Comparison of Performance of Sewage Treatment Facilities in Shimla

Project Report submitted in partial fulfilment of the degree of

Bachelor of Technology

In

Civil Engineering

Under the Supervision of

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By

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CERTIFICATE

This is to certify that the project entitled " **Comparison of Performance of Sewage Treatment Facilities in Shimla**" submitted by "**Rameshwar Dubey and Vanika Bajaj**" in partial fulfilments for the requirements of the award of B-Tech degree in Civil Engineering at Jaypee University of Information Technology, Waknaghat is an authentic work carried out by them under my supervision and guidance .

To the best of my knowledge, the matter embodied in the project report has not been submitted any other University or institute for the award of any Degree or Diploma.

Date-

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Abstract

Effective sewage treatment is crucial for healthy living. The comparison of various sewage treatment facilities of sewage treatment plants in Shimla draws a difference between the operational and design parameters for pre-monsoon, monsoon and post-monsoon season. **Phase 1** included the comparison of three sewage treatment plants namely Lalpani, Sanjauli and Dhalli. **Phase 2** includes the rest three plants situated in Summer Hill, North Disposal and Snowdon. The objective of this project was to establish the experimental and operational parameters of the plants and relate it with other plants. Influent and effluent parameters used for this study include pH, settleable solids, suspended solids (total and volatile), temperature (influent and effluent) BOD, COD, DO and chloride content. The study of various treatment processes in waste water treatment shows that temperature and pH are the important factors affecting efficiency of flocculation and settling properties. This study was performed to determine the effects of pH and temperature on settling of the flocs in these processes. Psychrophilic anaerobic process is an attractive option for sewage treated at moderate and low temperature. Anaerobic wastewater treatment differs from conventional aerobic treatment. The absence of oxygen leads to controlled conversion of complex organic pollutions, mainly to carbon dioxide and methane. Anaerobic treatment has favourable effects like removal of higher organic loading, low sludge production, high pathogen removal, biogas gas production and low energy consumption. Psychrophilic anaerobic treatment can be an attractive option to conventional anaerobic digestion for municipal sewage and industrial wastewaters that are discharged at moderate to low temperature. The effluent quality of a sewage treatment plant using activated sludge process and finally secondary treatment depends on the flocculation efficiency and settling of the flocs. The two main reasons behind the importance of using UASB are, generation of large volumes of low-strength wastewaters, which are often disposed untreated due to high costs, and the potential of stabilizing the organic wastes by producing valuable energy as by product. The report discusses possibilities of municipal sewage treatment in UASB and Extended aeration process provided in Shimla.

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 Location

Shimla town is geographically situated on latitude thirty Degree and six minutes north ,longitude seventy seven Degree and eleven minute with respect to Latitude-Longitude Co-ordinate system.

1.3 Topography

The town is situated at an altitude of 2026 metres above Mean Sea Level and has highly undulating terrain with sharp drops as well as rise in ground levels**.**

1.4 Climate

The winter temperature in Shimla varies from 18^0C to -4^0C and in summer from 32^0C to 6^0C. The city receives the monsoon during the months of July to September with annual average rainfall of about 150mm.

1.5 Existing Sewage Treatment and Disposal Facilities

Sewerage system is as important as the water supply system and forms an integral part of environmental character of a city. Sewage treatment facilities of Shimla have been substantially improved over the years to cater to future demand. Shimla Municipal Area has a well-laid underground sewerage system and is maintained by Irrigation and Public Health (I&PH). The first sewerage network was laid in the year 1880 to serve a population of 18000. In 2005, the Shimla Municipal Corporation (SMC) undertook an augmentation of the sewerage network by laying new lines and constructed 6 new sewage treatment plants with an installed capacity of 35.63 Mld at Lalpani, Summer hill, North disposal, Dhalli, Sanjauli-Maliyana and Snowdon. Figure 1 shows the sewerage system of Shimla.

1.6 Policy, Regulatory and Institutional Framework

Irrigation and Public Health (I&PH) and SMC are responsible for provision of sewerage system and related services in Shimla Planning Area (SPA). I&PH is involved in planning, construction, operation & maintenance of sewerage collection, treatment and disposal system.

1.7 Zone-wise proposal details

1.7.1 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 up to 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. Decentralised waste water treatment(DEWATS) can be incorporated as an extension of the already existing septic tanks providing primary treatment of the sewage.

1.7.2 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 Sanjauli 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 root zone treatment systems/SBT (Soil biotechnology) 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.

1.7.3 Sanjauli Malyana Zone

Some areas of Sanjouli Malyana (sub-zone – II) zone i.e. lower Panthaghati, 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.

1.7.4 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.

1.7.5 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.

1.7.6 Sewage Generation

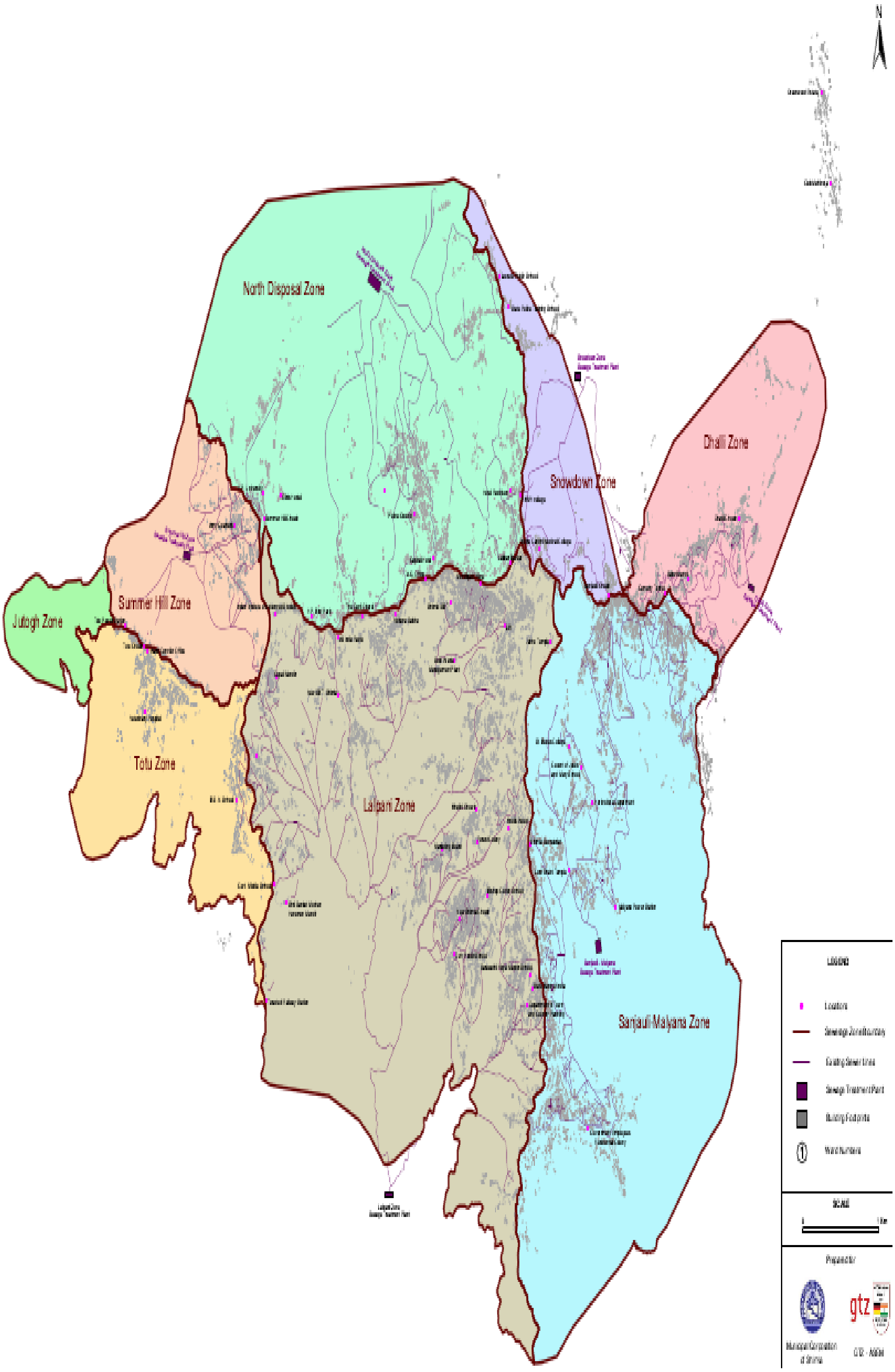
The City generates approximately 90 MT of solid waste per day. The collection efficiency is in the range of 70-80%. This translates into 65-70 MT of waste being collected and transported to the waste processing site. Around 10MT of waste is recycled (recyclables – plastic, paper) and there manning waste gets piled up for collection and some part of it finds its way into natural drains, storm water drains, hill slopes and open areas. At present, 68% of the population has access to central sewerage system for wastewater disposal (referred to as offsite system), 29% of the total population discharge their wastewater into septic tanks and / or soak pits (referred to as onsite system), and 3% discharge their wastewater directly into open drains .As per the latest information, MC Shimla has provided sewerage connections to 12,131 properties against a total of 40,000 registered properties within the MC Shimla limits.

TABLE 1.1 City Level Infrastructure demand as per water and sewerage generation

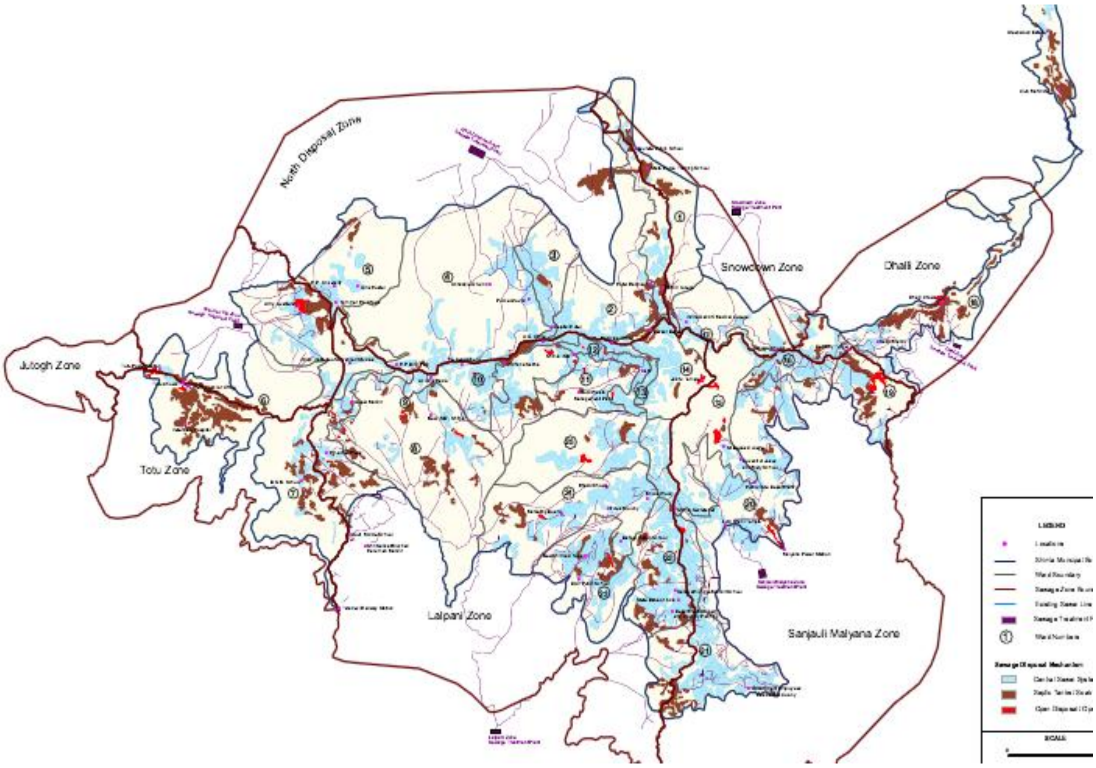
	2010	2011	2021	2031	2041
Residential Population	198717	207063	256883	349361	418296
Floating Population	16711	16711	16711	16711	16711
Water demand at consumers end (MLD)	29.08	30.20	36.93	49.41	58.72
Sewage Generation(MLD)	23.26	24.16	29.54	39.53	46.98
Solid waste generation (MT)	75.39	78.32	95.75	128.12	152.25

TABLE 1.2 Zone Wise population and sewage generation

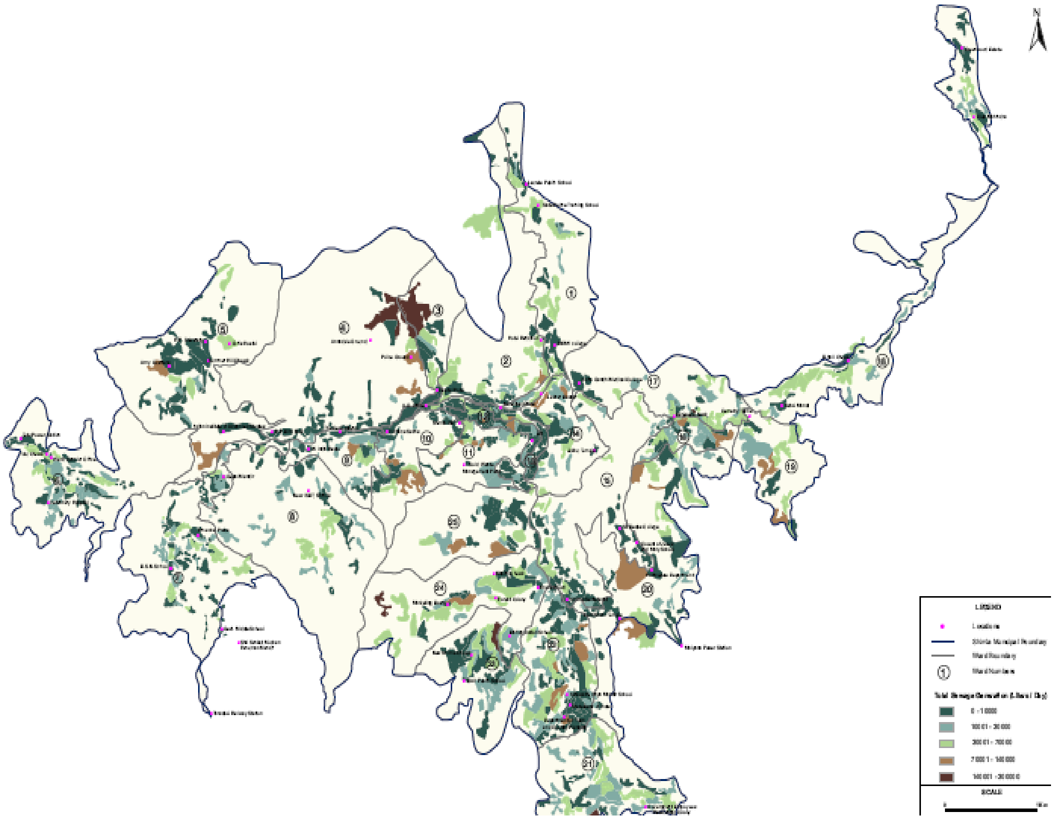
Ward No.	Ward Name	Residential Population (2010)	% of Total Population	Wastewater Collection Mechanism		
				Sewerage System %	Open Disposal %	Septic Tank / Soak Pit %
1	BHARARI	6305	3.17	1.42	1.75	
2	RALADUBHATTA	7511	3.78	2.16	1.62	
3	KAITHU	3270	1.65	1.42	0.22	
4	ANNADALE	6210	3.12	3.11	0.01	
5	SUMMER HILL	6801	3.42	2.48	0.94	
6	TOTU	10745	5.41	0.58	4.73	0.09
7	BOILEUGANJ	13763	6.93	2.88	3.79	0.26
8	TUTIKANDI	5252	2.64	1.12	1.34	0.18
9	NABHA	7118	3.58	3.46		0.12
10	PHAGLI	5217	2.63	1.55	1.04	0.04
11	KRISHNA NAGAR	11834	5.96	4.99	0.37	0.59
12	RAM BAZAAR	6540	3.29	3.02		0.28
13	LOWER BAZAAR	3829	1.93	1.87		0.06
14	JAKHOO	7037	3.54	2.80	0.75	
15	BANMORE	5595	2.82	2.51	0.09	0.21
16	ENGINE GHAR	8790	4.42	3.93	0.49	
17	SANJAULI	9193	4.63	3.78	0.84	
18	DHALLI	6991	3.52	0.60	2.91	
19	CHAMYANA	9136	4.60	1.40	2.90	0.30
20	SANGTI(MALYANA)	9405	4.73	3.81	0.89	0.03
21	KASUMPATI	10301	5.18	3.83	1.35	
22	CHOTTA SHIMLA	16542	8.32	7.13	1.11	0.09
23	PATEYOG	5558	2.80	2.42	0.23	0.14
24	KHALINI	9708	4.89	3.23	1.63	0.03
25	KANLOG	6067	3.05	3.01	0.03	0.02
	Total	198717	100	68.52	29.05	2.43



MAP 1: SEWAGE ZONES IN SHIMLA
(Source-Decentralised central water commission report Shimla)



MAP 2 : SEWAGE DISPOSAL MECHANISM
(Source-Decentralised central water commission report Shimla)



MAP 3:SEWAGE GENERATION-RESIDENTIAL(2010)
(Source-Decentralised central water commission report Shimla)

1.8 Objectives

The objectives of the project is that to draw the comparison between performances of sewage treatment facilities in Shimla & other objectives are written below.

- To study the performance of Sewage Treatment Facilities in order to produce an environmentally safe fluid waste stream (or treated effluent) and a solid waste (or treated sludge) suitable for disposal or reuse (usually as farm fertilizer).
- Evaluate advanced technologies so as to re-use sewage effluent for drinking water as in the case of Singapore; the only country to implement such technology on a production scale in its production of NEwater.
- To adopt a demand-based strategy and community participation in planning, implementation and management of sanitation infrastructure.
- To adopt locally suitable methods, technologies and materials, and provide necessary facilitation support to the Municipal Corporation.

1.9 Organization of Report

The organization of this report is so that all things related to this project can be achieved by this project report

1-Introduction
2- Literature review
3- Materials and Methods
4- Result and Discussions
5- Conclusion
6- Scope For Future Work
7- References
8- Appendix

Chapter 2
LITERATURE REVIEW

The wastewater generated in the City is being treated at Six STPs constructed in each of the sewerage zones as mentioned in Table 1. These STPs were constructed from funding received from OPEC in the year 2005. The total treatment capacity of all STPs combined is 35.63 MLD designed for the population needs of the year 2025.

TABLE 2.1 Sewage Zones in Shimla and treatment technology used

Name of the STP	Capacity of the plant(MLD)	Technology
Lalpani	19.35	UASB
Sanjauli-Malyana	4.44	EXTENDED AERATION
Dhalli	0.76	EXTENDED AERATION
Snowdon	1.35	EXTENDED AERATION
North Disposal	5.80	EXTENDED AERATION
Summer Hill	3.93	EXTENDED AERATION

2.1 ANAEROBIC WASTEWATER TREATMENT

A large number of technologies have been developed to achieve pollutant removal from wastewater. Both aerobic and anaerobic wastewater treatment systems are currently in use. They can be seen as complementary to each other, since in some situations anaerobic systems can not fulfil the requirements of effluent quality. The aerobic treatment processes were predominant in the biological treatment of wastewater up to the seventies. Interest in anaerobic processes emerged 10-15 years later due to the increase in energy costs. The anaerobic treatment of wastewater does not consume energy but can even produce energy through methane generation. The two major advantages of anaerobic wastewater treatment, which explain its progress at the expense of the classic aerobic treatment, are less sludge growth and considerable energy saving**.**

Anaerobic wastewater treatment differs from conventional aerobic treatment. The absence of Oxygen leads to controlled conversion of complex organic pollutions, mainly to carbon dioxide and methane. Anaerobic treatment has favourable effects like removal of higher organic loading, low sludge production, high pathogen removal, biogas gas production and low energy consumption. Anaerobic digestion consists of several interdependent, complex sequential and parallel biological reactions, during which the products from one group of microorganisms serve as the substrates for the next, resulting in transformation of organic matter mainly into a mixture of methane and carbon dioxide. Anaerobic digestion takes place in four phases: hydrolysis/liquefaction, acidogenesis, acetogenesis and methanogenesis. Anaerobic reactors have been used mainly for industrial wastewater treatment. Anaerobic systems such as the Upflow Anaerobic Sludge Blanket (UASB), can successfully treat high-strength industrial wastewater as well as low-strength wastewater.

2.2 UASB (UPFLOW ANAEROBIC SLUDGE BLANKET) Treatment

The Upflow Anaerobic Sludge Blanket Reactor (UASB) is a single tank process. Wastewater enters the reactor from the bottom, and flows upward. A suspended sludge blanket filters and treats the wastewater as the wastewater flows through it. The reactor maintains a high concentration of biomass through the formation of highly settleable microbial sludge aggregates.At the top of the reactor three phase separation between gas-liquid-solid takes place.Any biomass leaving the reaction zone is directly recirculated from the settling zone. Figure 2 shows a typical cross section of UASB Reactor.

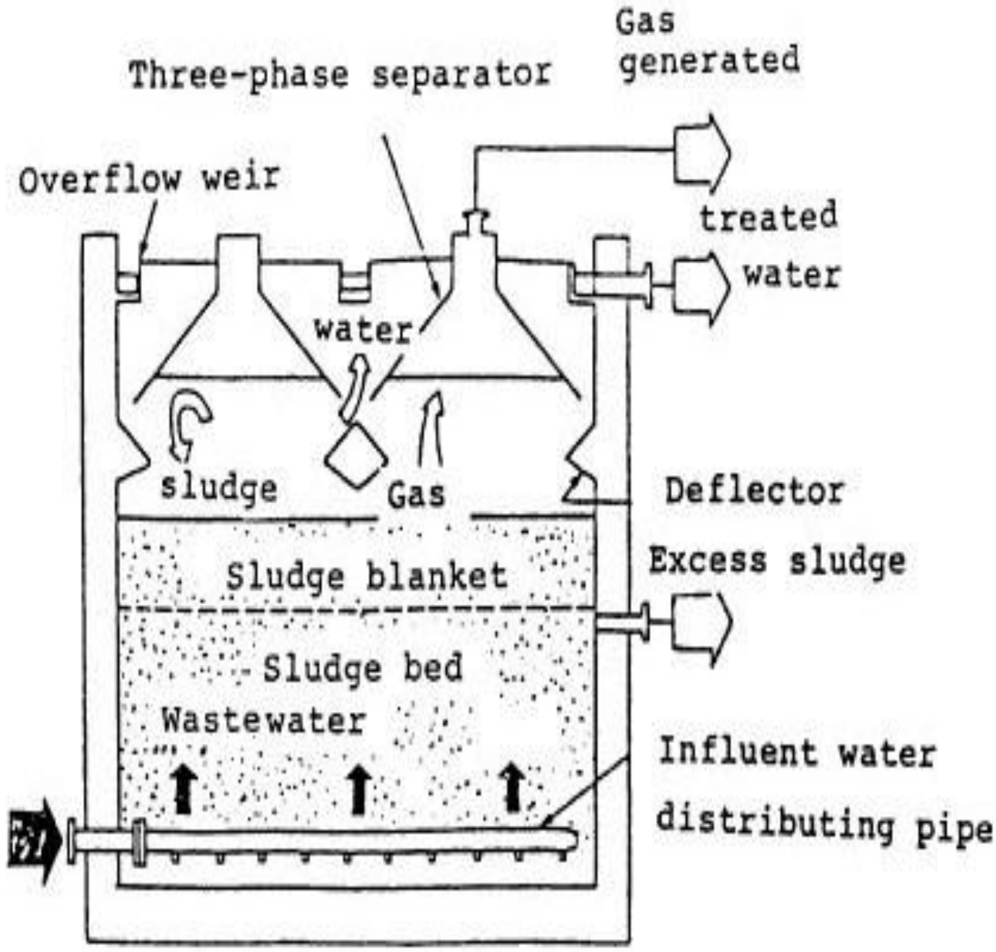


FIGURE 2.1 TYPICAL UASB REACTOR

(Source: S. K. Garg Environmental Engineering - II)

UASB type units are one in which no special media have to be used since the sludge granules themselves act as the 'media' and stay in suspension. UASB system is not patented. A typical arrangement of a UASB type treatment plant for municipal sewage would be as follows:

1. Initial pumping
2. Screening and degritting
3. Main UASB reactor
4. Gas collection and conversion or conveyance
5. Sludge drying bed
6. Post treatment facility

In the UASB process, the whole waste is passed through the anaerobic reactor in an upflow mode, with a hydraulic retention time (HRT) of only about 8-10 hours at average flow. No prior sedimentation is required. The anaerobic unit does not need to be filled with stones or any other media; the upflowing sewage itself forms millions of small "granules" or particles of sludge which are held in suspension and provide a large surface area on which organic matter can attach and undergo biodegradation. A high solid retention time (SRT) of 30-50 or more days occurs within the unit. No mixers or aerators are required. The gas produced can be collected and used if desired. Anaerobic systems function satisfactorily when temperatures inside the reactor are above 18-20°C. Excess sludge is removed from time to time through a separate pipe and sent to a simple sand bed for drying.

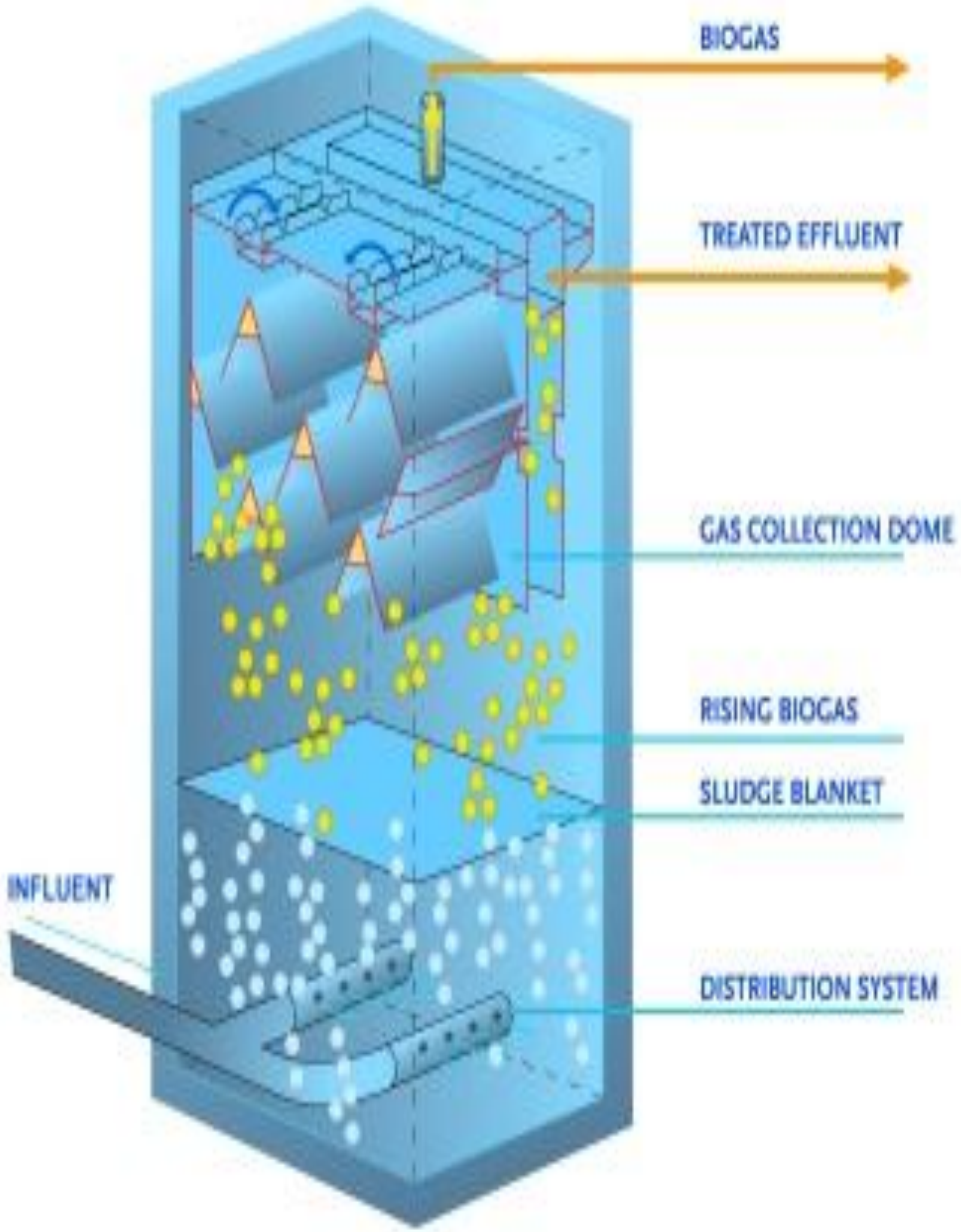


Figure 2.2 UASB REACTOR

(Source-http://missrifka.com/discussion/sizing-of-uasb-pond-for-wastewater-treatment-plant.html)

2.3 EXTENDED AERATION

In **extended aeration** process the raw sewage goes straight to the aeration tank for treatment. The whole process is aerobic. This simplification implies longer aeration time which has earned for the process the name "extended aeration". The BOD removal efficiency of the extended aeration process is higher than activated sludge process which makes it especially desirable to use where it is to be followed by tertiary treatment for reuse.

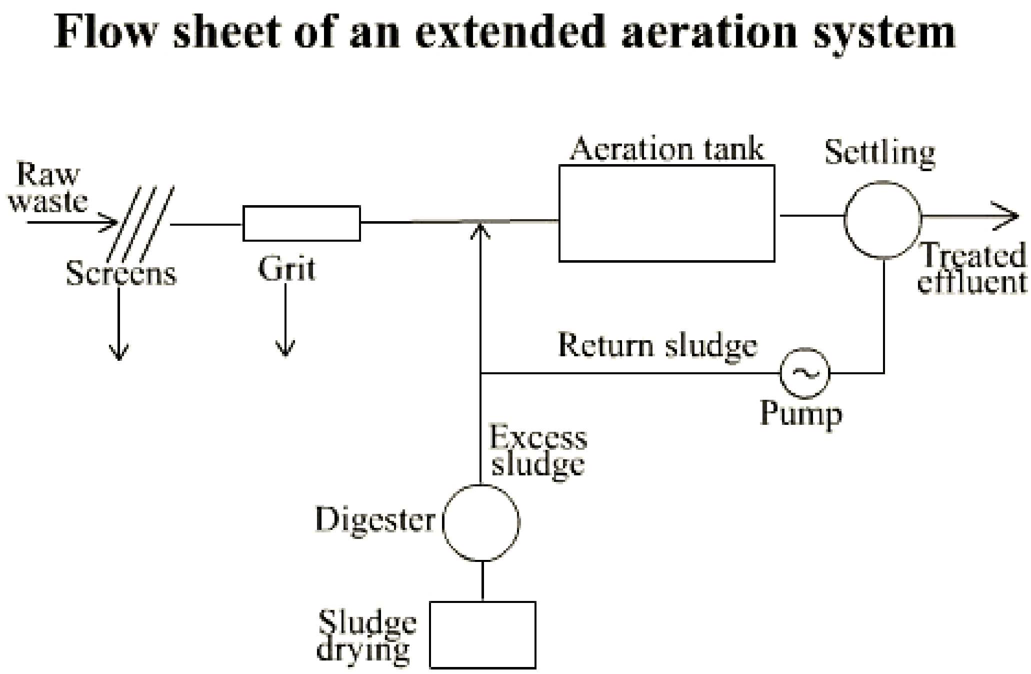


FIGURE 2.3 EXTENDED AERATION PROCESS

(Source- http://www.water-chemistry.in/2009/08/what-is-extended-aeration/)

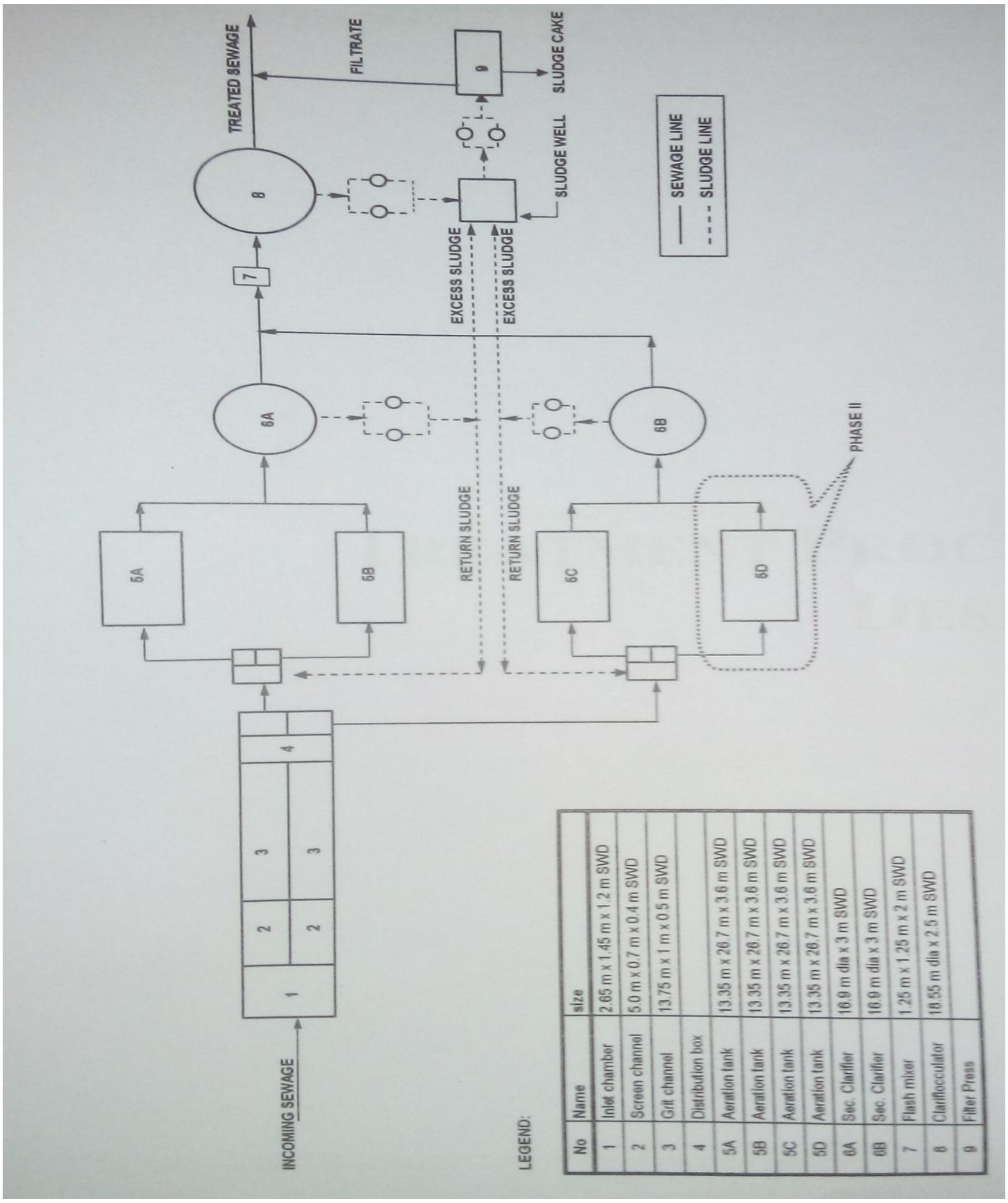


FIGURE 2.4 Schematic Diagram For Extended Aeration Process at (Sanjauli Malyana Plant)

(Source- IPH report on 4.44 MLD STP at Sajauli-Maliana)

Chapter 3
Material and Methods

Influents and effluent samples from all six specified sewage treatment plants are collected to perform the experiments to calculate the various parameters. The parameters are following:-

3.1 Experiments Performed

1- pH

2- Temperature

3-Total dissolved and suspended solids (TDS &TSS)

4-Chemical Oxygen Demand (COD)

5-Dissolved Oxygen (DO)

3.2 Methods of various Experiments

3.2.1 Determination of pH

By Digital pH meter DP-505

3.2.2 Determination of Temperature

Using Thermometer

3.2.3 Determination of Total Dissolved & Suspended Solids(TDS & TSS)

Total dissolved solids & total suspended solids are calculated using the residue left after evaporation and drying of unfiltered and filtered sample.

3.2.4 Determination of Chemical Oxygen Demand (COD)

The Chemical Oxygen Demand (COD) method determines the quantity of oxygen required to oxidize the organic matter in a waste sample, under specific conditions of oxidizing agent, temperature, and time. The method can be applied to domestic and industrial waste samples having an organic carbon concentration greater than 50 mg/L. For lower concentrations of carbon such as in surface water samples, the Low Level Modification should be used. When the chloride concentration of the sample exceeds 2000 mg/L, the modification for saline waters is required.

Summary Of Method - Organic and oxidizable inorganic substances in the sample are oxidized by potassium dichromate in 50% sulphuric acid solution at reflux temperature. Silver sulphate is used as a catalyst and mercuric sulphate is added to remove chloride interference. The excess dichromate is titrated with standard ferrous ammonium sulphate, using ortho phenanthroline ferrous complex as an indicator.

3.2.5 Determination of Bio Chemical Oxygen Demand (BOD)

The Biochemical oxygen demand is the amount of oxygen required by bacteria while establishing decomposable organic matter under aerobic condition. The quantity of oxygen required may be taken as a measure of its content of decomposable organic matter. The rate of BOD exertion is governed by the characteristics of sewage its decomposable organic content, bacterial population and temperature. The progressive BOD exertion takes place in two stages-

(a) Carbonaceous
(b) Nitrification

3.2.6 Dissolved Oxygen(DO)

The Winkler test is used to determine the concentration of dissolved oxygen in water samples. Dissolved oxygen (D.O.) is widely used in water quality studies and routine operation of water reclamation facilities. An excess of manganese(II) salt, iodide (I^-) and hydroxide (OH^-) ions is added to a water sample causing a white precipitate of $Mn(OH)_2$ to form. This precipitate is then oxidized by the dissolved oxygen in the water sample into a brown manganese precipitate. In the next step, a strong acid (either hydrochloric acid or sulphuric acid) is added to acidify the solution. The brown precipitate then converts the iodide ion (I^-) to iodine. The amount of dissolved oxygen is directly proportional to the titration of iodine with athiosulphate solution.

Chapter 4
Results and Discussions

In Shimla there are six treatment plants. Grab samples were collected from all plants and tested in laboratory and results obtained are shown below-

4.1 Yearly Average Data of Lalpani

Table 4.1 Yearly Average Data (April 2013 – March 2014) of STP at Lalpani

PARAMETERS	INLET (Yearly Average Values)	OUTLET (Yearly Average Values)
pH	7.85	6.75
BOD in mg/L	237.75	17.4
COD in mg/L	1173	138.5
TDS in mg/L	776.5	635.75
TSS mg/L	1156	72
MLSS in mg/L	3150	2500
Temperature in (^{0}C)	16.5	19.3

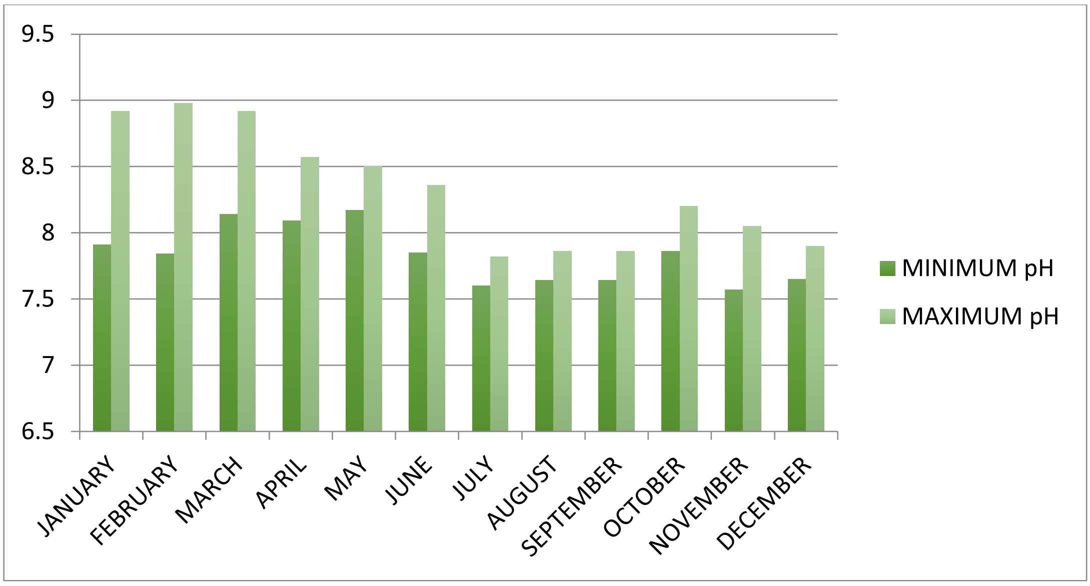


FIGURE 4.1 pH Variation at inlet of Lalpani STP throughout year

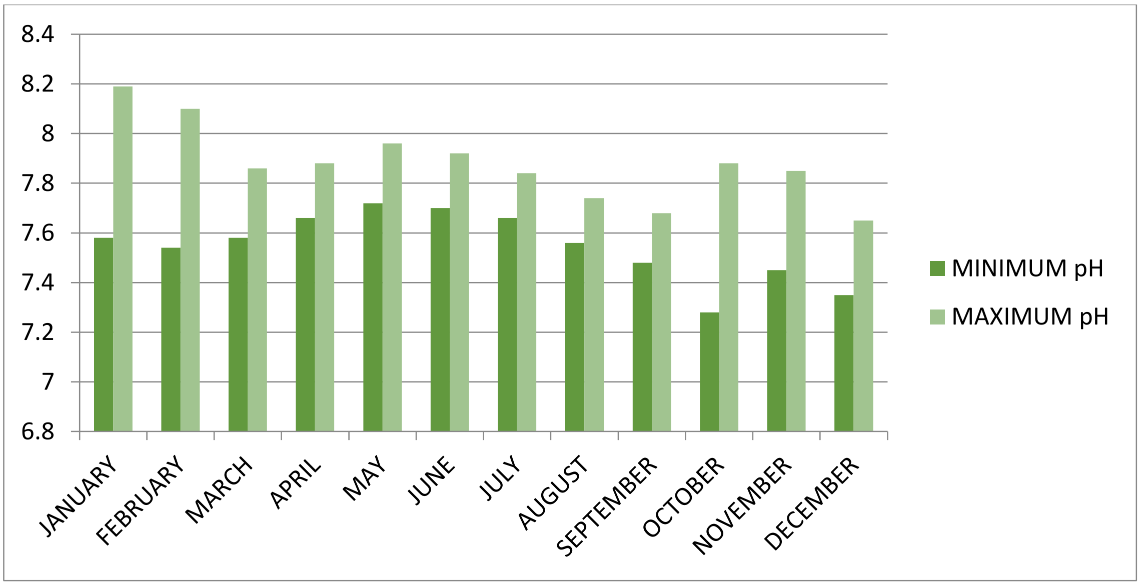


FIGURE 4.2 pH variation at outlet of Lalpani STP throughout the year

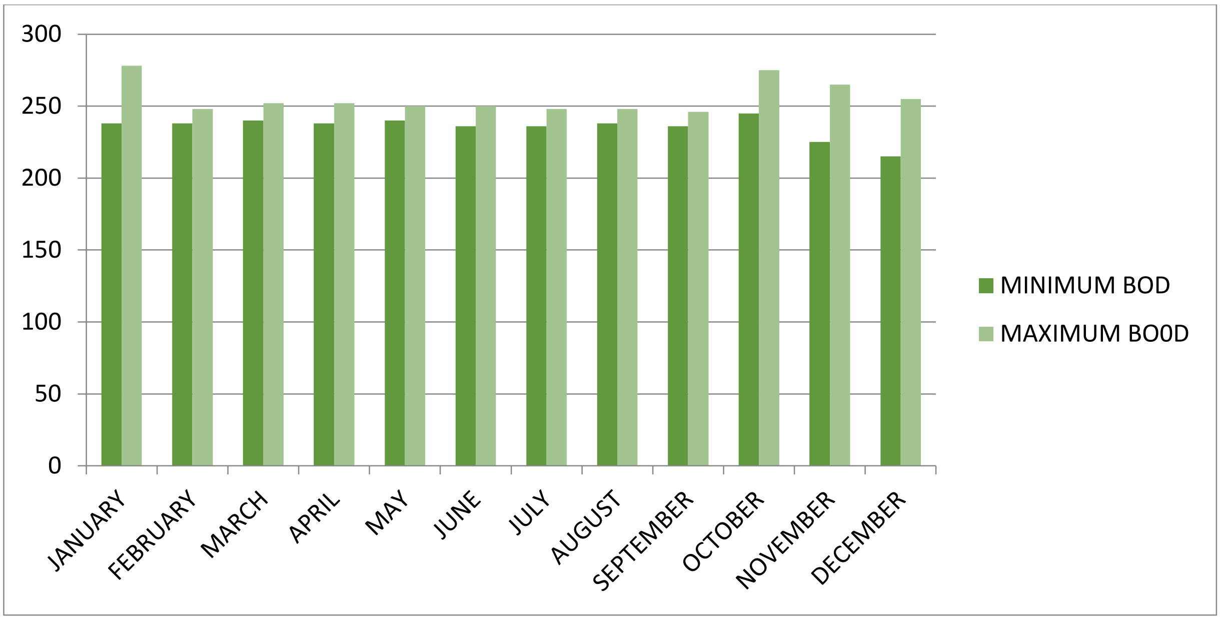


FIGURE 4.3 BOD variation at inlet of Lalpani STP throughout the year

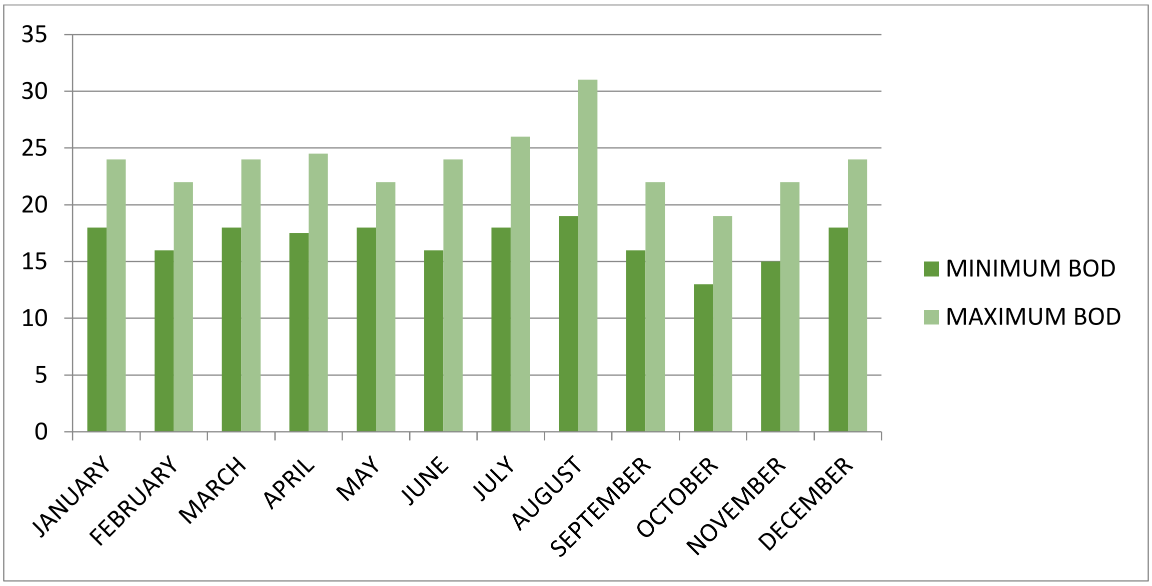


FIGURE 4.4 BOD variation at outlet of Lalpani STP throughout the year

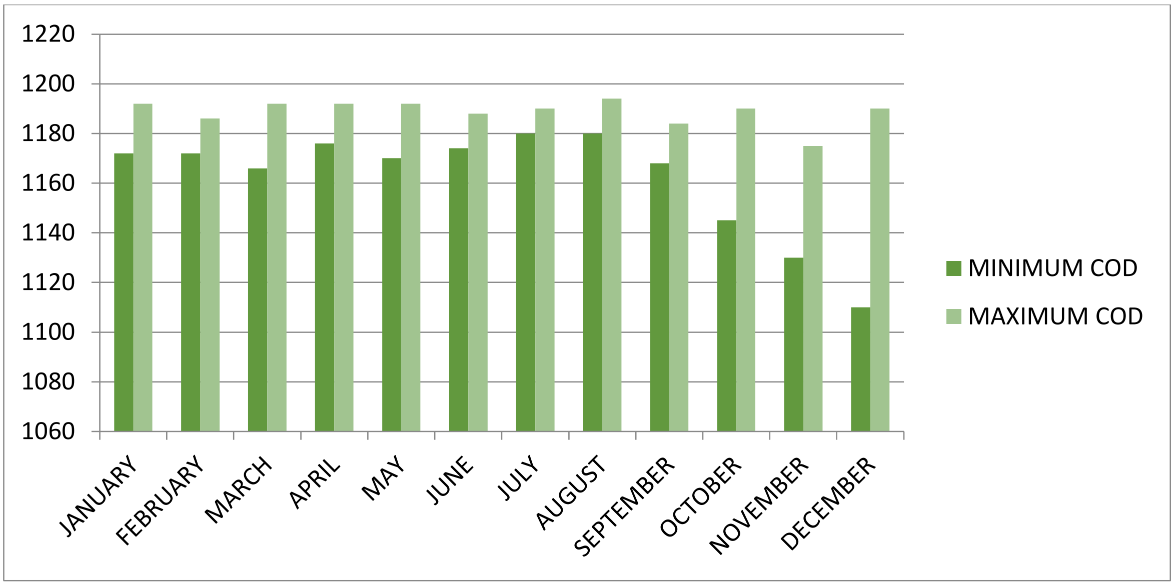


FIGURE 4.5 COD variation at inlet of Lalpani STP throughout the year

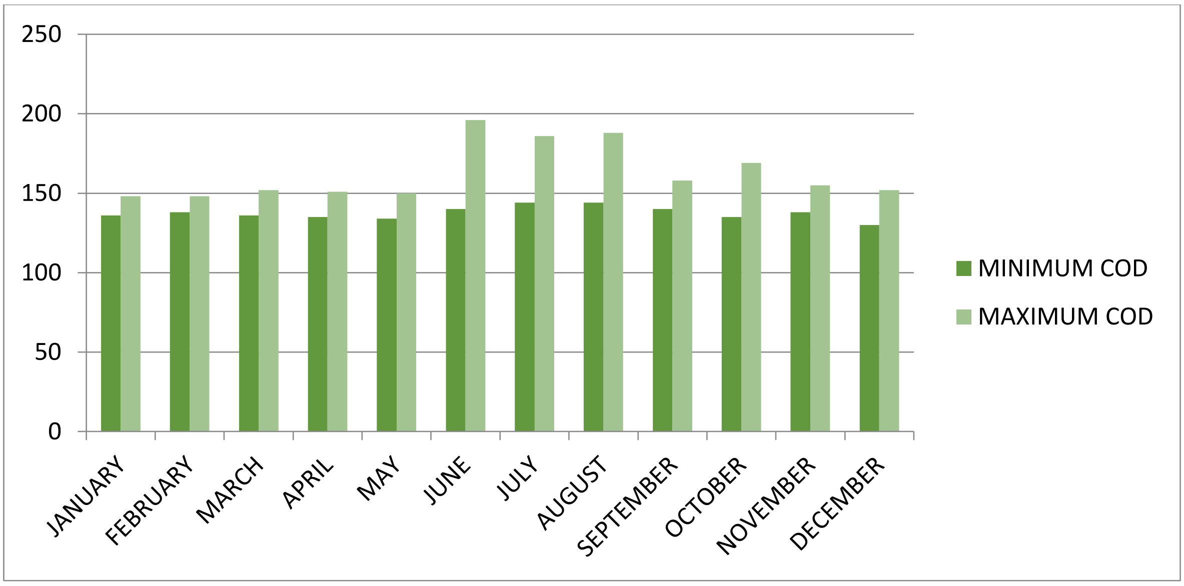


FIGURE 4.6 COD variation at outlet of Lalpani STP throughout the year

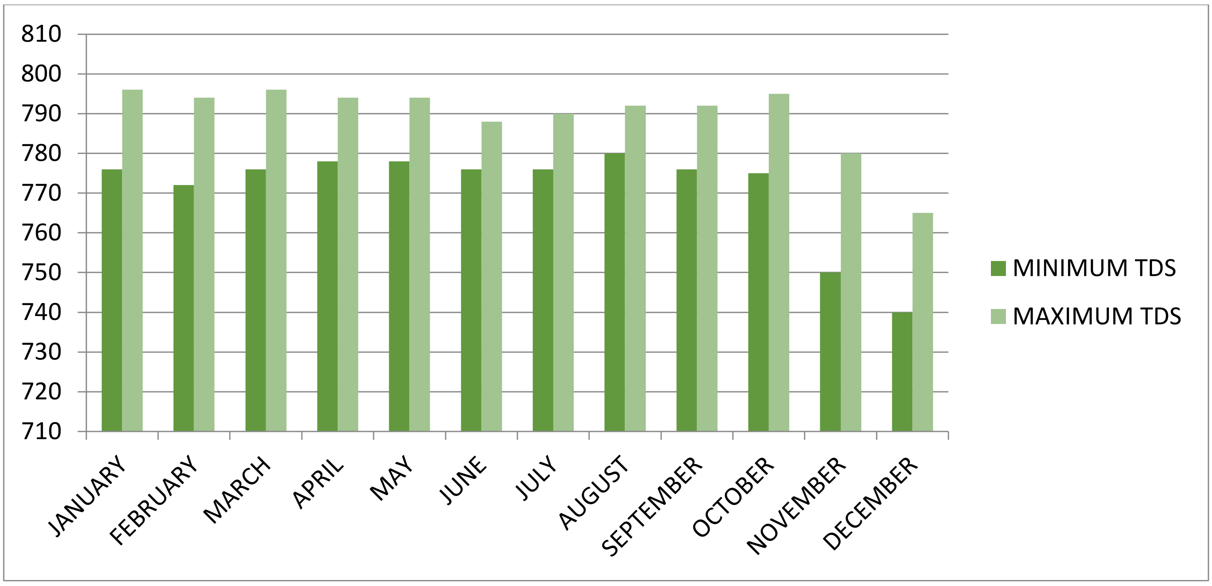


FIGURE 4.7 TDS variation at inlet of Lalpani STP throughout the year

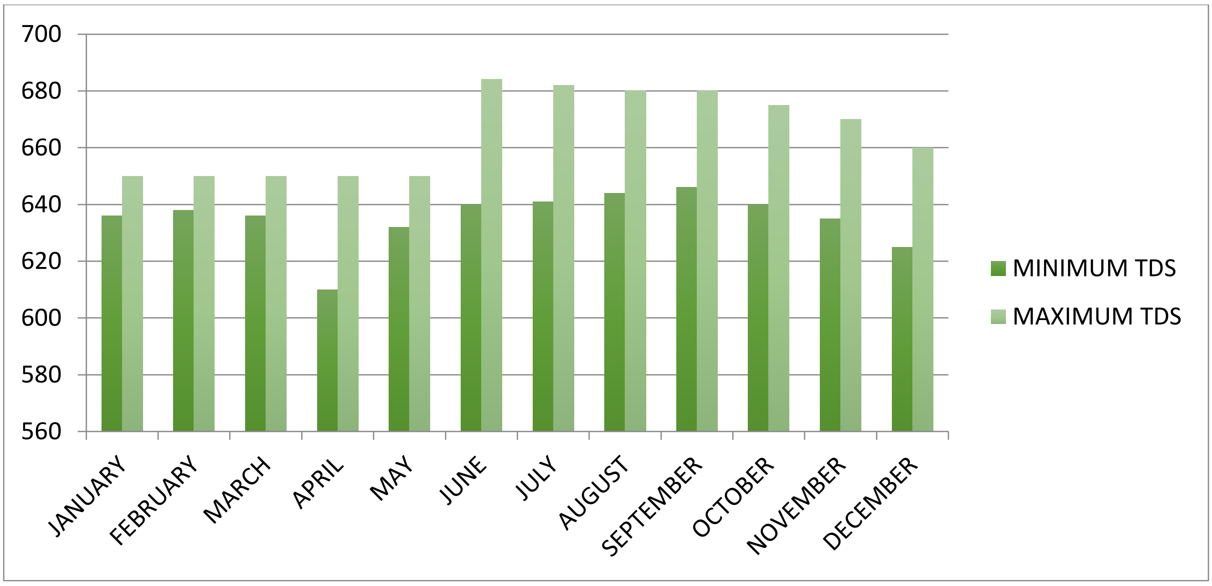


FIGURE 4.8 TDS variation at outlet of Lalpani STP throughout the year

- Above figures are showing maximum and minimum values of operational parameters which are compared with each other at inlet and outlet are showing that the sewage present in Shimla is a low strength sewage according to the operational parameters.

- The above results are showing that the temperature in the Lalpani zone sewage is generally lie in between 15-25^{0}C so mostly psychrophilic or mesosphilic conditions are reformed in Lalpani so instead of UASB also we can use Physicochemical process to treat this sewage & waste water.

- Psychrophilic anaerobic process is an feasible option for sewage treated at moderate and low temperature, according to geographical location, temperature of municipal wastewater varied between 5 and 25°C. Temperature below 10^{0}C can slow down the anaerobic processes of the wastewater treatment, however such extreme temperatures usually last only for a couple of days or weeks.It is obvious, that the observed removal efficiency of COD is at relatively low level. The cause of the such efficiency was unfavorable composition of the wastewater – the municipal sewage directly taken from WTP Lalpani contained a low concentration of organic pollutants.

4.2 Sanjauli Maliana STP Data(January 2013 – January 2014)

TABLE 4.2 SANJAULI MALIANA STP YEARLY AVERAGE VALUES

PARAMETERS	INLET (Yearly average values)	OUTLET (Yearly average values)
pH	7.95	6.85
BOD in mg/L	265	28
COD in mg/L	1110	225
TDS in mg/L	1065	750
TSS in mg/L	1475	95
MLSS in mg/L	4000	2150

For Sanjauli Maliana STP we have got the design parameters so further calculations are done-

Average Flow- 4440 m^3/day

Inlet BOD concetration-375mg/l

Inlet SS concentration- 750mg/l

F/M ratio- 0.10

MCRT- 30 days

4.2.1 Zone Wise Contributing Population to Sanjauli Maliana STP.

Table 4.3 Zone wise population in Sanjauli Maliana

Zone	2031	2016
Dhalli	1503	1002
Sanjauli	35562	23708
Maliana	7949	5299
Kasumpti	3010	20007
Total	**48024**	**32016**

It is seen from the above operation data that the population for the year 2016 is (2/3) times the population of year 2031.The ultimate flow in 2031 is 6.949 Mld and so the treatment plant for the year 2016 shall have a capacity of 4.44 Mld.

4.2.2 Design Assumptions for STP

Table 4.4 Design assumptions for Sanjauli Maliana STP

Parameter	Summer	Winter
Inlet BOD to Aeration Tank mg/l	375	375
BOD load in kg/day	375 x 4.44=1665	375 x 4.44=1665
BOD removal efficiency of extended aeration	92%	80%
Kg BOD removed in extended aeration	1665 x .92= 1531.8kg/day	1665x.80=1332kg/day
Outlet BOD from extended aeration mg/l	375x.08=30	375x.2=75
Inlet SS concentration in aeration tank	750	750
SS removal efficiency aeration tank	90%	80%
Outlet SS concentration from aeration tank	750x.1=75 mg/l	750x.2=150 mg/l
Minimum Temprature ^{0}C	16	8

It also shows that the BOD removal efficiency in summer is 92% and in winter it is 80% it means in winters the plant efficiency is reduced in winters due to fall of temperature In range 10 to 0^{0}C

4.3 Dhalli STP Data (February 2013 – February 2014)

Table 4.5 Dhalli STP Yearly average values

PARAMETERS	INLET (Yearly average values)	OUTLET (yearly average values)
pH	8.11	7.43
BOD in mg/L	274.8	18.83
COD in mg/L	488.3	76.86
TDS in mg/L	2182	506.3
TSS in mg/L	480.3	65.6

4.4 Summer Hill STP Data(March 2013 – March 2014)

Table 4.6 Summer Hill STP yearly average values

PARAMETERS	INLET (yearly average values)	OUTLET (yearly average values)
pH	8.21	7.53
BOD in mg/L	245.3	18.4
COD in mg/L	466	73
TDS in mg/L	1206	270.3
TSS in mg/L	256.3	60

4.5 North Disposal STP Data(April 2013 – April 2014)

Table 4.7 North Disposal STP yearly average values

PARAMETERS	INLET (Yearly average values)	OUTLET (Yearly average values)
pH	8.16	7.19
BOD in mg/L	276.2	21.46
COD in mg/L	414.8	64.9
TDS in mg/L	2029	412.3
TSS in mg/L	417.6	60.3

4.6 Snowdon STP Data(April 2013 – April 2014)

Table 4.8 Snowdon STP average values

PARAMETERS	INLET (Yearly average values)	OUTLET (Yearly average values)
pH	8.16	7.42
BOD in mg/L	255.6	17.67
COD in mg/L	360	48
TDS in mg/L	1283.3	324.67
TSS in mg/L	302	52.7

4.7 Taking cumulatively all plants excluding Lalpani STP are operating with the same process, so the effects are also relatively same on all other plants.

4.7.1 Temperature Biochemical reactions are very temperature dependent. Lower temperatures cause such reactions to be much slower. Thus, more bugs are required to do the same job during the winter than in the summer therefore the process of treatment of sewage in Shimla is more difficult than other high temperature cities.

4.7.2 pH The enzymes which regulate many of the biochemical reaction in bacteria are very pH dependent. The outlet pH should be between 7.0 and 7.5 for the proper activated sludge microorganisms to dominate.

4.7.3 BOD The BOD of treated sewage in between 20 to 60(mg O_2/litre of pollutant) and here is the outlet BOD is in the range of standard data. The BOD range for the raw sewage is in between 300 to 400 but here the inlet BOD is in the range of 230 to 260 which is easily treatable to attain standards to dispose the sewage.

The BOD removal efficiency in all plants is about 90% in summer and about 80% in winter it means plants are easily working in summers but facing some problems in winters to treat the sewage.

4.7.4 COD Typically the ranges of COD produced from domestic sewage is in between 200to 1200 mg/l and the outlet standards for COD to disposing sewage in between 200 to700 this means the plant is working properly and following the standard data.

High COD may accelerate the generation of sulphides in sewer mains and consequently odours and corrosion problems.

May overload treatment units at the sewage treatment works.

May cause non-compliance with the Sewage treatment Works licence condition.

4.7.5 F/M RATIO We measure the amount of biodegradable matter the bacteria use for food by measuring the amount of BOD or COD in the influent to the aeration basin. We estimate the weight of microorganisms in the mixed liquor by measuring the amount of volatile suspended solids (VSS) in the activated sludge. The F/M ratio tells us something about growth and cell condition. If the F/M ratio is high, the bugs normally grow quite rapidly (because this means there is a lot of "food" available in comparison to the amount of microorganism); if the F/M ratio is low, the bug normally grow very slowly (because) little food is available for growth.

4.7.6 Mean Cell Residence Time (MCRT) The effect of mean cell residence time on domestic wastewater treatment performance had been investigated using four bench-scale pre-denitrification submerged membrane bioreactors (MBR) operated in parallel. The MCRT MBR had the lowest microbial activities in terms of specific oxygen uptake rate, specific denitrification rate and observed sludge yield.

Excellent COD removal efficiency (more than 95%) and nitrification (more than 97%) were observed in MBRs. Even though high nitrification can be achieved in the MBRs, total nitrogen (TN) removal efficiency was found to be affected by MCRT with a maximum of 77% at MCRT.

Better TN removal efficiency achieved in the MCRT MBR was due to the combined effect of high mixed liquor concentration and lower dissolved oxygen concentration in the recycled mixed liquor.

The UASB reactor could maintain stable treatment with a COD removal efficiency of 63 ± 13% and a UASB effluent of 118 ± 40 mg/L in a temperature range of 10.6–27.7 °C at an HRT of 8 h.

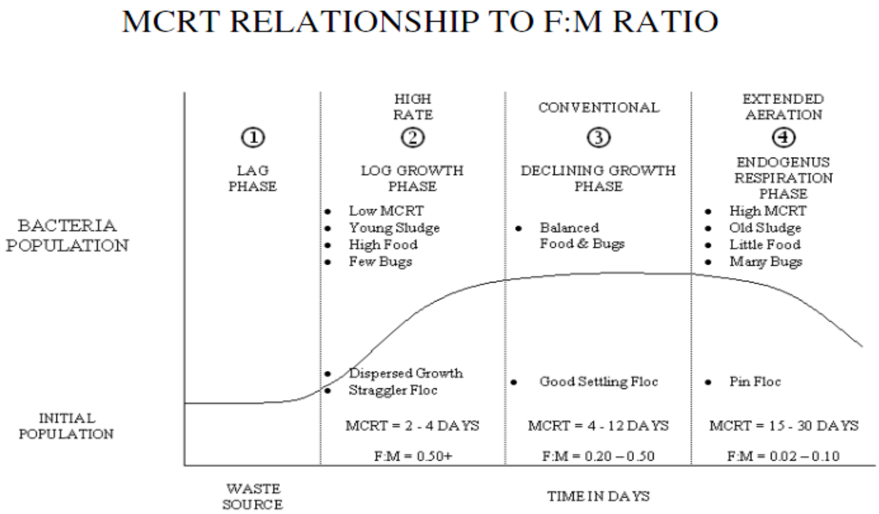


Figure 4.9 MCRT relationship with F/M ratio

(Source- http://water.me.vccs.edu/courses/ENV149/lesson17_print.htm)

Chapter5
Conclusions

- Taking temperature effect into consideration, it successfully simulated the blanket height in the UASB reactor during the operational period at temperature 20°C and above but it failed to explain the hydro dynamic pattern at lower temperatures.

- The COD/BOD reduction in the aeration of UASB effluent was found to depend on HRT and the mass transfer of oxygen.

- The diffused aeration of UASB effluents for 30 min. at 5–6 mg/L DO was found to reduce the BOD of UASB effluent to less than 30 mg/L.

- From the simulation of the effluent COD concentration and estimation of kinetic parameters, it is found that the sludge bed behaves as a CSTR(stirred tank reactor)*.

- The performance of the 111 ML/day UASB-aeration-FPU system was evaluated and compared to the performance of a UASB-aeration FPU system but the performance of the aeration would depend on the feed characteristics, which in turn, depend on the performance of UASB reactor.

- The COD/BOD reduction in the aeration of UASB effluent was found to depend on HRT and the mass transfer of oxygen.

- Existing STPs can be modified to provide a diffused aeration system within the inlet zone of final polishing units. The baffles already present can divide the FPU into an aeration unit and a settling unit.

* **Source** - "Minimization of Short-Circuiting Flow through Upflow Anaerobic Sludge Blanket Reactor " Raja Chowdhury and Indu Mehrotra.

- An increase in bed height drastically reduces the short-circuiting flow through the bed.

- For low strength, one can decrease short-circuiting flow by increasing the sludge bed height, For a high strength waste the influent COD concentration should be fixed judiciously so that high gas velocity cannot disintegrate the sludge or should not lift the biomass in such fashion that the GLSS device cannot incorporate the settling of the biomass.

- The dissolved oxygen limits should not exceed 4 mg/l and 2mg/l for both plants respectively.

- Lower sewage temperature would tend to increase viscosity and solubility of oxygen and decrease setting rate, oxygen transfer rate microbial growth, 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 utilization ,auto- oxidation of MLSS (endogenous respiration) , BOD removal efficiency ,nitrification etc. follow Arrhenius relationship over the temperature range 5-25^{0}C. Consequently , a decrease in temperature during winter period would tend to have an adverse effect on the above biochemical transformation.

- The cumulative effects could results in 20-30 % less BOD removal efficiency at low temperature operation compared to performance at 25-30^{0}C

- Activated sludge MLSS in ASP/EA require a longer period (several weeks) to acclimatize to changes in temperature during cold weather operation .Temperature changes also have a significant effect on the composition of the heterogeneous bacterial biomass (MLSS) and its settling behaviour.

- Extended aeration (EA) mode of operation is a variation of conventional activated sludge process ,designed to minimize the yield of excess biological sludge. This is achieved by increasing the hydraulic retention time and oxygen input (aeration) to oxidise the sludge by endogenous respiration process. ideally this would result in zero net yield of sludge and thereby eliminate minimise sludge handling equipment .

- Extended aeration requires high higher HRT entailing higher aeration tank volume (3-5 times), higher MLSS (3000-5000 VS 2000-3000mg/l) , lower F/M ratio (0.1-0.25 VS 0.3- 0.6) higher oxygen consumption (50-100%) and energy demands besides slow settling sludge. The Extended aeration system recommended on lower sludge yield potential and safe ultimate disposal of stabilized sludge as the major considerations.

- Conventional Activated Sludge Process(ASP) mode will require smaller aeration tank and low HP compare to Extended aeration based on these criteria ASP would certainly be attractive in terms of lower land requirements and energy costs , compared to extended aeration process .

- Sludge digester (for ASP sludge) is not considered appropriate in view of the generally low water/sewage temperature , low methanogenic activity below 15^0C and need for digester heating to maintain desired temperature range of 30-40^0C for satisfactory anaerobic sludge treatment and biogas generations . Alternate methods of sludge stabilizations (in open pits) could be considered for the ultimate disposal of the dewatered sludge cake in a safe manner. Simple sludge drying bed could be considered instead of filter press (automatic) for excess sludge from extended aeration process and the dried cake disposed off as soil conditioner or low grade fertilizer.

- While anaerobic digestion of sewage sludge has been in vogue for several decades , anaerobic treatment of raw or settled domestic sewage in novel bioreactors is relatively the new adaptation in Environmental Biotechnology. The main concern is about sustained operation /performance during the cold weather period with low temperature (below 15^0C) . Methenoganic activity declines below 20^0C and essentially ceases at 10^0C.UASB reactor efficiency is assumed to be 55-60% and the balance BOD will be removed by the downstream extended aeration system.

- It has been proposed to incorporate additional capacity in the extended aeration system to handle the total sewage flow during the three month winter period , when the UASB system will be at its minimum efficiency , serving as a sedimentation unit for the removal of suspended solids equivalent to 15-20% BOD removal. Extended aeration system with modular construction has been suggested to meet this additional capacity during winters.

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 the 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 develop the new phases in the city.

Our Project is mainly based on to collect the data from sewage treatment plants present in Shimla namely Lalpani, Sanjauli, Dhalli, and also includes our college sewage treatment plant.

In this project we have visited all six plants and collected the data of daily figures which will be calculated to find out the performance of the plant and other parameters of the plant to evaluate and compare the performance of several sewage treatment facilities in Shimla through analysis of various Physical, Chemical and Biological characteristics of Influent and Effluent and their treatment efficiencies in relation to design and operational parameters.

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Appendix

Appendix (A)

Laboratory Parameters

PARAMETER	CONVENTIONAL ACTIVATED SLUDGE	HIGH RATE ACTIVATED SLUDGE	EXTENDED AERATION	CONTACT - STABILIZATION CONTACT	REAERATION	STEP AERATION	FORMULA
AERATION DETENTION TIME (hrs)	4 - 8	2 - 4	18 - 30	0.5 - 1.0	3 - 6	3 - 6	(TANK VOLUME, cu ft)(7.5 gal/cu ft)(24 hr/day) / FLOW, gal/day
AERATION TANK ORGANIC LOADING (lb BOD/1000 cu ft)	25 - 50	50 - 100	5 - 15	30 - 70		30 - 70	(PRIMARY EFFLUENT BOD, mg/L) (FlOW, mgd) (8.34 lb/gal) / VOLUME AERATION TANK, 1000 cu ft
MIXED LIQUOR SUSPENDED SOLIDS (mg/L)	1,500 – 3,000	1,200 – 2,500	2,000 – 6,000	1,000 – 2,500	4,000 – 10,000	2,000 – 3,500	(DRY WEIGHT OF SAMPLE, g) (1000 mg/g) (1000 ml/L) / SAMPLE SIZE, mL
FOOD-to-MICROORGANSIM RATIO (F:M)	0.2 - 0.5	0.5 - 1:0	0.02 - 0.10	0.2 – 0.6		0.2 - 0.5	(PRIMARY EFF BOD, mg/L) (FLOW, mgd) (8.34 Lb/gal) / (MLVSS, mg/L) (AERATION TANK VOLUME, mg) (8.34 lb/gal)
SLUDGE AGE - SRT (days)	4 – 10	2 - 4	20 - 40	4 - 16		4 - 10	(MLSS, mg/L)(AERATION TANK VOLUMR, mg)(8.34 lb/gal) / (RAS, mg/L)(WAS, mgd)(8.34) + (Effluent TSS, mg/L)(Q, mgd)(8.34)
AIR REQUIREMENT (cu ft/lb BOD REMOVED)	750 – 1,200	650 - 850	2,000 – 3,500	750 – 1,200		600 - 850	AIR APPLIED, cu ft / PRIMARY EFFLUENT. BOD, mg/L)(FLOW, mgd)(8.34 lb/gal)
OXYGEN REQUIREMENT (lb/lb BOD, REMOVED)	0.8 - 1.1	0.7 - 0,9	1.4 - 1.6	0.8 - 1.2		0.6 - 0.8	OXYGEN APPLIED lbs / (PRIMARY EFFLUENT BOD, mg/L)(FLOW, mgd)(8.34 lb/gal)
RESPIRATION RATE - OUR (mg/hr/g MLSS)	7 - 15	15 - 25	3 - 8	20 - 30	10 - 30	8 - 20	(OUR, mg/L/hr)(1,000 mg/g) / MLSS, mg/L
SOLIDS AECUMULATON RATE (lb/lb BOD REMOVED)	0.7 - 0.9	0.8 • 1.0	0.65 - 0.B	0.9-1.1		0.7 - 0.9	(RAS, mg/L)(WAS, mgd)(8.34) + (EFF, mg/L)(Q, mgd)(8.34) / (PRIMARY EFF - FINAL EFF BOD, mg/L) (FLOW, mgd) (8.34)
SLUDGE VOLUME INDEX - SVI (ml/g)	50 • 150	50 - 150	25 - 110,	50 - 150		50 - 150	(30-MINUTE -SETTLED SLUDGE VOLUME, mL)(1000) / MLSS, mg/L
RETURN SLUDGE CONCENTRATION (mg/L)	, 6,000	6,000	7,500	8,000		6,000	(DRY WT OF SAMPLE, g)(1000 mg/g)(1000 mL/L) / SAMPLE SIZE, mL
RETURN SLUDGE (% OF INFLUENT)	25 - 75	25 - 100	-50 - zoo	50 - 125		25 - 75	(RETURN ACTIVATED SULDGE FLOW, mgd)(100) / - (INFLUENT FLOW, mgd)
CLARIFIER OVERFLOW RATE (gal/sq ft/day)							FLOW, gal/day / (CKLARIFIER SURFACE AREA, sq ft)l
PRIMARY			800-1,200				
SECOIWARY	400 - 800		200 - 400	400 - 800			
PRIMARY CLARIFIER DETENT ION TI ME C(hrs)			1 - 2				
CLARIFIER DEPTH (ft)							(TANK VOLUME, cu ft)(7.5 gal/cu ft)(24 hr/day) / FLOW, gal/day
PR IMARY			10 - 12				
SECONDARY			1 - 15				
CLARIFIER WEIR LOADING (gal/ft/day)			20,000				FLOW, gal/day / (LENGTH OF EFFLUEN WEIR, ft)
SOLIDS LOADING (lb/day/sq ft)	20 – 30	20 - 30	5 - 25	20 - 30		20 – 30	(FLOW, mgd + RAS, mgd) (MLSS, mg/L) (8.34) / (CLARIFIER SURFACE AREA, sq ft)

PARAMETER	HOLDING/SAMPING	PRETREATMENT	APPARATUS	PROCEDURE	COMMENTS	CALCULATIONS
Biochamical Oxygen Demand (BOD), mg/L [See Appendix W]	24 hr, refrigerate at 4ºC, grab or composite	-pH 6.4 to 7.5 -dechlorinate - temperature 20ºC	-300 mL BOD incubation bottles -Incubator @ 20ºC	5 days in the dark @ 20ºC	-dilution water depletion must not exceed 0.2 mg/L	$\frac{(DO_{initial} - DO_{final}) \times 300}{sample\ volume}$ DO depletion in sample bottles must be at least 2 mg/L and final DO must be at least 1.0 mg/L
Total Suspended Solids (TSS), mg/L	7 days, refrigerate at 4ºC, grab or composite	- well mixed sample	-glass fiber filter (Whatman 934AM, Millipore AP40, Gelman A/E)	Dry in oven @ 105ºC ± 2ºC until constant weight is achieved	-insert filter paper wrinkled side up.	$\frac{(Wt.\ of\ filter\ \&\ sample - wt\ of\ filter)}{sample\ volume(mL)}$
Settleable Solids mL/L	48 hr, refrigerate at 4ºC, grab		-Imhoff cone	Settle for 45 min., stir gently, settle for 15 min. longer		Direct read
Fecal Coliform colonies/100mL	30 hr, refrigerate @ 4ºC, grab	-dechlorinate if necessary	-filter paper -filter funnel -nutrient broth -culture dishes -incubator	Incubate at 35ºC ±0.5ºC for 22 to 24 hours	20 to 60 colony range desired	$\frac{(colonies\ counted) \times 100}{sample\ volume(mL)}$
E. coli Colonies/100 mL	30 hr, refrigerate @ 4ºC, grab	-dechlorinate if necessary	-filter paper -filter funnel -nutrient broth -culture dishes -incubator	Incubate at 35ºC for 2 hrs then at 44.5ºC for 22 hrs ±2 hrs	20 to 80 colony range desired	$\frac{(colonies\ counted) \times 100}{sample\ volume(mL)}$
pH	Analysis must be done immediately, grab		-pH meter	Calibrate pH meter against at least 2 known buffers that bracket the expected pH value	-meter must be accurate to ±0.1 units -sample must fall between buffer values	Direct read
Total Chlorine Residual (TRC), mg/L	Analysis must be done immediately, grab		-spectrophotometer or colorimeter -TRC reagents	Add reagent to sample, mix well, let stand 3-5 min., read results		Direct read
Specific Oxygen Uptake Rate (SOUR), (mg/g)/hr [See Appendix H]	Analysis must be done immediately, grab	-adjust temp to ~20ºC -oxygenate sample by vigorous shaking	-DO meter/ stirrer probe & temp -stopwatch -BOD bottle	Fill BOD bottle to overflowing with sample. Insert probe and activate stirrer	After DO stabilizes, read DO level every minute for 15 min or until DO <1.0	$\frac{DO\ Uptake\ rate}{MLVSS(g/L)} \times \frac{60 min}{hr}$
Settled Sludge Volume (SSV) mL/L and Sludge Volume Index (SVI) [See Appendix G]	Analysis must be done immediately, grab		-Mallory settle-ometer or equiv w/ stirrer -thermometer	Mix sample w/ stirrer, pull striier gently from settleometer, record settled sludge volume every 5 min.	SVI Calculated from SSV at 30 minutes and MLSS concentration	$\frac{SSV\ at\ 30 min \times 1000}{MVSS(mg/L)}$

Appendix (B)

TABLE 1
Mean values, standard deviations, variation coefficients and range of parameters

Parameters	Units	Mean	σ	Range		CV
				Minima	Maxima	
Oil (eff.)	kg/d	63.48	38.05	21.57	205.19	59.94
Oil (inf.)	kg/d	96.80	51.57	6.59	293.31	53.27
Acidity (eff.)	kg AcH/d	47.80	21.32	10.07	120.23	44.60
Acidity (inf.)	kg AcH/d	44.80	20.67	7.78	125.14	46.14
Alkalinity (eff.)	$kgCO_3Ca/d$	270.65	85.61	59.93	441.5	31.63
Alkalinity (inf.)	$kgCO_3Ca/d$	223.49	94.91	13.51	633.27	42.47
Flow	m^3/d	983	213	458	1322	21.70
Bacteria (eff.)	number/d	1.43E+16	6.35E+16	1.18E+09	2.92E+17	444.34
Bacteria (inf.)	number/d	1.70E+16	6.83E+16	1.65E+12	3.15E+17	401.06
Chloride (eff.)	kg/d	58.86	21.13	24.62	107.31	35.90
Chloride (inf.)	kg/d	60.44	20.76	26.83	107.22	34.35
BOD (eff.)	kg/d	102.92	56.86	30.41	374.7	55.25
BOD (inf.)	kg/d	328.75	127.94	125.09	724.2	38.92
Detergents (inf.)	kg/d	9.63	4.08	1.04	20.18	42.37
COD (eff.)	kg/d	279.35	133.42	44.82	834.67	47.76
COD (inf.)	kg/d	649.18	239.99	159.07	1408.91	36.97
Phosphate (eff.)	kg/d	5.11	2.86	0.76	12.49	55.97
Phosphate In	kg/d	5.01	2.66	1.84	13.88	53.09
$N-NH_3$ (eff.)	kg/d	40.25	13.20	8.64	78.78	32.80
$N-NH_3$ (inf.)	kg/d	29.96	12.66	7.98	63.71	42.26
N-Total (eff.)	kg/d	48.09	16.63	12.9	96.17	34.58
N-Total (inf.)	kg/d	44.81	26.46	15.56	171.82	59.05
SSet (eff.)	kg/d	0.82	0.88	0.21	8.89	107.32
SSet (inf.)	kg/d	5.06	1.23	2.23	7.81	24.31
FSS (eff.)	kg/d	34.53	28.39	3.00	193.00	91.03
FSS (inf.)	kg/d	47.11	24.06	4.00	122.00	54.91
TSS (eff.)	kg/d	122.29	102.89	8.94	523.62	84.14
TSS (inf.)	kg/d	203.61	111.68	26.83	586.07	54.85
VSS (eff.)	kg/d	83.75	84.16	3.94	398.72	100.49
VSS (inf.)	kg/d	160.59	98.64	9.69	515.21	61.42
Sulphate (inf.)	kg/d	46.18	19.16	7.02	115.21	41.49
Sulphide (inf.)	kg/d	0.047	0.050	0.010	0.286	106.38
pH (eff.)	units	6.63	0.10	6.20	7.00	1.51
pH (inf.)	units	7.09	0.16	6.50	7.90	2.26
pH Rea	units	6.63	0.10	6.10	7.00	1.51
Temp. air	°C	23.8	1.8	19.5	28.0	7.74
Temp. (eff.)	°C	24.4	1.7	21.0	28.0	6.84
Temp. (inf.)	°C	24.4	1.7	21.0	28.0	6.88
Temp. Rea	°C	24.5	1.7	22.0	28.0	7.03
HRT	h	7.76	2.32	5.41	15.62	29.90