areas of this zone is discharged into a natural nallah which, on its course, joins one of the tributaries draining into Ashwani Khad . To meet the treatment needs of the estimated sewage generation of 120 Kld, 4 DEWATS units, treating 30 Kld of sewage each, can be installed, fed by the septage generated from the septic tanks already existing in the region.

1.6.4 Totu Zone

The population in Totu zone is estimated to be approximately 12909 persons (2010). The downhill region of *Chakkar* area in Totu zone cannot be connected to the main sewerage network due to the gravity flow restrictions because of being located at a lower altitude. The sewage generation in this region is estimated as 1.39 mld. Given the huge quantum of sewage (1390 Kld) generated in this unsewered zone, a total of twelve to fifteen DEWATS/SBT units of varying capacity can be installed here, each treating approximately 100 Kld of wastewater. Totu zone has dense and sparse population patches. Also the topography of the catchment areas varies within the zone. The size and design specifications of the DEWATS/SBT units to be installed here would vary with the population density and topography of each catchment.

1.6.5 Jutogh Zone

Jutogh zone (covering the areas of Jatog Cant. & Dhar) is not connected to the sewerage network presently and is estimated to have a population of 5204 persons (2010). The sewage generation in this region is around 0.56 mld (based on water supply of 135 lpcd). Estimated the present sewage generation in this zone as 0.56 mld, ten DEWATS units can be installed, each having a capacity of 55 KLD.

1.7 Sewage Treatment Plants

I&PH have constructed 6 STPs with total capacity of 35.63 MLD through OPEC funding. I&PH have given operation and maintenance of these STPs on management contract. The details of treatment plants are presented in Table 1.1.

Table 1.1: Sewage treatment Plants and its descriptions

S.No	Name Of Sewerage Treatment Plant	Capacity (MLD)	Technology Used
1	Lalpani	19.35	UASB
2	Sanjauli Malyana	4.44	Extended Aeration System
3	Dhalli	0.76	
4	Snowdown	1.35	
5	North Disposal	5.80	
6	Summer Hill	3.93	

1.7.1 Lalpani Sewage Treatment Plant

1.7.1.1 Location of STP

Lalpani STP is located near Baragaon on Shogi bypass as shown in Plate 1..

Plate 1. Location of Lalpani Sewage Treatment Plant**.**

1.7.1.2 Lalpani Sewerage Zones, Population and Sewage Quantity

Lalpani sewerage zones cover different areas of Shimla town having different residential population. The contributory populations from various Water Supply zones are given in Table 1.2.

Table 1.2: Flow Calculations

Sr.	**Water Supply Zones**	**Density wise residential population**					
		High	**Medium**	**Low**	**Complex**	**Govt. Est.**	**Total**
1.	Kasumpati	13,510	3,515	1,780	126	-	18,931
2.	Mansfield	15,498	912	-	-	-	16,410
3.	B.C.S	17,535	5,850	5,788	-	-	29,173
4.	Sanjauli	24,320	372	-	-	-	24,692
5.	Ridge	4,632	23,160	-	3,010	7,720	38,522
6.	High Court	-	36,253	-	-	-	36,253
7.	Chakkar	-	4,095	439	2,573	-	7,107
8.	Kamna Devi	-	984	1,200	-	-	2,184
9.	Viceregal Lodge	14,335	2,458	18,400	-	-	35,193
10.	A.G. Office	17,072	6,789	11,733	-	-	35,603
	Total	1,06,902	84,397	39,340	5,709	7,720	2,44,068

The wastewater generated is taken as 80% of the water supplied in the contributory area. The wastewater generated in the year 2031 & 2016 on the basis of the contributory population given in Table 1.2 is tabulated in Table 1.3. Population for year 2016 is 2/3 that of the year 2013 and wastewater generated in 2016 is 19.35 MLD.

Table 1.3: Wastewater generation in 2031 and 2016

Sr.	Population	Population in 2031	Total water Demand in 2031	Wastewater generated	
	Type			2031	2016
		(nos.)	(nos.)	(MLD)	(MLD)
1	Permanent	1,77,793	26.669	21.335	14.22
2	Floating	66,275	6.627	5.302	3.53
3	Others		3.361	2.689	1.793
2	Total	2,44,068	36.657	29.02	19.35

1.8 TREATMENT PROCESS

The treatment process at the Lalpani STP consists of different treatment unit i.e. Inlet Chamber (Figure 1.2), Screen Chamber (Figure 1.3), Grit Chamber (Figure 1.4), UASB Reactor (Figure 1.5), Extended Aeration Tank (Figure 1.6), Secondary Clarifier (Figure 1.7), Flash Mixer, Clariflocculator, Sludge Pumping Stations, Distribution Boxes, and Filter Press. The inlet chamber receive raw sewage and pass it further to screen channel and grit channel where the floating matters are trapped and removed in screen channel and grit is removed in grit channel. This treatment is known as primary treatment. After primary treatment the screened sewage is treated biologically in UASB reactor followed by extended aeration process comprising of aeration tank and secondary settling tank. During winter season due to fall in temperature the removal efficiency of extended aeration process is reduced and effluent from secondary settling tank is treated physico-chemically by adding alum in flash mixer and settling out the flocs in Clariflocculator. The sludge from UASB reactor and secondary settling tank is then dewatered using filter press for further disposal.

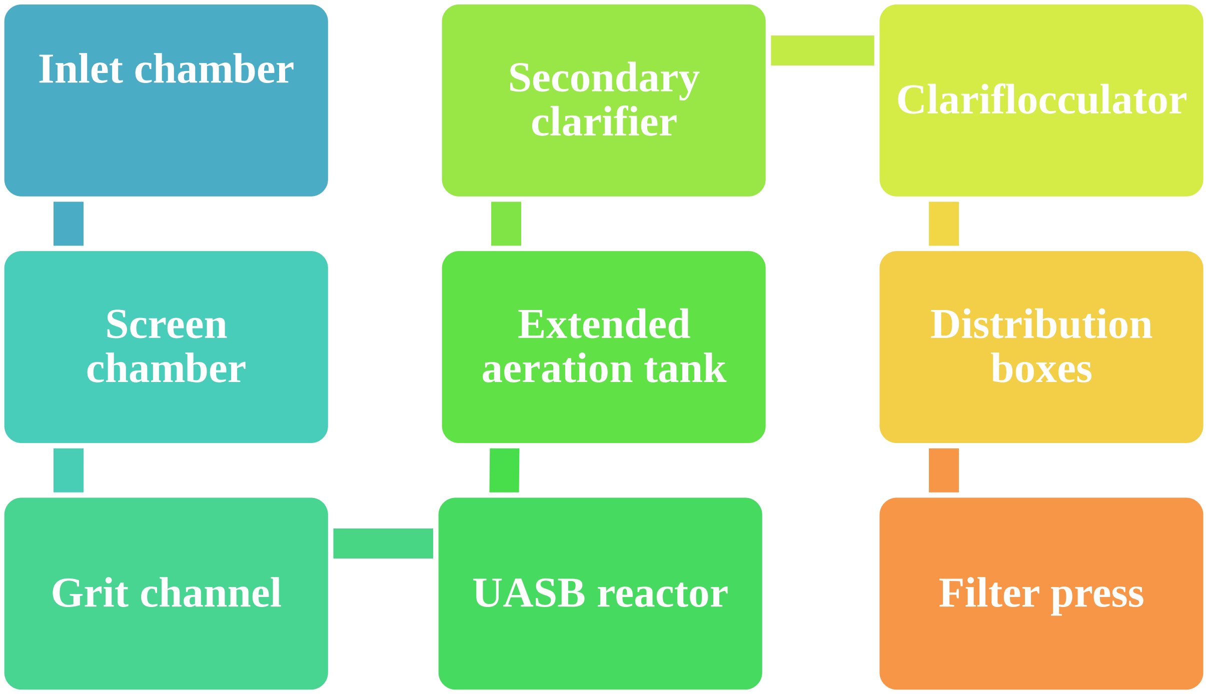

Figure 1.1: Flow diagram of the Lalpani STP.

Figure 1.2: Inlet Channel

Figure 1.3: Screen Channel

Figure 1.4: Grit Channel

Figure 1.5: UASB Reactor

Figure 1.6: Aeration Tank

Figure 1.7: Secondary Clarifier

1.8.1 Inlet Chamber

The wastewater from the sewer system is collected in the inlet chamber with a maximum of 30 seconds of hydraulic retention time. The inlet chamber (also known as equalisation chamber) is also provided with the diversion valve to divert the excess wastewater entering the treatment unit. An Inlet Chamber is provided ahed of screen chamber to receive the sewage from the incoming main trunk sewers

1.8.2 Mechanical Screen

The waste water is passed through a channel provided with screens with opening of 15mm. The larger solid particles are sieved in this process and the wastewater enters the grit channel. Screening is an essential step in sewage treatment to remove large size floating materials like rags, wooden pipes, plastics, etc. Which otherwise would damage pumps and interfere with satisfactory operation of various treatment units .screen channel consists of bars placed across the channel to trap the floating material . The bars arrest the floating materials, which have to be removed periodically.

1.8.3 Grit Chamber

The grit channel is designed for a maximum velocity of 0.3 meter/second. The grit (sand, stone and other particles with higher density) are settled in this unit. The wastewater from the outlet of grit chamber is distributed in the aeration tanks (through distribution chambers), clarifiers and clariflocculators. This process ensures an increase in dissolved oxygen and removal of dissolved and suspended solids from the wastewater. Alum is used as a flocculent and is mixed with wastewater in the flash mixer before sending wastewater to the clari-flocculator

1.8.4 UASB Reactor

Lettinga develop Upflow Anaerobic Sludge Blanket Reactor (UASB) in 1970s in the Netherlands. UASB is a suspended growth system and require a proper hydraulic and organic loading rate in order to facilitate the granulation which is also known as dense biomass aggregation. The granules are bigger in size (1-3 mm diameter) and heavier, which made them to settle down and to retain within the reactor. The biomass concentration in the reactor may become as high as 50 g/L. Thus, even at a very low HRT of 4 hours very high Sludge Retention Time (SRT) can be achieved. At top of reactor three phase separation between gas-liquid-solid takes place. Any biomass leaving the reaction zone is directly recirculates from settling zone. Figure 1.10 and Figure 1.11 shows a typical cross section of UASB reactor and full scale UASB reactor located in Lalpani STP.

Figure 1.8: Full view of UASB reactor at Lalpani STP.

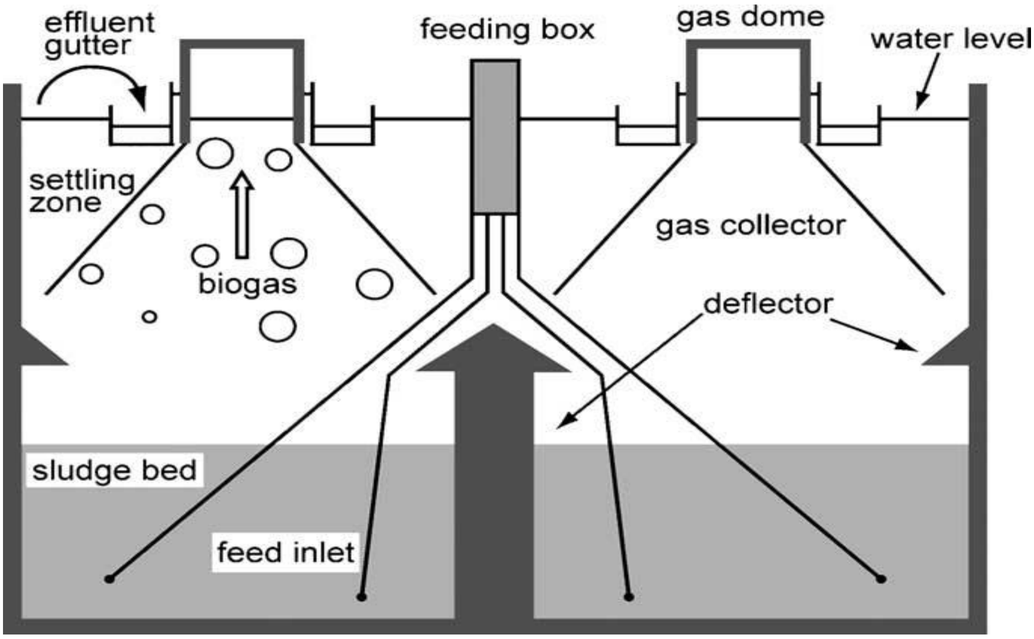

Figure 1.9: Sectional View of UASB Reactor

1.8.5 Extended Aeration Tanks

Extended aeration is a method of sewage treatment using modified activated sludge procedures. It is preferred for relatively small waste loads, where lower operating efficiency is offset by mechanical simplicity.Sewage from UASB reactors enters an extended aeration tank for aerobic treatment. This tank for aerobic treatment provides oxygen to the bacteria to carry out the degradation of organic matter. The environmental conditions for the proper functioning of process are established by maintaining the proper F/M ratio and MLSS in the aeration tank.

1.8.6 Secondary Clarifier

Secondary clarifiers help to separate the solids from the liquid phase of the mixed liquor, and remove settled solids from the floor. The three secondary clarifiers at the Glens Falls plant are of the circular, center-column, siphon feed type. Each of these clarifiers are 90 feet in diameter with a water depth of 12 feet. The clarifiers have a detention time of 4.5 hours and an overflow rate of 479 gallons per day per square foot.

The sludge settled at the bottom of secondary clarifier is pumped through through the return sludge pumps to circulate it back in the aeration tank. This active sludge helps to maintain in MLSS concentration in the aeration tank. This active sludge helps in to maintain in MLSS concentration in the aeration tank.

1.9-Objectives of the project

- To evaluate the performance of each unit of sewage treatment plant (STP) at Lalpani, Shimla.
- To assess the performance of UASB Reactor during cold (Psychrophilic) conditions with respect to COD removal.

1.10 Scope of the project

1.10.1 Project task

Sample collection from the Sewage Treatment Plant and performing the associated experiments and analyzing the different parameters.

1.10.2 Project cost

Cost of the different experiments, Transportation cost for the collection of the sample.

1.10.3 Project Deadline

Analyzing the data till May,2016.

1.10.4 Project Goal

To obtain all the objectives of the project.

1.11 Significance Of the project

To give an idea about different processes like filtration, activated sludge process and use of rotating biological contactors involved in primary and secondary treatment of waste water.

After acquiring all the parameters from the samples we will be able to analyse the efficiency & quality of the treatment plant & the treated water respectively. Difference caused by the use of UASB reactor in the quality of treated water

Chapter 2

LITERATURE REVIEW

2.1 INTRODUCTION

Since the mid 1990s, approximately 10 years after the installation of the first pilot scale up-flow anaerobic sludge bed (UASB) reactors for the treatment of municipal sewage in Cali Colombia (Lettinga et al. 1993; Schellinkhout et al. 1985) and Brazil (Vieira and Souza 1986), there has been a rapid increase in the number of large scale municipal UASB sewage treatment plants (STPs) installed in sub-tropical countries. In particular, Brazil and India have extensively adopted the UASB technology. For example, the authors were able to identify over 45 municipal UASB STPs in India with an average daily flow rate of 10,000 m3 or more (the largest STP was designed for a flow rate of 338,000 m3 ·d-1) while 15 such STPs were identified in Brazil. The main benefits associated with UASB based STPs compared to conventional aerobic treatment are a significant reduction in energy consumption and the potential for energy self sufficiency. Constraints include potential odour problems and difficulties associated with, including nutrient removal in the treatment scheme. . The rapid uptake of the municipal UASB technology was stimulated by the excellent performance of the Cali pilot plant and some other early municipal UASB plants such as Pedregal, Bucaramanga and Kanpur (van Haandel and Lettinga 1994; Schellinkhout and Collazos 1992; Schellinkhout and Osorio 1994; Draaijer et al. 1992 and 1994). The obtained maximum removal efficiencies for COD, BOD and SS reached 70-80%, 75-85%, and 70- 80%, respectively. Table 4.2 lists average values from the early plants obtained in Colombia, Brazil and India. The mentioned reduction in investment costs is attributed to the omission of electro-mechanical units, such as aerators, as well as the reduced need for volumetric unit capacity, owing to the so-called ‘shared functionality’ of the anaerobic treatment tank. In fact, a UASB reactor comprises 4 functional units 1.Primary clarifier: removal/entrapment of (non)biodegradable suspended solids from the influent. 2. Biological reactors (secondary treatment): Removal of biodegradable organic compounds by converting them into methane. 3. Secondary clarifier: clarifying the treated effluent in the settler zone at the top part of the UASB reactor. 4. Sludge digester: stabilisation (digestion) and improving the dewatering characteristics of the retained influent primary sludge

2.2 UASB (Upflow anaerobic sludge blanket) treatment

Singh et al., (1998) analysed the possibility and implications involved in starting and operating UASB reactors with a municipal wastewater at a lower temperature of 20ºC. The UASB reactor is a methanogenic (methane-producing) digester that evolved from the anaerobic clarigester. A similar but variant technology to UASB is the e expanded granular sludge bed (EGSB) digester. UASB uses anaerobic process whilst forming a blanket of granular sludge which suspends in the tank. Wastewater flows upwards through the blanket and is processed (degraded) by anaerobic microorganisms. The upward flow combined with the settling action ofgravity suspends the blanket with the aid of flocculants. The blanket begins to reach maturity at around three months. Small sludge granules begin to form whose surface area is covered in aggregations of bacteria. In the absence of any support matrix, the flow conditions create a selective environment in which only those microorganisms capable of attaching to each other survive and proliferate. Eventually the aggregates form into dense compact bio-films referred to as "granules".

UASB uses an anaerobic process whilst forming a blanket of granular sludge which suspends in the tank. Wastewater flows upwards through the blanket and is processed (degraded) by the anaerobic microorganisms. The upward flow combined with the settling action of gravity suspends the blanket with the aid of flocculants. The blanket begins to reach maturity at around three months. Small sludge granules begin to form whose surface area is covered in aggregations of bacteria. In the absence of any support matrix, the flow conditions create a s

Biogas with a high concentration of methane is produced as a by-product, and this may be captured and used as an energy source, to generate electricity for export and to cover its own running power. The technology needs constant monitoring when put into use to ensure that the sludge blanket is maintained, and not washed out (thereby losing the effect). The heat produced as a by-product of electricity generation can be reused to heat the digestion tanks.

The blanketing of the sludge enables a dual solid and hydraulic (liquid) retention time in the digesters. Solids requiring a high degree of digestion can remain in the reactors for periods up to 90 days.[3] Sugars dissolved in the liquid waste stream can be converted into gas quickly in the liquid phase which can exit the system in less than a day.

UASB reactors are typically suited to dilute waste water streams (3% TSS with particle size >0.75mm).

2.3 REACTOR SIZE AND SHAPE

Most UASB STPs are built using the modular design. The volume of individual UASB modules generally varies between 1500 to 3000 m^3, even though a UASB module of nearly 8000 m^3 has been constructed in India (Sato et al. 2006).

In general, UASB reactors have a square or rectangular design, both in the cross sectional area and the superficial area

2.4 ANAEROBIC WASTEWATER TREATMENT

The anaerobic process is in many ways ideal for waste treatment. It has several significant advantages over other available methods and is almost certainly assured of increased usage in the future. Anaerobic treatment is presently employed at most municipal treatment plants, and is responsible for the major portion of waste stabilization that occurs there. However, in spite of the present significance and large future potential of this process, it has not generally enjoyed the favourable reputation it truly deserves. The primary obstacle has been a lack of fundamental understanding of the process, required both to explain and control the occasional upsets which may occur, and to extend successfully this process to the treatment of a wide variety of industrial wastes. An increasing realization of the potentials of anaerobic treatment is evident from the reporting each year of larger numbers of research investigations on this process. Already, significant advances have been made extending the process so it can be used successfully on many more organic wastes. Advantages The advantages of anaerobic treatment can best be indicated by comparing this process with aerobic treatment. In aerobic treatment, as represented by the activated sludge and trickling filter processes, the waste is mixed with large quantities of microorganisms and air. Microorganisms use the organic waste for food, and use the oxygen in the air to burn a portion of this food to carbon dioxide and water for energy. Since these organisms obtain much energy from this oxidation, their growth is rapid and a large portion of the organic waste is converted into new cells. The PART ONE I Chemistry and Microbiology portion converted to cells is not actually stabilized, but 'is simply engaged in form. Although these cells can be removed from the waste stream, the biological sludge they produce still presents a significant disposal problem. In anaerobic treatment, the waste is also mixed with large quantities of microorganisms, but here, air is excluded. Under these conditions, Bacteria grow which are capable of converting the organic waste to carbon dioxide and methane gas. Unlike aerobic oxidation, the anaerobic conversion to methane gas yields relatively little energy to the microorganisms. Thus, their rate of growth is slow and only a small portion of the waste is converted to new cells, the major portion of the degradable waste being converted to methane gas.

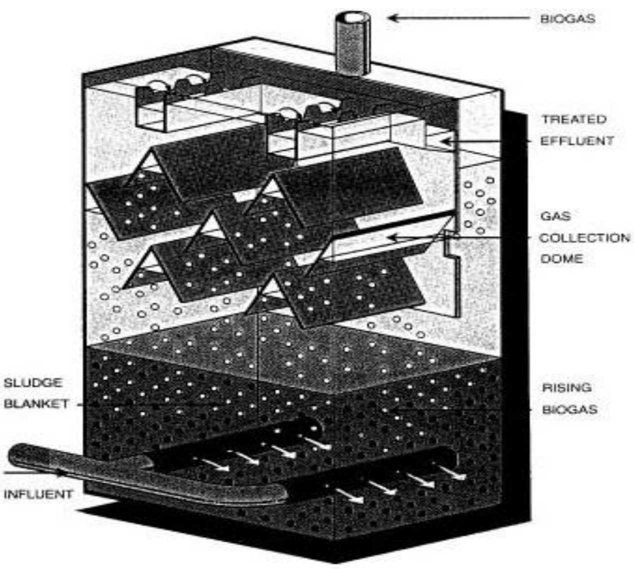

Figure 2.1 Sectional View of UASB Reactor

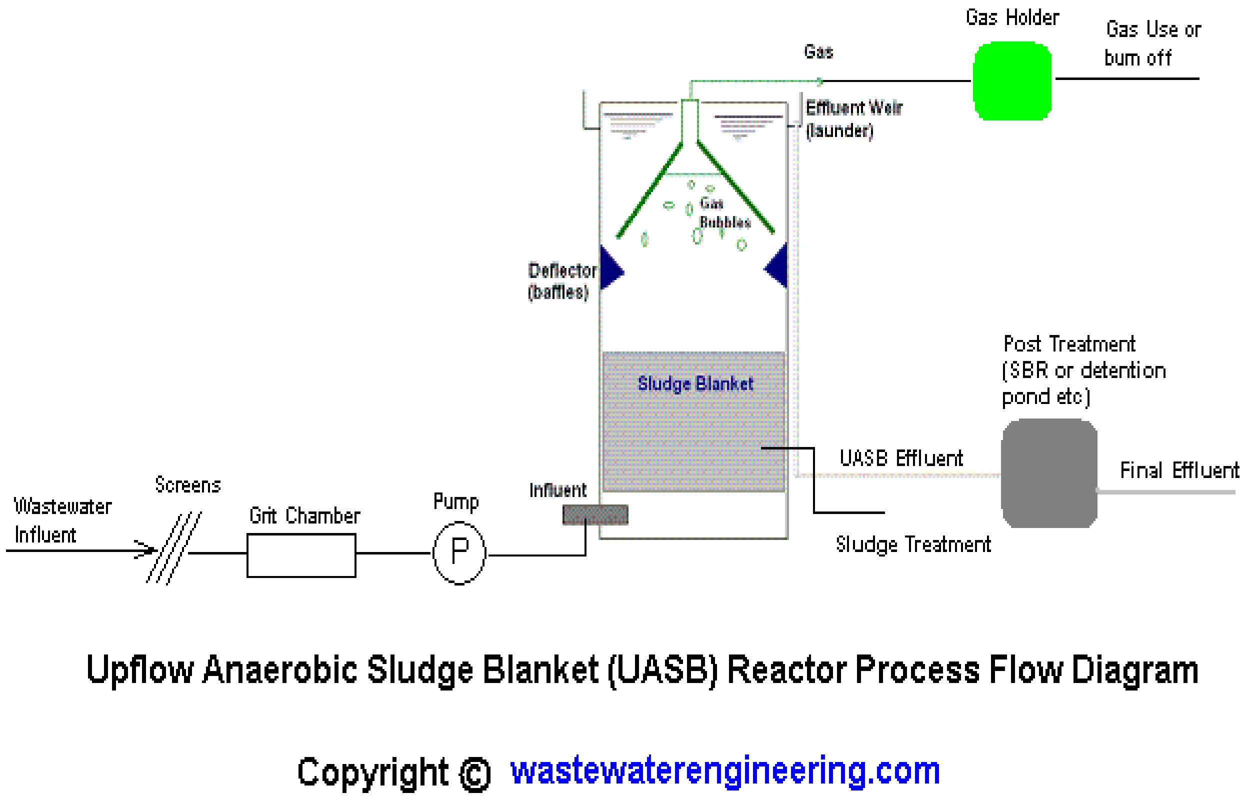

Figure 2.2 UASB reactor process flow diagram.

CHAPTER 3

MATERIALS AND METHODS

After fixing the objectives of the study, an experimental programme was conducted.

3.1 Experimental Materials and Methods for STP Studies

An influent and effluent sample of different units of sewage treatment plant was collected once in a month to perform the experiments, to calculate various parameters.

3.1.1Analytical Procedures

Parameters considered for study of different units of STP and experiments were analyzed as per Standard Methods for the Examination of Wastewater. The analytical techniques adopted are presented in Table 3.1. The frequency of analysis of various parameters in full scale reactor studies is given in Table 3.2.

Table 3.1: Analytical Techniques adopted for the determination of Various Parameters

S.No.	Parameter	Method
1.	pH	Digital pH meter
2.	BOD	5 Day BOD Test
3.	COD	Open reflux
4.	Alkalinity	Titration method
5.	TS	Oven dry at 103-105ºC
6.	VS	Ignited at 550ºC

Table 3.2: Frequency of Analysis for Various Parameters

S.No.	Paramheter	Frequency of analysis
1.	pH, Alkalinity	once a month
2.	BOD,COD	once a month
3.	TS,VS	once a month

3.2pH Determination

pH of wastewater is determined by digital pH meter as shown in Figure 3.1.

Figure 3.1: Digital pH meter

3.3Alkalinity Determination

Alkalinity of wastewater is defined as its acid-neutralizing capacity. Alkalinity parameter is used to control the various processes of wastewater. It is determined by Titration method. The set-up of titration method is shown in Figure 3.2.

Apparatus: Pipettes, Flasks and Burettes.

Reagents: Sodium sulphuric acid or hydrochloric (0.1N).

Indicators: Methyl Orange and Phenolphthalein (Figure: 3.3).

Figure 3.2: Alkalinity test set-up   **Figure 3.3:** Indicators and Reagent

3.4 Biological Oxygen Demand Determination

Biological oxygen demand determines the relative oxygen requirements of wastewaters. The test measures the amount of oxygen consumed by microorganisms during a specific incubation period for biological degradation of organic matter. It is determined by 5-Day BOD test in which diluted wastewater is incubated at 20˚C temperature for 5 days. Initial DO and final DO is measured with DO probe. BOD_5 is determined by subtracting initial and final DO and multiply by dilution factor.

Apparatus: Incubation bottles (300mL) (Figure: 3.4), Digital DO Meter (Figure: 3.5), Incubator (Figure: 3.6).


Figure 3.4: BOD Bottles **Figure 3.5:** Digital DO meter **Figure 3.6:** Incubator

3.5 Chemical Oxygen Demand Determination

The Chemical oxygen demand measures the amount of pollutant present in wastewater. It determines the amount of chemical oxygen consumed by microorganisms. COD is determined by Closed Reflux, Titrimetric Method.

Apparatus: Digestion vessels, Digester (Figure: 3.7)

Reagents: Standard potassium dichromate solution (Figure: 3.8), Sulphuric acid reagent, Standard Ferrous ammonium sulphate (FAS) (0.1N).

Indicator: Ferroin indicator solution (Figure 3.9).

Figure 3.7: Digester

Figure 3.8: Standard potassium dichromate

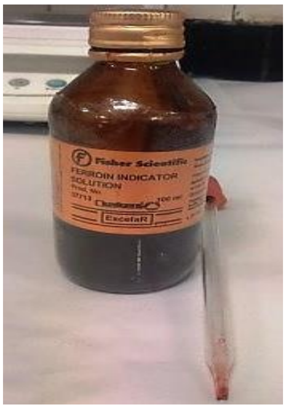

Figure 3.9: Ferroin

3.6 Solids Determination

Solids are present in two forms in wastewater, i.e., in suspended form and in dissolved form. Solids affect effluent quality in many ways. Total solids are the material residue left in the vessel after evaporation of the sample and drying in oven at 103˚C - 105˚C temperature. Total solids include suspended solids which are defined as the portion of total solids retained by filter paper and dissolved solids which pass through the filter paper.

3.6.1Total Solids

Sample is evaporated and dried to constant weight in an oven at 103˚C - 105˚C temperature. The increase in weight of dish represents the total solids.

Apparatus: Oven (Figure: 3.10), Evaporating dishes, Desiccator (Figure: 3.11), Analytical balance (Figure: 3.12) and Graduated cylinder.

Figure 3.10: Oven

Figure 3.11: Desiccator

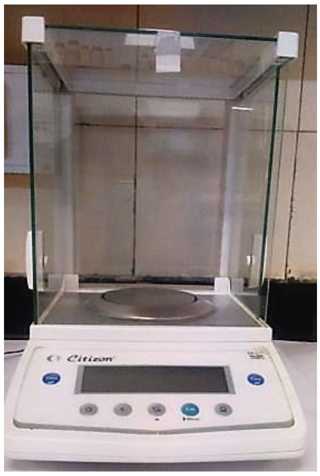

Figure 3.12: Analytical Balance

3.6.2 Suspended Solids

The Sample is filtered through filter paper and residue retained on the filter is dried to a constant weight at 103˚C - 105˚C temperature. The increase in weight of filter paper determines the suspended solids.

Apparatus: Oven, Filter paper, Evaporating dishes, Desiccator, Analytical balance and Graduated cylinder.

3.6.3 Dissolved Solids

The filtrate left during suspended solids filtration is evaporated in an oven to a constant weight. The increase in dish weight represents the dissolved solids.

Chapter 4

RESULTS

Sample 1:

Time of Sampling: 12:00 pm **Date: 31/10/2015**

Temperature at Site: 20.5˚C

Table 4.1 Experimental results obtained for the sample, sampled on the date 31/10/2015

S. No.	Parameters	Units	Inlet Screen	Outlet Screen	UASB inlet	UASB outlet	Aeration outlet	Clarifier outlet
1	pH		7.45	7.35	7.3	7.25	7.2	7.1
2	Alkalinity	mg/l	298	306	305	286	399	365
3	Suspended Solids	mg/l	2658	2543	1987	1120	3245	105
4	Total Dissolved Solids	mg/l	750	658	613	678	509	676
5	BOD	mg/l	309	358	285	188	365	84
6 .	COD	mg/l	1121	852	437	325	564	161

Sample 2:

Time of Sampling: 12:15 pm **Date: 17/11/2015**

Temperature at Site: 19.5˚C

Table 4.2 Experimental results obtained for the sample , sampled on the date 17/11/2015

S. No.	Parameters	Units	UASB inlet	UASB outlet
1	pH		7.5	7.3
2	Alkalinity	mg/l	308.5	458
3	Total Dissolved Solids	mg/l	530.9	568
4	Suspended Solids	mg/l	34	42
5	Total Solids	mg/l	569.2	610
6	BOD	mg/l	202.81	197.91
7	COD	mg/l	672	384

Sample 3:

Time of Sampling: 12:25 pm **Date: 23/11/2015**

Temperature at Site: 21˚C

Table 4.3 Experimental results obtained for the sample , sampled on the date 23/11/2015

S. No.	Parameters	Units	Inlet Screen	Outlet Screen	UASB inlet	UASB outlet	Aeration outlet	Clarifier outlet
1	pH		8.2	7.6	7.8	7.6	7.3	7.4
2	Alkalinity	mg/l	281	295	382	400	399	309
3	Total Dissolved Solids	mg/l	760	650	611	668	520	653
4	Suspended Solids	mg/l	2746	2556	1863	1150	3810	165
5	Total Solids	mg/l	3506	3206	2474	1818	4330	818
6	BOD	mg/l	305	340	286.2	184.8	355	96
7	COD	mg/l	864	751	448	320	612	158

Sample 4:

Time of Sampling: 12:00 pm **Date: 18/1/2016**

Temperature at site: 15˚C

Table 4.4 Experimental results obtained for the sample, sampled on the date 18/1/2016

S. No.	Parameters	Units	Inlet Screen	Outlet Screen	UASB inlet	UASB outlet	Aeration outlet	Clarifier outlet
1	pH		7.45	7.35	7.3	7.25	7.2	7.1
2	Alkalinity	mg/l	306	325	319	286	409	385
3	Suspended Solids	mg/l	3790	3560	902	454	2945	88
4	Total Dissolved Solids	mg/l	650	596	570	605	500	660
5	BOD	mg/l	300	360	285	228	250	98
6	COD	mg/l	1331	991	536	428	366	254

Sample 5:

Time of Sampling: 12:15 pm **Date: 11/02/2016**

Temperature at Site: 16˚C

Table 4.5 Experimental results obtained for the sample, sampled on the date 11/02/2016

S. No.	Parameters	Units	Inlet Screen	Outlet Screen	UASB inlet	UASB outlet	Aeration outlet	Clarifier outlet
1	pH		7.5	7.4	7.3	7.2	7.2	7.2
2	Alkalinity	mg/l	328	315	308.5	458	470	396
3	Total Dissolved Solids	mg/l	608	596	586	607	560	656
4	Suspended Solids	mg/l	4563	3658	796	722	2506	109
5	BOD	mg/l	305	375	437	424	456	105
6	COD	mg/l	956	832	768	672	412	226

Sample 6:

Time of Sampling: 12:25 pm **Date: 01/03/2016**

Temperature at Site: 14˚C

Table 4.6 Experimental results obtained for the sample, sampled on the date 01/03/2016

S. No.	Parameters	Units	UASB inlet	UASB outlet
1	pH		7.5	7.2
2	Alkalinity	mg/l	350	368
3	Total Dissolved Solids	mg/l	554	603
4	Suspended Solids	mg/l	1009	186
5	Total Solids	mg/l		
6	BOD	mg/l	401	221
7	COD	mg/l	576	480

Table 4.7: Average removal efficiency of each treatment unit for different parameters.

S.no	Treatment unit	pH	Alkalinity	Dissolved solids	Suspended Solids	BOD	COD
1.	Inlet screen	2.833743	-2.47813	9.255423	11.83174	-17.571	18.89764
2.	Grit Chamber	0.020079	-6.31377	4.719794	29.13837	10.12865	35.66516
3.	UASB rector	1.88	20.92	-7.096	40.96	27.426	24.39
4.	Aeration tank	1.33167	-21.2219	18.04508	-109.029	-50.8612	-27.903
5.	Clarifier	0.351979	13.17259	-26.8823	31.62758	71.92943	55.34591

Graphs:

1. pH

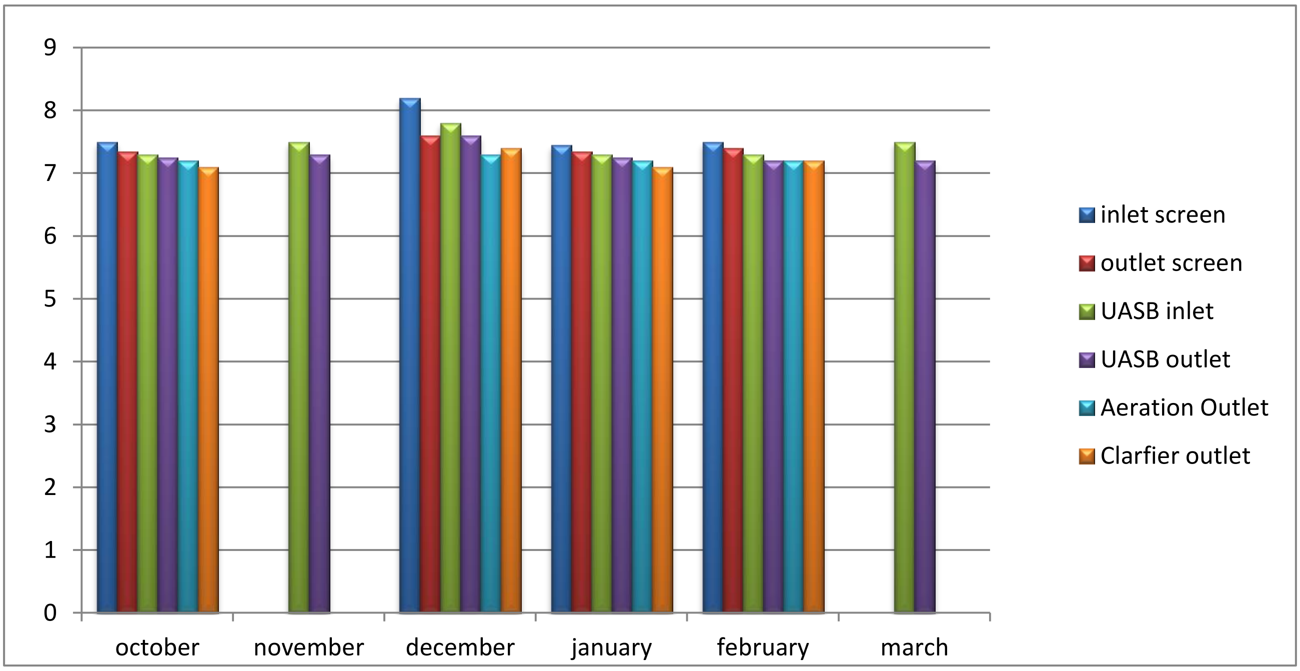

Figure4.1: pH values of the sample for different month

2. Alkalinity

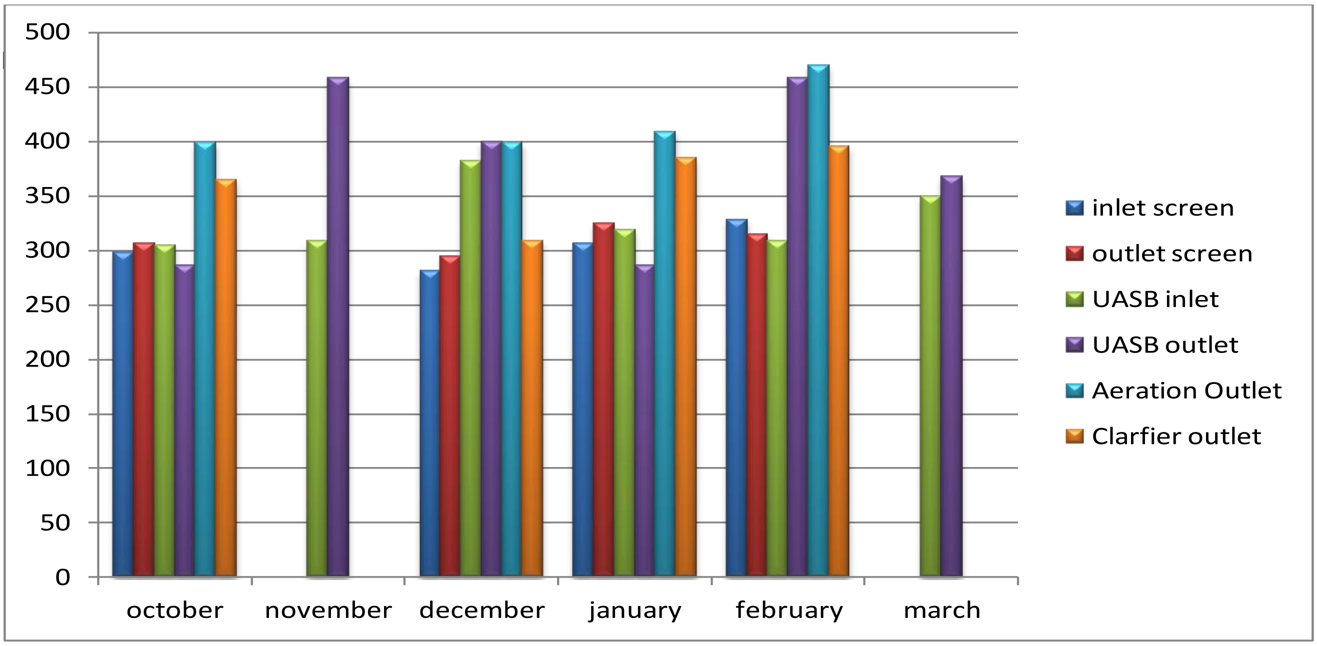

Figure 4.2: Alkalinity values of the different sample for different month

3. Suspended solids

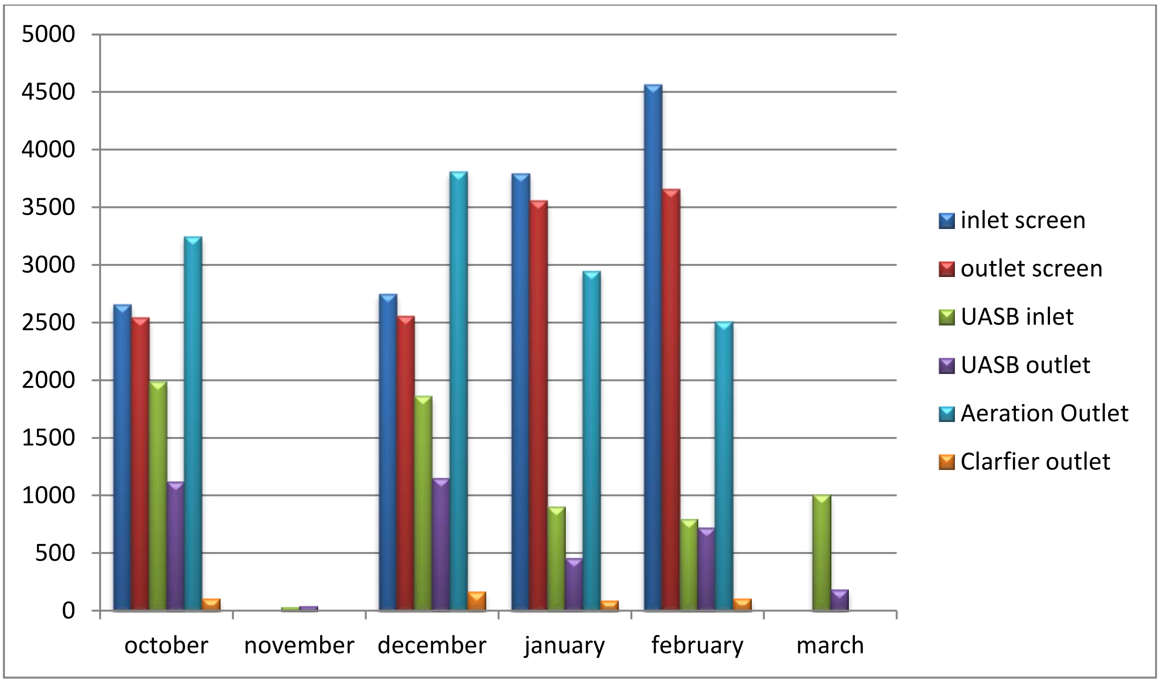

Figure4.3: suspended solids values of the different sample for different month.

4. Total Dissolved solids

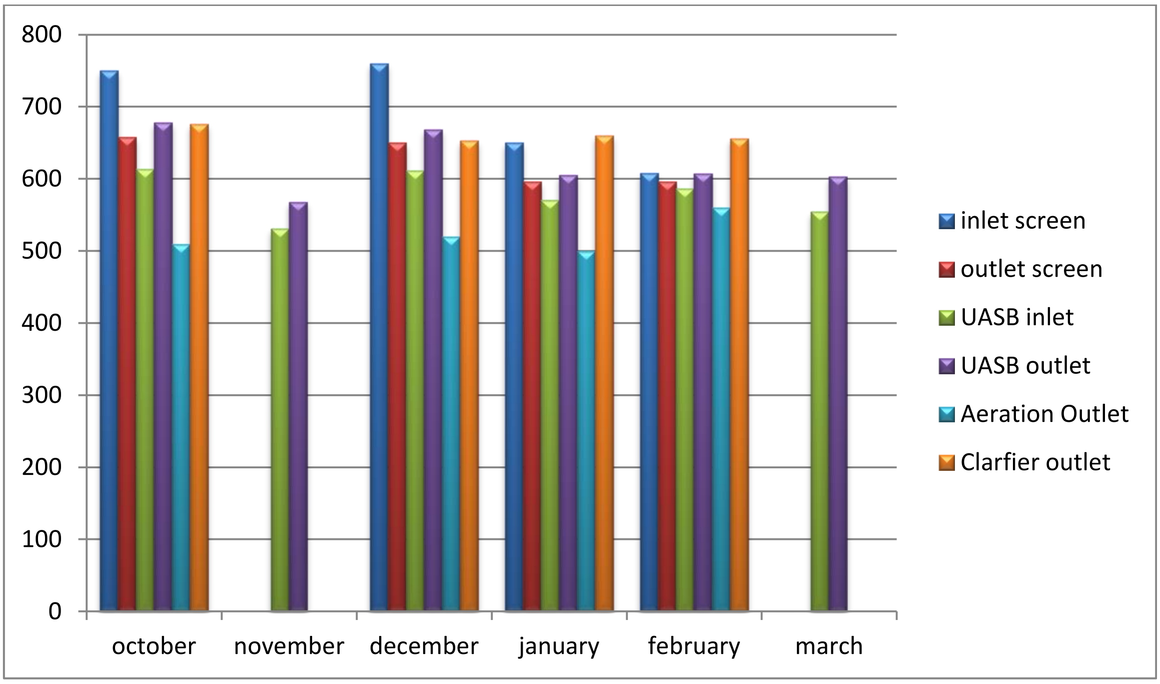

Figure 4.4: dissolved solids values of the different sample for different month

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5.BOD

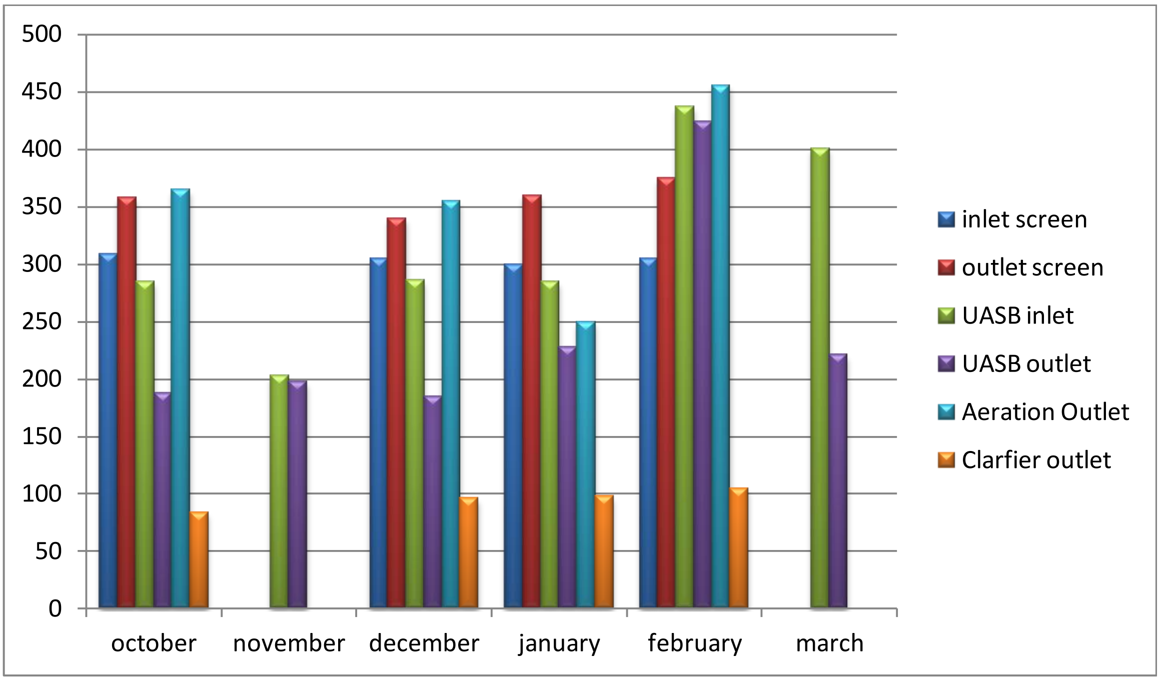

Figure 4.5: BOD values of the different sample for different month

6.COD

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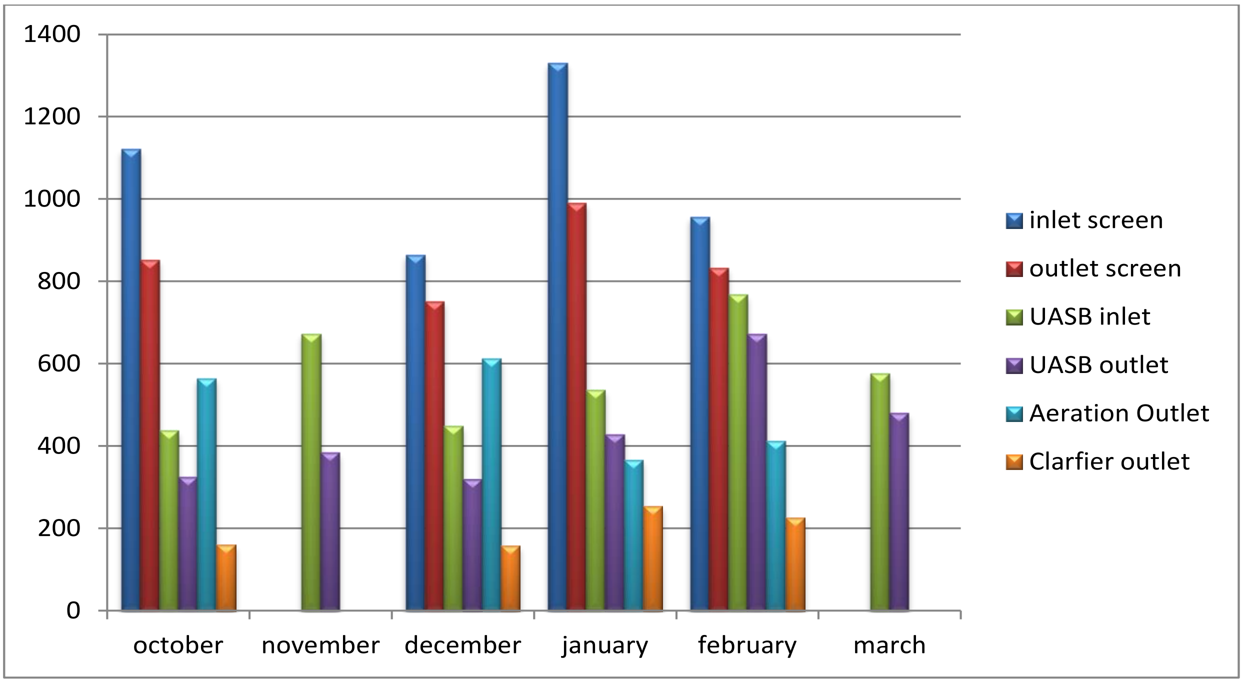

Figure 4.6: COD values of the different sample for different month

After analysing the different values of the samples from each treatment unit of the Lalpani STP

- **Temperature:**
  The temperature of Shimla is comparatively less than other cities so biological reactions are relatively slow. Hence sewage treatment is comparatively difficult.
- **pH:**
  The effluent pH of UASB should be between 7-7.5 for the successive post-treatment in activated sludge process. The obtained results from effluent of UASB were in conformity with the existing guidelines for proper functioning of the STP.
- **BOD:**
  The BOD of the final effluent from the STP varied from 84 – 105 mg/L indicating presence of dissolved and/or suspended organic matter. As per CPCB guidelines the effluent having a BOD of 6-99 mg/l indicates somewhat polluted, usually indicates organic matter is present & bacteria's are decomposing these waste.
- **COD:**
  The COD of the final effluent from STP was ≤ 250 mg/L. According to government regulations, COD value between 200-1000 mg/l must be reached before wastewater and industrial water can be returned to the environment. The obtained results were within the range.
- **BOD/COD:** Average BOD/COD ratio of the effluent was found to be 0.494 , which suggests that there is some non -biodegradable organic matter.

- **Alkalinity:**
  The alkalinity of the final effluent varied between 330-400 mg/L. The effluent is safe and enough to maintain pH between 7-8.

- **Suspended Solids:**
  The suspended solids in the final effluent varied from 88-165 mg/l. As per the government norms for the treated water to appear dirty its value of suspended solids should be greater than 150 mg/l and from the obtained values it appears that the water was mostly in range of the limits.

- **Dissolved solids:**
  As per the government norms, the value of dissolved solids should be less than 700 mg/l and the obtained values were in range.

Discussion Of The Results

- Inlet screen is in proper order and is working properly. The larger solid particles are sieved and trap the floating material. Average efficiency of removal of Suspended solids is 11.83%.

- The grit channel is designed properly for a maximum velocity of 0.3 meter/second. Cleaning and maintenance is done regularly .its efficiency for different parameters as shown in table 4.7.

- Out of 5 aeration tanks, 3 are in working condition and 2 are standby. Its efficiency decreases at lower temperature. Irregularity in electricity supply also decreases its efficiency.
- Size of the sludge drying bed is small.
- Some of the clarifier and clari- flocculator are not in use.
- Sludge well is not working because it is damaged due to landslide.

- The fall in the temperature during extreme winter season reduces the efficiency of UASB process and extended Aeration process. Hence during this period, the effluent from secondary clarifier is further treated by coagulation and flocculation of suspended particles. Alum is added as a coagulant in the wastewater for coagulation purpose in flash mixer.

- The results indicate that the temperature of sewage in Lalpani STP is generally 15-25 degree Celsius during October to March. Hence, psychrophilic or mesosphilic conditions are found in lalpani STP. Therefore, apart from treatment of sewage in UASB, we can also use physicochemical process to treat this sewage.

- The COD removal efficiency from November to March was 13% - 42% for UASB. The experimental results show that temperature has significant influence on COD removal. At high temperature, the COD removal rates also increases and this was found to be independent of the influent concentrations. The maximum COD removal was 42% for UASB, which corresponds to an influent COD of 550 mg/L at 18ºC temperature and the minimum COD removal rate was 13% corresponding to an influent COD of 768 mg/L at 16ºC.

- The average BOD concentrations in the influent and effluent of the UASB reactor were (365 mg/L ± 76) and (275 mg/L ± 96) respectively.

- The BOD removal efficiency was 3% to 36% for UASB under psychrophilic conditions. The maximum BOD removal efficiency of UASB was 36% which corresponds to an influent BOD of 286 mg/L at 18ºC.

- Low removal efficiency under psychrophilic conditions may be due to incomplete sludge granulation and inadequate volume of settled solids and biomass, therefore, reduced the methanogenic activity of sludge microorganisms and slow down the hydrolysis (Hulshoff Pol, 1989; Lehtomaki et al., 2008; Lettinga et al., 2008; Van der Last and Lettinga, 1992). The BOD removal and the quality of the effluent depend on the retention time and temperature.

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Chapter 5

CONCLUSIONS

Performance evaluation of 19.35 MLD STP at Lalpani in Shimla was carried out during the months October'15 – March'16. Physico-chemical tests were conducted for inlet and outlet of each unit i.e., Screens, grit channel, UASB, Aeration Tank, clarifier. Grab samples were collected once in a month.

Based on the observations within the plant and physico-chemical analysis on the samples obtained, the following conclusions are drawn:

- There are many missing links where branch sewer lines of the old sewer network have not been connected to the newly laid sewer network
- In areas served by the sewerage system, many households discharge their wastewater in septic tanks/soak pits
- In STP at Lalpani, Upflow Anaerobic Sludge Blanket (UASB) (mainly for gas extraction) has been adopted followed by extended aeration.
- Due to influent quantity of wastewater into the Lalpani STP, some of the clarifier and clari-flocculator is not in use
- One of the UASB is not in working condition.
- Frequent low voltage of electricity, generator facility is not available during the electricity.
- Sludge well structure is damaged due to landslide.
- Size of the sludge drying bed is small.
- Centrifuge filter press is not in use.
- The performance of the full scale reactor under low temperature conditions was not very accurate. The sewage treatment plant lacks proper operation and maintenance of UASB reactor.
- Instability in performance of UASB reactor in terms of removal of solids was due to improper desludging, variations in influent characteristics, incomplete consumption of dissolved organic matter and poor operation and maintenance.
- Maximum 42% of COD removal was obtained in full scale UASB reactor whereas according to some authors 60-80% of COD reduction can be achieved under psychrophilic conditions. Similarly, 36% of BOD removal was observed in UASB effluent. Low removal efficiency of the reactor was due to low temperature, which limits the process of hydrolysis and insufficient amount of active settled biomass which reduces the methanogenic activity of sludge.

- Lower sewage temperature would tend to increase viscocity and solubility of oxygen and decrese setting rate,oxygen microbial growth and the rate of all biological process

.the effect of temperature is a major factor affecting all physicochemical and biological (aerobic or anaerobic) processes.

- Higher temperature of sewage in summer generally leads to an increase in metabolic activity. In activated sludge process all the biochemical reaction rates such as organic substrate utilisation , production of biomass cells (MLVSS) maintenance energy requirements , oxygen utilisation , auto oxidation of MLSS (endogenous respiration) , BOD removal efficiency, nitrification etc, follow Arrhenius relationship over the temperature range 5-25˚C. Consequently, a decrease in temperature during winter period would tend to have an adverse effect on the above biochemical transformation.

Chapter 6

SCOPE FOR FUTURE WORK

In the planning of any city sanitation plan is the most important according to the point of view of public health and other parameters for the beautification of the city so the sanitation planning plays an important role in planning of city and its scope is vast because India is a developing country and more and more small phases are developed which use this whole theory and parameters to develope the new phases in the city.

Our project is mainly based on to collect samples from the different treatment units of the Lalpani Sewage Treatment Plant.

In this project we have visited the Lalpani treatment plant and collected samples from each treatment unit to figure out the performance of the plant and other parameters of the plant to evaluate the performance of the sewage treatment facility in shimla through analysis of various Physical and Chemical characteristics of different treatment units and their treatment efficiencies in relation to design and operational parameters.

Since the effluent BOD from STP doesnot confirm to the regulatory standards, either enhancement of the performance of existing activated sludge process or further post treatment options has to be evaluated.

Proper Sludge management measures need to be evaluated.

Drawbacks in operation and maintenance of STP need to be further studied and suitable measures have to be evaluated.

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Appendix

Appendix (A)

GENERAL STANDARDS FOR DISCHARGE OF ENVIRONMENTAL POLLUTANTS PART-A : EFFLUENTS

S. No.	Parameter	Standards			
		Inland surface water	Public Sewers	Land for irrigation	Marine coastal areas
1	2	3			
		(a)	(b)	(c)	(d)
1.	Colour and odour	See 6 of Annexure-I	--	See 6 of Annexure -I	See 6 of Annexure-I
2.	Suspended solids mg/l, Max.	100	600	200	(a) For process waste water-100 (b) For cooling water effluent 10 percent above total suspended matter of influent.
3.	Particulate size of suspended solids	Shall pass 850 micron IS Sieve	--	--	(a) Floatable solids, max. 3 mm. (b) Settleable solids, max. 850 microns.
[2]4.	***	*	--	***	--
5.	pH Value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
6.	Temperature	shall not exceed 5^oC above the receiving water temperature	--	--	shall not exceed 5^oC above the receiving water temperature

[1] Schedule VI inserted by Rule 2(d) of the Environment (Protection) Second Amendment Rules, 1993 notified vide G.S.R. 422(E) dated 19.05.1993, published in the Gazette No. 174 dated 19.05.1993.

[2] Omitted by Rule 2(d)(i) of the Environment (Protection) Third Amendment Rules, 1993 vide Notification No.G.S.R.801(E), dated 31.12.1993.

S. No.	Parameter	Standards			
		Inland surface water	Public Sewers	Land for irrigation	Marine coastal areas
1	2	3			
		(a)	(b)	(c)	(d)
7.	Oil and grease mg/l Max.	10	20	10	20
8.	Total residual chlorin mg/l Max.	1.0	--	--	1.0
9.	Ammonical nitrogen (as N), mg/l Max.	50	50	--	50
10.	Total Kjeldahl Nitrogen (as NH_3) mg/l, Max.	100	--	--	100
11.	Free ammonia (as NH_3) mg/l, Max.	5.0	--	--	5.0
12.	Biochemical Oxygen demand [1][3 days at 27°C] mg/l max.	30	350	100	100
13.	Chemical Oxygen Demand, mg/l, max.	250	--	--	250
14.	Arsenic (as As), mg/l, max.	0.2	0.2	0.2	0.2
15.	Mercury (as Hg), mg/l, Max.	0.01	0.01	--	0.01
16.	Lead (as Pb) mg/l, Max.	0.1	1.0	--	2.0
17.	Cadmium (as Cd) mg/l, Max.	2.0	1.0	--	2.0
18.	Hexavalent Chromium (as Cr+6), mg/l max.	0.1	2.0	--	1.0

[1] Substituted by Rule2 of the Environment (Protection) Amendment Rules, 1996 notified by G.S.R.176, dated 2.4.1996 may be read as BOD (3 days at 27°C) wherever BOD 5 days 20°C occurred.

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Appendix (B)

BIS (ISI) Standards for Discharge of sewage and Industria Effluents in Surface and Public Sewers.

Table 3.16 BIS (ISI) Standards for Discharge of Sewage and Industria' Effluents in Surface Water Sources* and Public Sewers

Sr. No. (1)	Characteristic of the Effluent (2)	Tolerance limit for Sewage Effluent discharged into Surface Water Sources, as per IS 4764–1973 (3)	Tolerance Limit for Industrial effluents discharged into	
			Inland surface waters, as per IS 1490–1974 (4)	Public sewers as per IS 3306–1974 (5)
1.	BOD_5	20 mg/l	30 mg/l	500** mg/l
2.	COD	–	250 mg/l	–
3.	pH value	–	5.5 to 9.0	5.5 to 9.0
4.	Total Suspended Solids (TSS)	30 mg/l	100 mg/l	600 mg/l
5.	Temperature	–	40°C	45°C
6.	Oil and grease	–	10 mg/l	100 mg/l
7.	Phenolic compounds (as Phenol)	–	1 mg/l	5 mg/l
8.	Cyanides (as CN)	–	0.2 mg/l	2 mg/l
9.	Sulphides (as S)	–	2 mg/l	–
10.	Fluorides (as F)	–	2 mg/l	–
11.	Total residual chlorine	–	1 mg/l	–
12.	Insecticides	–	Zero	–
13.	Arsenic (as As)	–	0.2 mg/l	–
14.	Cadmium (as Cd)	–	2 mg/l	–
15.	Chromium, hexavalent (as Cr)	–	0.1 mg/l	2 mg/l
16.	Copper	–	3 mg/l	3 mg/l
17.	Lead	–	0.1 mg/l	1 mg/l
18.	Mercury	–	0.01 mg/l	–
19.	Nickel	–	3 mg/l	2 mg/l
20.	Selenium	–	0.05 mg/l	–
21.	Zinc	–	5 mg/l	15 mg/l
22.	Chlorides (as Cl)	–	–	600 mg/l
23.	Sodium	–	–	60%
24.	Ammoniacal nitrogen (as N)	–	50 mg/l	50 mg/l
25.	Radioactive meterials (i) α–emitters	–	10^{-7} µC/ml (micro curie/ml)	–
	(ii) β–emitters		10^{-6} µC/ml	–