“Characterization of Sewage from different Treatment Plants in and around Shimla”

A PROJECT

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Under the supervision of

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CONTENTS

CHAPTERS

CERTIFICATE………………………………………………………………… **I**

ACKNOWLEDGEMENT………………………………………………………… **II**

ABSTRACT…………………………………………………………………...**III**

1. INTRODUCTION

1.1 Background……………………………………………………………..1

1.2 Objectives of the Project………………………………………………….1

1.3 Need for Work…………………………………………………………….2

1.4 Layout of the Work……………………………………………………..2

2. LITERATURE REVIEW…………………………………………………3

3. METHOLODOGY

3.1 Study Site……………………………………………………………...6

3.2 Existing Sewage Treatment and Disposal Facilities………………………6

3.3 Study of Treatment Techniques……………………………………………11

3.3.1 Extended Aeration Process…………………………………………………11

3.3.2 UASB: Upflow Anaerobic Sludge Blanket………………………………12

3.4 Sampling Techniques…………………………………………………….14

3.5 Analytical Methods………………………………………………………14

3.5.1 pH……………………………………………………………………...14

3.5.2 Total solids……………………………………………………………….15

3.5.3 Acidity…………………………………………………………………….16

3.5.4 Alkalinity………………………………………………………………….17

3.5.5 Chlorides………………………………………………………………….19

3.5.6 Dissolved Oxygen………………………………………………………...19

3.5.7 Biological Oxygen Demand………………………………………………20

3.5.8 Chemical Oxygen Demand …………………………………………………21

4. RESULTS

4.1 Results of Dhalli STP……………………………………………………………23

4.2 Results of Snowdon STP………………………………………………………...25

4.3 Results of Lalpani STP…………………………………………………………..27

4.4 Results of Malyana STP…………………………………………………………29

4.5 Results of Summer Hill STP…………………………………………………….31

4.6 Results of North Disposal STP………………………………………………..33

5. CONCLUSION…………………………………………………………………35

SCOPE FOR FUTURE WORK………………………………………………37

REFERENCES…………………………………………………………………38

APPENDIX……………………………………………………………………..42

LIST OF FIGURES

Fig. No.	TOPIC	PAGE No.
Fig 3.1	Map Showing Different Sewage Zones	7
Fig 3.2	Flow Diagram of Extended Aeration	12
Fig 3.3	Sectional View of UASB Reactor	13
Fig 3.4	pH Meter	15
Fig 3.5	Oven	16
Fig 3.5	Dessicator	16
Fig 3.7	Balance	16
Fig 3.8	Titration of Acidity	17
Fig 3.9	Titration of Alkalinity	18
Fig 3.10	Experiment of DO	20
Fig 3.11	BOD Bottles	21
Fig 3.12	COD Apparatus	22
Fig 4.1	Dhalli BOD variation	23
Fig 4.2	Dhalli Alkalinity variation	23
Fig 4.3	Dhalli Acidity variation	24
Fig 4.4	Dhalli Total Solids variation	24
Fig 4.5	Dhalli Chlorides variation	24
Fig 4.6	Dhalli DO variation	24
Fig 4.7	Dhalli pH variation	24
Fig 4.8	Dhalli COD variation	24
Fig 4.9	Snowdon pH variation	25
Fig 4.10	Snowdon BOD variation	25
Fig 4.11	Snowdon DO variation	26
Fig 4.12	Snowdon Alkalinity variation	26
Fig 4.13	Snowdon Acitidy variation	26
Fig 4.14	Snowdon Total Solids variation	26

Fig 4.15	Snowdon Chlorides variation	26
Fig 4.16	Snowdon COD variation	26
Fig 4.17	Lalpani pH variation	27
Fig 4.18	Lalpani BOD variation	27
Fig 4.19	Lalpani DO variation	28
Fig 4.20	Lalpani Alkalinity variation	28
Fig 4.21	Lalpani Acidity variation	28
Fig 4.22	Lalpani Total Solids variation	28
Fig 4.23	Lalpani Chlorides variation	28
Fig 4.24	Lalpani COD variation	28
Fig 4.25	Malyana pH variation	29
Fig 4.26	Malyana BOD variation	29
Fig 4.27	Malyana DO variation	30
Fig 4.28	Malyana Alkalinity variation	30
Fig 4.29	Malyana Acidity variation	30
Fig 4.30	Malyana Total Solids variation	30
Fig 4.31	Malyana Chlorides variation	30
Fig 4.32	Malyana COD variation	30
Fig 4.33	Summer Hill pH variation	31
Fig 4.34	Summer Hill BOD variation	31
Fig 4.35	Summer Hill DO variation	32
Fig 4.36	Summer Hill Alkalinity variation	32
Fig 4.37	Summer Hill Acidity variation	32
Fig 4.38	Summer Hill Total Solids variation	32
Fig 4.39	Summer Hill Chlorides variation	32
Fig 4.40	Summer Hill COD variation	32
Fig 4.41	North Disposal pH variation	33
Fig 4.42	North Disposal BOD variation	33
Fig 4.43	North Disposal DO variation	34
Fig 4.44	North Disposal Alkalinity variation	34

Fig 4.45	North Disposal Acidity variation	34
Fig 4.46	North Disposal Total Solids variation	34
Fig 4.47	North Disposal Chlorides variation	34
Fig 4.48	North Disposal COD variation	34

LIST OF TABLES

Table No.	TOPICS	PAGE No.
Table 3.1	Sewage Treatment Plants	7-11
Table 3.2	Capacity of all treatment plants as % of total capacity	11
Table 3.3	Types of Alkalinity	18
Table 4.1	Results for Dhalli STP	23
Table 4.2	Results for Snowdon STP	25
Table 4.3	Results for Lalpani STP	27
Table 4.4	Results for Malyana STP	29
Table 4.5	Results for Summer Hill STP	31
Table 4.6	Results for North Disposal STP	33

CERTIFICATE

This is to certify that the work which is being presented in the project title "Characterization of Sewage from Six Treatment Plants in and near Shimla" in partial fulfilment 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 Shivam Agarwal and Aditya Upadhya during a period from July 2015 to May 2016 under the supervision of Dr. Rajiv Ganguly Associate Professor, Civil Engineering Department, Jaypee University of Information Technology, Waknaghat.

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ABSTRACT

Effective sewage treatment is crucial for healthy living. Comparison of various sewage treatment facilities of sewage treatment plants in Shimla draws a difference between the operational and design parameters for Summer and Winter seasons. The report includes comparison between different sewerage zones and a seasonal variation between the eight parameters which are pH, BOD, Do, Alkalinity, Acidity, Total Solids, Chlorides and COD. The objective of this project was to establish experimental and operational parameters of plant and rate it with other plants. Influent and effluent parameters used for this study includes pH, solids, BOD, COD, DO, Acidity, Alkalinity, Chlorides. Study of various treatment processes in waste water treatment shows that temperature and pH are the important factors effecting the efficiency of flocculation and settling properties. Psychrophilic anaerobic processes is an attractive option for sewage treatment and moderate and low temperature. Anaerobic wastewater treatment differs from conventional aerobic treatment. The absence of oxygen leads to controlled conversion of complex organic pollutants mainly CO2 and methane. Anaerobic treatment has favourable effects like removal of higher organic loading, low sludge production, high pathogen removal, biogas production, low energy consumption. Psychrophilic anaerobic treatment can be an attractive option to conventional anaerobic digestion for municipal sewage and industrial wastewater that are discharge at moderate or low temperature. The effluent quality of the sewage using activated sludge process and finally secondary treatment depends on flocculation efficiency and settling of the flocs. The two main reason behind the importance of using UASB are generation of large volume of low strength of wastewater which can be often disposed untreated due to high cost and the potential of stabilizing the organic waste by producing the valuable energy as by product. Report Discusses the possibility of municipal sewage treatment in UASB , Extended aeration process provided in Shimla.

CHAPTER 1 INTRODUCTION

1.1 Background

Wastewater is a combination of water and water-carried wastes originating from households, commercial and industrial amenities and institutions. Untreated wastewater generally contains high levels of organic material, numerous pathogenic microorganisms, nutrients and toxic compounds leading to environmental pollution and health hazards. So, the waste water must be treated appropriately before final disposal, which leads to protection of the environment with public health and socioeconomic concerns.

It is a mixture of sewage water, manufacturing waste effluents, agricultural drainage and hospitals facilities; it is well known that the wastewater from domestic origin contains pathogens, suspended solids, and other organic and inorganic pollutants. In order to diminish the environmental and health hazards, these contaminants and impurities need to be brought down to permissible limits for safe disposal of wastewater. Therefore, removal of the organic contaminants and pathogens from wastewater is of paramount important for its reuse in different activities. The waste water that flows after being used for domestic, industrial, manufacturing and other purposes is known as sewage. Sewage comprises water as the main constituent, while other constituent, and include organic waste and chemical. Assessment of water and wastewater is very crucial to safeguard public health and the environment. Sewage discharges are a major source of water pollution, contributing to demand of oxygen and nutrient loading of the water bodies; promoting toxic; algal blooms and leading to a destabilized aquatic ecosystem.

1.2 Objectives of the Project

1. To collect sewage samples from the influents and effluents of the six different sewage treatment plants and test them for the following parameters-

- pH
- Acidity
- Alkalinity
- Dissolved Oxygen
- Total Solids
- BOD
- COD
- Chlorides

2. To calculate the BOD removal efficiency Total Solids removal efficiency of all the sewage treatment plants.

3. To study the performance of sewage treatment facilities in order to produce environmentally safe fluid waste stream(or treated effluent) and a solid waste (or treated sludge) suitable for disposal resuse.

1.3 Need For Work

1. After the completion of the project we will be able to determine the BOD removal efficiency of all the six Sewage Treatment Plants.

2. We will be able to determine the difference caused by the use of UASB technology rather than Extended Aeration Process.

3. We will be able to depict the seasonal variations in the results obtained from the experiments.

4. Our results may help the STPs to perform better if their results are not satisfactory.

1.4 Layout Of Work

1. Chapter 1 includes the background of sewage system in Shimla and the Objectives of the project.
2. Chapter 2 includes the Literature Review, the papers referred for the project.
3. Chapter 3 includes the Methodology and the different analytical methods adopted to conduct the experiments.
4. Chapter 4 includes the Results of the experiments conducted on the influent and effluent samples from the different STPs and discussion on the result obtained.
5. Chapter 5 includes the conclusion.

Chapter 2 LITERATURE REVIEW

Sewage treatment has always been an important issue of discussion. Problems caused by the invasion of sewage water into streams and rivers are far too many. Many researchers have studied various methods to treat sewage water. *Jules B. van Lier, Nidal Mahmoud and Grietje Zeeman* gave a study that Anaerobic treatment itself is very effective in removing biodegradable organic compounds. Anaerobic treatment can be conducted in technically plain systems, and the process can be applied at any scale and at almost any place. Moreover the amount of excess sludge produced is very small and well stabilised, even having a market value when the socalled granular anaerobic sludge is produced in the bioreactor. Moreover, useful energy in the form of biogas is produced instead of high-grade energy consumed. Accepting that anaerobic digestion in fact merely removes organic pollutants, there are virtually few if any serious drawbacks left, even not with respect to the rate of start-up of the system. The following advantages of AnWT over aerobic treatment are-

- Analysing the reasons why the selection for AnWT was made, the following striking advantages of AnWT over conventional aerobic treatment systems can be given:
- reduction of excess sludge production up to 90%.
- up to 90% reduction in space requirement when using expanded sludge bed systems.
- high applicable COD loading rates reaching 20-35 kg COD per m3 of reactor per day, requiring smaller reactor volumes.

Liu in his paper stated that Excess sludge production from wastewater biological treatment process is highly, and the disposal of excess sludge will be forbidden in a near future, thus increased attention has been turned to look into potential technology for sludge reduction. Recently, some novel sludge reduction techniques have been developed based on chemical oxidation and metabolic uncoupling. This paper attempts to review those chemical-assisted sludge reduction processes, including sludge alkaline–thermal treatment, activated sludge-ozonation process, chlorination-combined activated sludge process,
sludge reduction by metabolic uncouplers and high dissolved oxygen activated sludge process. In these combined activated sludge processes, excess sludge production can be reduced up to 100% without significant effect on process efficiency and stability. This paper would be useful when one is looking for appropriate environmentally and economically acceptable solutions for reducing or minimizing excess sludge production from wastewater biological treatment process. Compared to microbiological methods (e.g. the manipulation of maintenance, endogenous respiration, lysis, decay and predation), the chemical-combined activated sludge processes would be more efficient for excess sludge reduction. In addition, the chemical assisted sludge reduction processes have advantages of easy control, stable performance, and high operation flexibility. The relatively high operation cost of these systems currently limits their application in industrial practice. However, it is expected that the increased operation
and capital costs due to chemical addition can becompensated from saving the cost of excess sludge posttreatment. In this sense, the chemical-enhanced sludge reduction techniques would

be attractive and have great industrial potentials, but have to be optimized economically in future.

Wastewater has a number of substitute uses and each substitute is connected with a set a costs from the start of treatment to the start of use. Consequently, wastewater recycling can fulfil more than one objective like: decrease the nutrients discharge to natural water bodies, save or substitute drinkable water, and fetch more land under cultivation and above all saving water for environmental purposes. In Melbourne treatment of waste water was even used for thrusting a rocket. In current experiments, Gayathri Devi, Mekala Brian Davidson, Madar Samad and Anne-Maree have demonstrated that nitrous oxide gas could be produced under laboratory conditions from wastewater by means of a low-oxygen technique but there's a drawback in the process. Nitrous oxide is a noteworthy greenhouse gas and is more than 300 times more powerful than carbon dioxide.

Ida Medawatyi and R. Pamekas(2011) used membrane bioreactor and fixed film bed biofilm in waste water treatment for water reuse in urban housing area. Their research indicated that water treatment reuse trains have probable application for treating domestic wastewater in urban housing area for non-portable water source. They engaged treatment system using fixed bed biofilm or bio-filter system that could yield water reuse standard quality and also advised substitute technology using MBR system for possible application for treating primary treatment municipal wastewater treatment plant effluent. It was found that the water quality reuse from these operations met the standard for public and urban purposes of use according to USEPA, 2004.

Nidal Mahmoud talked about High Strength Sewage Treatment in a UASB reactor. He stated that The upflow anaerobic sludge blanket (UASB) reactor is extensively used in tropical nations for sewage treatment, such as India and Brazil. The ambient temperature in these countries, ranges between 20 and 30 degree Celsius throughout the year and sewage is of low to medium strength. The present challenge in development of anaerobic technology is to alter the system to treat municipal sewage in severe situation. For example, in Jordan and Palestine sewage is has high COD concentrations greater than 1000 mg/L.

R. N. Singh *(1998) stated that* the waste auditing technique provides a powerful tool to assess periodically the efficacy of the mine wastewater treatment system. This will provide an opportunity to the mine operators to change the mining and processing conditions so that the environmental and economic goals can be achieved. This technique has been successfully applied to a mine site in the mawarra region where wastewater of dissimilar chemical characteristics could be segregated into separate streams for further treatment. Improved process of water managements systems is also proposed. Relatively simple alterations to the operation of the coal wash filtration drains are expected to reduce the periods of inefficient operation of these drains by 95%. As highlighted in this paper, often there is significant economic benefit resulting from the application of waste minimization. In addition, there is always a major benefit to the environment

Catherine N. Mulligani and Bernard F. Gibbs (2004) Biological treatment of wastewater has been engaged successfully for numerous types of industries. Aerobic processes have been used expansively. Large production of sludge is the main problem and methods such as bio filters and membrane bioreactors are being developed to combat this occurrence. Anaerobic waste treatment has experienced noteworthy developments and is now consistent with low retention times. The UASB though a high rate anaerobic reactor is now becoming less prevalent than the EGSB reactor. New developments such as the Annam ox process are highly promising for nitrogen removal. For metal removal, processes such as bio sorption and bio surfactants combined with ultrafiltration membranes are under development. Bio surfactants have also shown promise as dispersing agents for oil spills. Wetlands can be used to reduce biological oxygen demand (BOD), total suspended solids (TSS), nutrients and heavy metals if sufficient space is available.

Zhaoqian Jing and Shiwei Cao (2012) stated that the effluent from the secondary clarifiers of the WWTP includes many organic pollutants, most of which are difficult to be decomposed. Direct treatment along with additional biological processes cannot make acceptable performance. AOPs are usually effective in refractory pollutants elimination and can be combined with biological processes in a very low biodegradable wastewater treatment. UV and O3 oxidation was combined with Biological Aerating Filter (BAF) in tertiary treatment. The tests results indicated that though UV photolysis alone was not quite effective for COD elimination, it could improve its performance of ozonation because when UV photolysis was combined along with ozonation, COD in the wastewater secondary effluent was removed by 45%.

Pawar Avinash Shivajirao (2012) recommended for membrane systems for treatment of waste water with additional technical advancement and equivalent cost reductions, making them capable of purifying waters in single step processes at reasonable costs. Around one-third for wastewater and two-thirds of the market will be for water. His result further supported the Membrane technologies for receiving superior recognition as substitutes to 12 conventional water treatment and also for enhancing treated wastewater effluent for reuse applications that can ominously decrease operation and maintenance costs and energy use.

Chapter 3 METHODOLOGY

3.1 Study Site

Discovered in 1819 by British, Shimla has evolved from a small hill settlement to one of the popular tourist destinations in India. Himachal Pradesh was carved out of erstwhile Punjab state in 1966 and Shimla became capital of Himachal Pradesh. Shimla located in the south of Himachal Pradesh is surrounded by Kullu and Kinnaur district in the North East, Sirmaur district in South East, Solan and Mandi districts and Dehradun district of Uttaranchal in the North West. Shimla is situated in the Central Himalayas, south of river Satluj at 31°4′ to 31°10' north latitude and 77°5' to 77°15' east longitude.

Shimla, one of the most visited tourist destination is well connected with major cities of North India and all parts of Himachal Pradesh. National Highway (NH) 22 connects Shimla with major cities such as Delhi, Chandigarh and Ambala, while NH 88 links Shimla with Kangra and Hamirpur in Himachal Pradesh. Apart from the national highways, state roads provide connectivity to other major tourist destinations like Manali, Kullu, Chamba and Dharmashala. Shimla has railway access through a narrow gauge line, connecting Shimla with Kalka town. Shimla airport located 23 Km from the city has flight connectivity to Delhi, Chandigarh and Kullu. The winter temperature in Shimla varies from 18°C to -4°C and in summer from 32°C to 6°C. The city receives the monsoon during the months of July to September with annual average rainfall of about 150mm.

3.2 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) Department.The first sewerage network was laid in 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 :

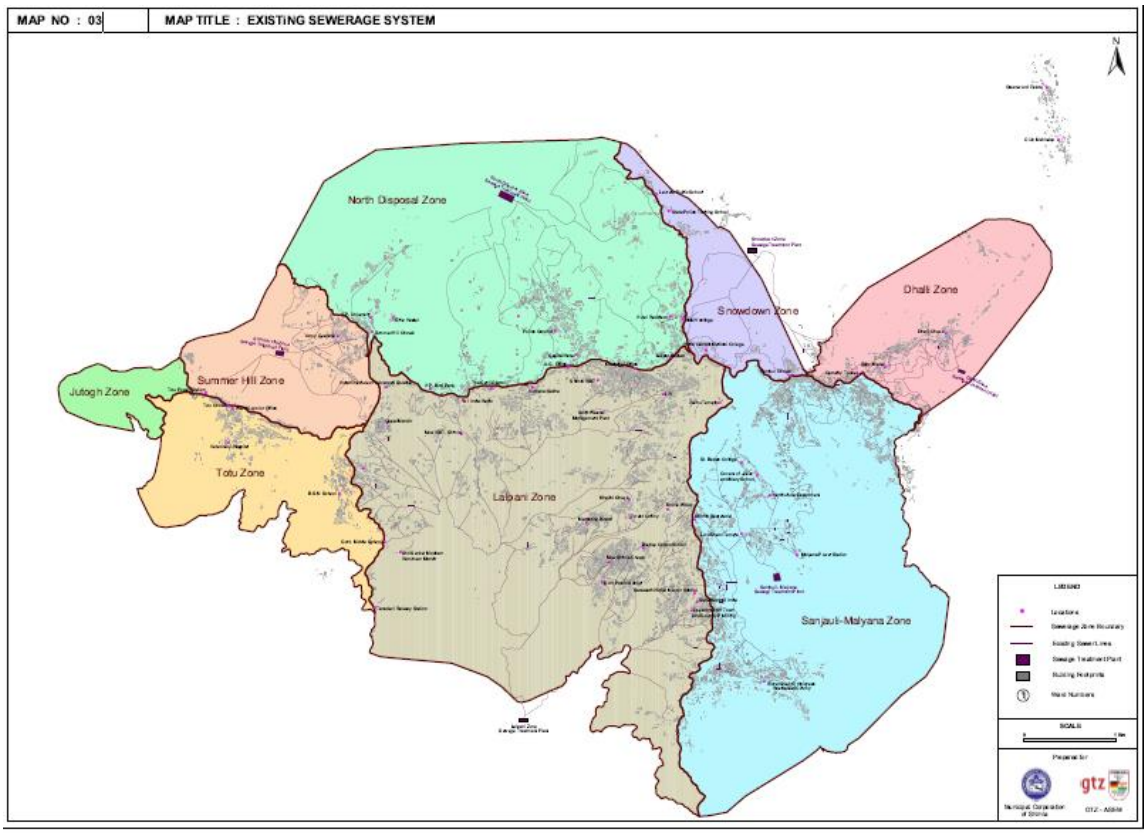


Fig. 3.1 Map showing different Sewage Zones

The following tables shows the different sewage treatment plants along with their location and capacity.

S.No	Sewerage Zone/Name of STP	Location Of STP	Treatment Units	STP Capacity (MLD)	Treatment Technology	Average Flow (MLD)	Peak Flow (MLD)
1.	Lalpani	On Shogi Mehli Bypass	1.Inlet Chamber 2.Screen Chambers 3.Grit Chambers 4.Distribution Box 5.UASB Reactor	19.35	UASB	1.25	2.56

			6.Extended Aeration Tanks 7.Secondary Clarifier 8.Flash Mixer 9.Sludge Well 10.Sludge Drying Bed				
2.	Summer Hill		1.Inlet Chamber 2.Screen Chambers 3.Grit Chambers 4.Distribution Box 5.Extended Aeration Tanks 6.Secondary Clarifier 7.Flash Mixer 8.Sludge Well 9.Centifuge filter press	3.93	Extended Aeration	0.164	0.285
3.	North Disposal		1.Inlet Chamber 2.Screen Chambers 3.Grit Chambers 4.Distribution Box	5.80	Extended Aeration	0.57	0.145

			5.Extended Aeration Tanks 6.Secondary Clarifier 7.Sludge Recycling Pump 8.Flash Mixer 9.Sludge Well 10.Sludge Drying Bed				
4.	Dhalli		1.Inlet Chamber 2.Screen Chambers 3.Grit Chambers 4.Distribution Box 5.Extended Aeration Tanks 6.Secondary Clarifier 7.Sludge Recycling Pump 8.Flash Mixer 9.Sludge Well 10.Sludge Drying Bed	0.76	Extended Aeration	0.53	1.061
5.	Sanjauli-Malyana		1.Inlet Chamber	4.44	Extended Aeration	1.25	2.41

			2.Screen Chambers 3.Grit Chambers 4.Distribution Box 5.Extended Aeration Tanks 6.Secondary Clarifier 7.Sludge Recycling Pump 8.Flash Mixer 9.Sludge Well 10.Sludge Drying Bed				
6.	Snowdon		1.Inlet Chamber 2.Screen Chambers 3.Grit Chambers 4.Distribution Box 5.Extended Aeration Tanks 6.Secondary Clarifier 7.Sludge Recycling Pump 8.Flash Mixer	1.35	Extended Aeration	0.10	0.145

			9.Sludge Well 10.Sludge Drying Bed				
	Total			35.63		3.664	

Table 3.1 Sewage Treatment Plants

The following table shows the % capacity of each treatment plant taking the total capacity as a relative measure.

S.No.	Name of STP	% capacity
1.	Dhalli STP	2.13%
2.	Snowdon STP	3.79%
3.	Malyana STP	12.25%
4.	Summer Hill STP	11.03%
5.	North Disposal STP	16.28%
6.	Lalpani STP	54.31%

Table 3.2 Capacity of all treatment plants as % of the total capacity

Shimla being a small city with a not very large population still needs so many different sewage treatment plants because-

- It is situated in hilly terrains so the cost of installing sewage pipelines will increase if the number of plants are reduced.
- If there are only 1 or 2 treatment plants then the cost of pumping the sewage will be high in the long run.
- Also the amount of effluent discharged is high so there is not a very big stream to discharge it if a single STP is installed.

3.3 Study of Treatment Techniques

3.3.1 Extended Aeration Process

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. The primary sedimentation is frequently avoided in this process but grit chamber is provided for screenings. As its name suggests aeration period is quite large and extends to about 12-24 hours as compared to 4-6 hours in conventional plant. The process permits low organic loading, high mix liquor suspended solids, low F/M ratio. The BOD removal efficiency is high. Air requirement is high which increases the running cost of the plant considerably. Plant however offers another advantages as no separate sludge digestor is required here, because the solids undergo considerable endogenous respiration and get well stabilised over long detention periods, adopted in aeration tanks. The sludge produced is, capable of directly taking to sludge drying beds. Excess sludge production is minimized. Process is also simpler due to elimination of primary settling and separate sludge digestion. Such process is suitable for sewage flow close to 4 MLD. Extended aeration is typically used in prefabricated "package plants" intended to minimize design costs for waste disposal from small communities, tourist facilities, or schools. In comparison to traditional activated sludge, longer mixing time with aged sludge offers a stable biological ecosystem better adapted for effectively treating waste load fluctuations from variable occupancy situations. Supplemental feeding with something like sugar is sometimes used to sustain sludge microbial populations during periods of low occupancy; but population response to variable food characteristics is unpredictable, and supplemental feeding increases waste sludge volumes. Sludge may be periodically removed by septic tank pumping trucks as sludge volume approaches storage capacity.

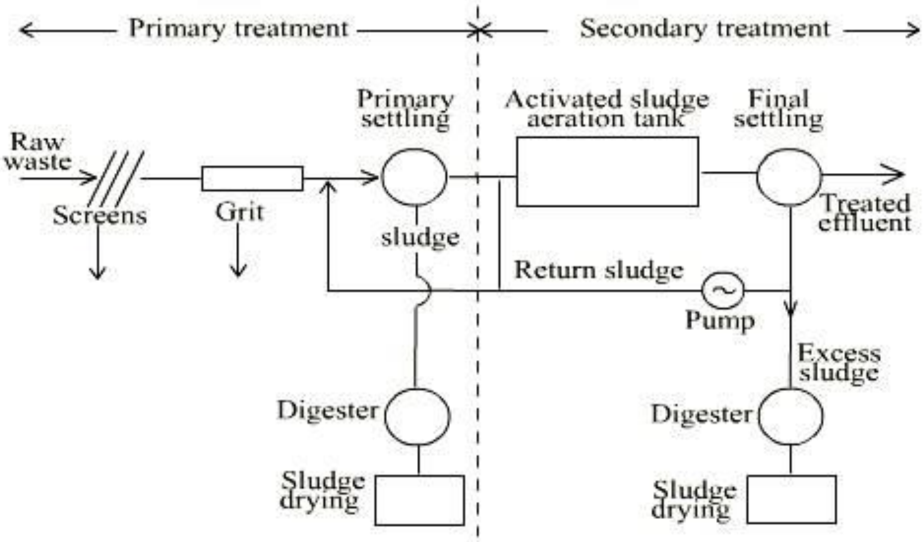


Fig. 3.2 Flow Diagram of Extended Aeration Process

3.3.2 UASB: Up flow Anaerobic Sludge Blanket

The process is essentially based on a special flow regime allowing the sewage to get into contact with a „sludge blanket“ or “sludge bed” situated in the reactor, and a following 3-phase-separation of water, sludge and gas (methane). Within the sludge bed, the organic matter in the sewage is reduced by bacteria. In the anaerobic milieu of the reactor, the methane is formed due to bacterial activity during the fermentation process, which can be utilised as energy source. In order to achieve the best performance of the reactor, several parameters such as COD (Chemical Oxygen Demand), required retention time and others have to be taken into consideration.

Major Advantages of UASB

- low land demand
- reduction of CH_4 emissions from uncontrolled disposal/”open” treatment (ponds) due to enclosed treatment and gas collection
- reduction of CO_2 emissions due to low demand for foreign (fossil) energy and surplus energy production
- low odour emissions in case of optimum operation • hygienic advantages in case of appropriate post-treatment
- low degree of mechanisation
- few process steps (sludge and wastewater are treated jointly)

Major Disadvantages of UASB

- insufficient standardisation and adaptation for several implementation possibilities
- economically not feasible in colder climates with sewage temperature lower than 15°C
- methane and odour emissions (also of end-products) in case of inappropriate plant design or operation
- insufficient pathogen removal without appropriate post-treatment

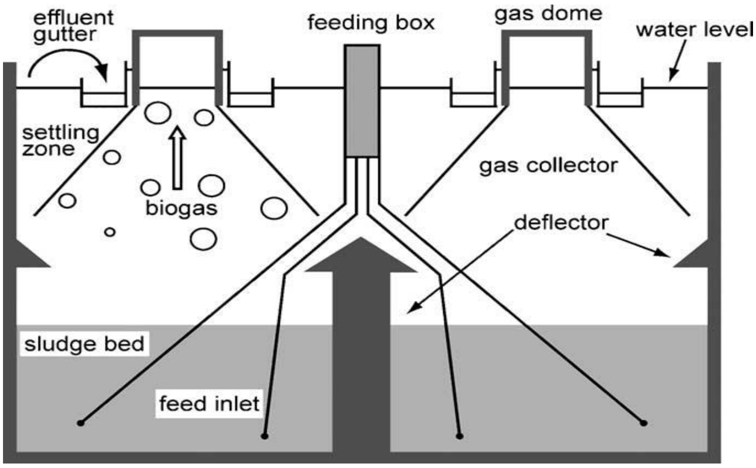


Fig 3.3 Sectional view of UASB reactor

3.4 Sampling Techniques

There are two types of sampling techniques –

- Grab Sampling
- Composite Sampling

Grab sampling reflects performance only at the point in time that the sample was collected, and then only if the sample was properly collected.

Composite samples are collected over a period of time within the same shift. Take one sample per hour for an 8-hour shift. Thus you will have 8 samples of 125 mL each (sub-sample bottle) to make a 1 litre composite solution.

Advantages of Grab Sampling

- Grab sampling allows the analysis of specific types of unstable parameters such as pH, dissolved oxygen, chlorine residual, nitrites and temperature.
- The results can be formulated quickly.
- Useful for areas where weather fluctuations are minimal.

Disadvantages of Grab Sampling

- Grab sample takes a snapshot of the characteristics of the sewage at a specific point and time so it may not be completely representative of the entire flow.
- Grab sampling is only suitable for small plants with low flows and limited staff.

  Our project focuses on Grab Sampling because composite sampling was not possible as the sewage treatment plants were very far from our location so it was not possible to collect samples at different times on the same day.

3.5 Analytical Methods

Laboratory tests were conducted for physiochemical and biological paramters.

3.5.1 pH

Determination of pH is one of the important objectives in biological treatment of wastewater. In anaerobic process, if pH goes below 5 due to excessive accumulation of acids, process is severely affected. Shifting of pH beyond 5-10 upsets the aerobic treatment of wastewater. In these circumstances, the pH is generally adjusted by addition of suitable acid or alkali to optimize the treatment of the wastewater. pH value or range is of immense importance for any chemical reaction. A chemical shall be highly effective at a particular pH. Chemical coagulation, disinfection, water softening and corrosion control are governed by pH adjustment.

APPARATUS USED

- pH meter
- Thermometer

PROCEDURE :

- The instrument with a buffer solution of pH near that of the sample is standardized and electrode against at least one additional buffer of different pH value is checked.
- The temperature of the water is measured and if temperature compensation is available in the instruments it is adjusted accordingly.
- After the standardization place the sample in the beaker and immerse the electrode, then take the reading in the pH meter and the temperature

Fig 3.4 pH meter

3.5.2 Total Solids

Solids analysis are important in the control of biological and physical waste water treatment processes and for assessing compliance with regulatory agency waste water effluent limitations. The amount of solids in wastewater is frequently used to describe the strength of the water. The environmental impact of solids in all forms have detrimental effects on the quality since they cause putrefaction problems. If solids in wastewater are mostly organic, the impact on a treatment is greater than if the solids are mostly inorganic.

APPARATUS USED

- Pit crucible
- A desiccator
- Beaker

PROCEDURE

- The pit crucible was cleaned and was placed in a 103 degree Celsius oven for 1 hr.
- The crucible was placed in a desiccator until cools, and then it was weighed.

- The sample thoroughly was mixed and was measured as 100 ml. by volumetric flask or pipette.
- The sample was transferred to the dish and the flask was rinsed or pipetted several times with small portions of distilled water and the rinsing was added to the dish. It has to be making sure that all suspended matter is completely transferred to the crucible.
- After the sample is evaporated, the crucible is dried and residue in the 1030C oven for 1 hr., cool in the desiccator and weigh

CALCULATION

[Increase in weight (cm) × 1000] ÷ Ml. of sample = ppm total solids

Fig. 3.5 Oven

Fig 3.6 Dessicator

Fig 3.7 Balance

3.5.3 Acidity

Acidity is of important considerations in determining whether removal by aeration or simple neutralisation with lime will be chosen as the treatment method. Carbon dioxide is of important considerations in determining whether removal by aeration or simple neutralisation with lime soda ash or NaOH will be chosen as the water treatment method. The size of equipment, chemical requirements, storage spaces and cost of the treatment all depends on the carbon dioxide present. Aquatic life is affected by high water acidity. The organisms present are prone to death with low pH of water. Water containing mineral acidity is not fit for drinking purposes.

APPARATUS USED

- Pipette – Minimum 100 ml. capacity
- Conical flask
- A burette

PROCEDURE

- 100 ml. of the sample was pippeted into an Erlenmeyer flask.
- Then 3 drops of phenolphthalein indicator was added.
- 0.02N sodium hydroxide from burette was added until the first permanent pink color appears and the no. of ml. of sodium hydroxide used was recorded

CALCULATION

ml.of 0.02N sodium hydroxide × 10 = p.p.m. total acidity expressed in terms of $CaCO_3$

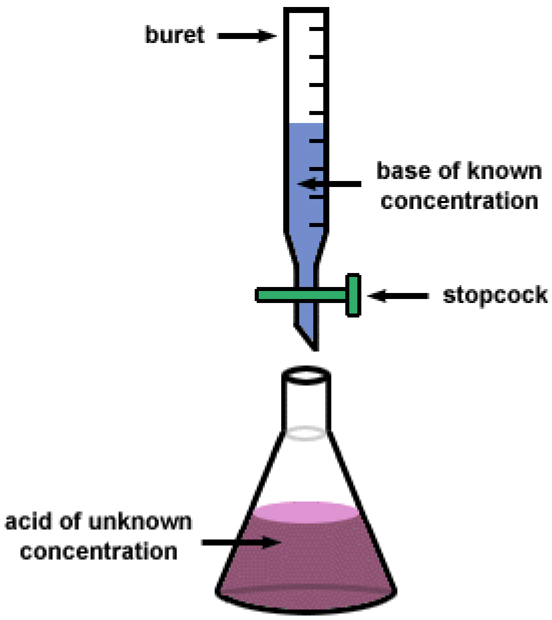


Fig 3.8 Titration of Acidity

3.5.4 Alkalinity

The principle objection of alkaline water is the reactions that can occur between alkalinity and certain cations in water. The resultant precipitate can corrode pipes and other accessories of water distribution systems. Alkalinity is important for fish and aquatic life because it protects or buffers against rapid pH changes. Higher alkalinity levels in surface waters will buffer acid rain and other acid wastes and prevent pH changes that are harmful to aquatic life. Large amount of alkalinity imparts bitter taste in water. Wastewaters containing excess alkalinity are not to be discharged into natural water bodies or sewers.

APPARATUS USED

- Pipette – Minimum 100 ml. capacity
- Conical flask
- A burette

PROCEDURE

- 100 ml. of the sample was pipetted into the Conical flask and the same quantity of distilled water was taken into another.
- 3 drops of phenolphthalein indicator was added to each.
- If the sample shows pinkish color 0.02N sulfuric acid was added from a burette until the pink color just vanishes and no. of ml. of acid used was recorded.
- 3 drops of methyl orange indicator was added to each flask.
- If the sample becomes yellow in color, 0.02N sulfuric acid is added until the first difference in color is noted in comparison with the distilled water. If the end point is orange the no. of ml. of acid used is recorded.

CALCULATIONS

Value of P and T	Alkalinity due to		
	Hydroxyl Ions	Carbonate ions	Bicarbonate Ions
P=0	0	0	T
P< 0.5T	0	2P	T-2P
P=0.5T	0	2P	0
P>0.5T	2P-T	2P-T	0
P=T	T	0	0

Table 3.3 Types of Alkalinity

Where P is Phenolphthalein Alkalinity and T is Total Alkalinity

P= vol. of Sulfuric acid used*1000/100 , using phenolphthalein indicator

T= vol. of Sulfuric acid used*1000/100 , using methyl orange

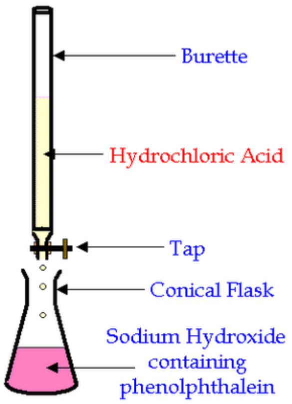


Fig 3.9 Titration of Alkalinity

3.5.5 Chlorides

Chloride is necessary for water habitats to thrive, yet high levels of chloride can have negative effects on an ecosystem. Chloride may impact freshwater organisms and plants by altering reproduction rates, increasing species mortality, and changing the characteristics of the entire local ecosystem. In addition, as chloride filters down to the water table, it can stress plant respiration and change the quality of our drinking water. It can also corrode concrete. Magnesium chloride in water generates hydrochloric acid after heating which is also highly corrosive and creates problem in boilers. Chlorides interfere in the determination of COD.

APPARATUS USED

- A burette
- A pipette

PROCEDURE

- 100 ml. of the sample was pippeted in the Conical Flask
- The same quantity of distilled water was placed into second dish for color comparison.
- 1 ml. of potassium chromate indicator was added to each.
- Standard silver nitrate solution was added to the sample from a burette, a few drops at a time, with constant alternating until the first permanent reddish coloration appears. This can be determined by comparison with the distilled water. The ml. of the silver nitrate solution used was recorded.

CALCULATION

[(Ml. of silver nitrate used) × 1000] ÷ Ml. of sample = p.p.m. chloride

3.5.6 Dissolved Oxygen

Most plants maintain about 2 mg/L of DO so the bugs contained inside the floc can also get oxygen. If the DO is less than 2 mg/L, the bugs in the centre of the floc may die since the bugs on the outside of the floc use up the DO first. If this happens, the floc breaks up. If the DO content is too low, the environment is not stable for these bugs and they will die due to anaerobic zones, the sludge will not be properly treated, and plants will be forced to conduct an expensive and time-consuming biomass replacement process. Because of this risk, many plants compensate by adding excessive amounts of DO to their process. However, when the DO levels become too high, energy is wasted, expensive aeration equipment undergoes unnecessary usage, and unwanted organisms

REAGENT LIST:

- BOD Bottles
- alkali-iodide-azide

- concentrated sulfuric acid
- starch solution
- Sodium thiosulfate .

PROCEDURE:

- Take 10 ml of sample and dilute it to 300 ml using distilled water.
- Add 1 ml of Potassium Iodide and 1ml of Manganese sulphate solution to the sample.
- To this, add 2 ml of conc. Sulphuric acid.
- Fill 2 BOD bottles with above sample.
- Shake it properly.
- Take 203 ml of this solution add 4 drops of starch. Colour will change to black.
- Titrate it with N/40 Sodium Thiosulphate.
- The amount of Sodium Thiosulphate used gives the DO of the sample.

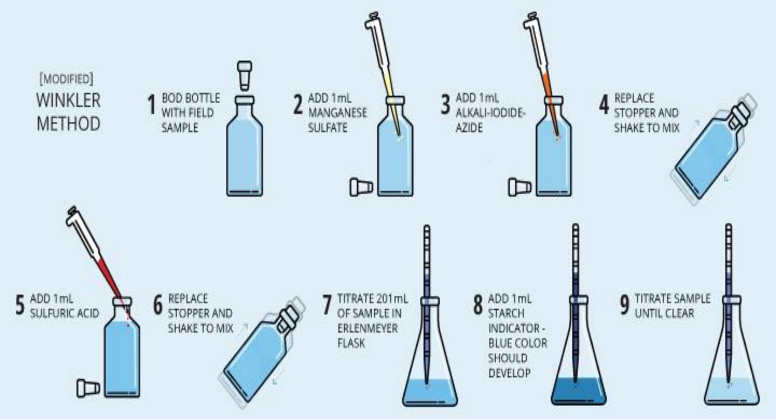


Fig 3.9 Experiment of DO

3.5.7 Biological Oxygen Demand

A high BOD indicates a high content of easily degradable, organic material in the sample and a low BOD indicates a low volume of organic materials, substances which are difficult to break down.

APPARATUS USED :

- Incubation bottles- 300 ml capacity
- Burette

PROCEDURE:

- Take 10 ml of sample and dilute it to 300 ml using distilled water.
- Add 1 ml of Potassium Iodide and 1ml of Manganese sulphate solution to the sample.
- To this, add 2 ml of conc. Sulphuric acid.
- Fill 4 BOD bottles with above sample. Keep 2 of these in the incubator and 2 are used for further steps.

- Shake it properly.
- Take 203 ml of this solution add 4 drops of starch. Colour will change to black.
- Titrate it with N/40 Sodium Thiosulphate.
- The amount of Sodium Thiosulphate used gives the DO of the sample.
- Repeat from 5-9 for the BOD bottles kept in incubator after 5 days.
- This gives DO on 5th day.

CALCULATION

BOD = (DO on first day – DO on fifth day)* D.F.

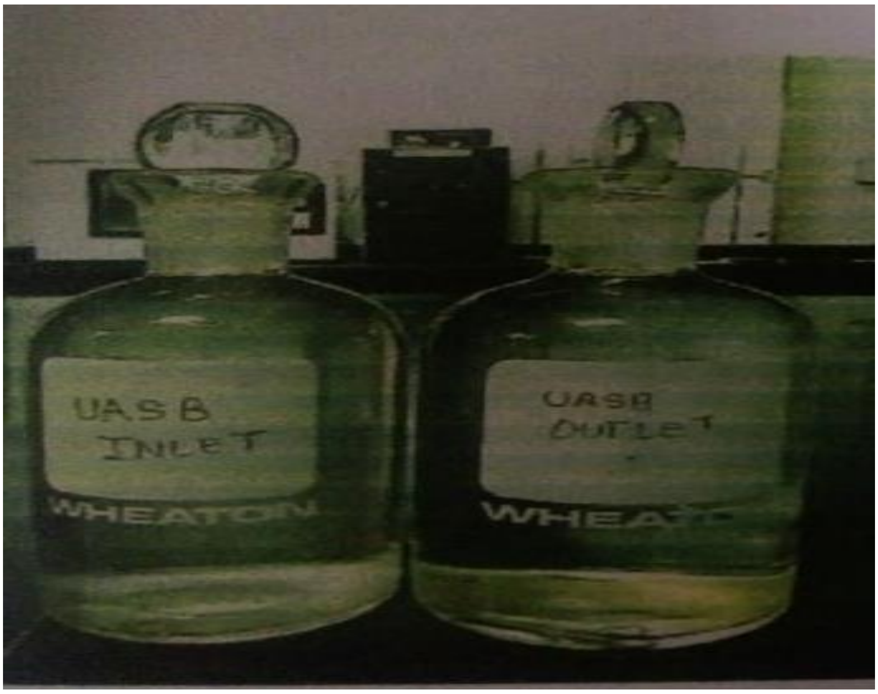


Fig 3.10 BOD Bottles

3.5.8 Chemical Oxygen Demand

In environmental chemistry, the chemical oxygen demand (COD) test is commonly used to indirectly measure the amount of organic compounds found in water. Most applications of COD determine the amount of organic pollutants found in surface water. COD values are particularly important in the surveys design to determine and control the losses of sewer systems.

APPARATUS REQUIRED

- COD Bottles
- COD Digester
- Burette

PROCEDURE

- Take 2.5 ml of sewage sample. Put it in a COD bottle.
- Add 1.5 ml of Potassium Chromate to it.
- To this add 3.5 ml of conc. Sulfuric Acid.
- Repeat these above steps with distilled water.
- Keep both COD bottles in COD Digester.
- After 2 hrs remove the bottle and add Ferroin indicator.
- Titrate it with Ferrous Ammonium Sulphate(FAS).

CALCULATIONS

COD = (B-S)*0.1*8*1000/ml. of sample

B = vol. of FAS used for distilled water

S= vol. of FAS used for sample

Fig 3.12 COD Apparatus

4.1 Results for Dhalli STP

The following table shows the influent and effluent characteristics of both summer and winter season.

Parameters		Summer		Winter	
		Influent	Effluent	Influent	Effluent
pH		8.3	7.7	8.2	7.3
BOD		254 mg/l	21 mg/l	198 mg/l	29 mg/l
DO		0.63 mg/l	4.25 mg/l	1.26 mg/l	5.16 mg/l
Alkalinity	HCO_3^-	450 mg/l	340 mg/l	253 mg/l	110 mg/l
	CO_3^{2-}	0	0	0	0
	OH^-	0	0	0	0
Acidity		132 mg/l	75 mg/l	110 mg/l	40 mg/l
Total Solids	TSS	255 mg/l	79 mg/l	492 mg/l	68 mg/l
	TDS	1560 mg/l	573 mg/l	2250 mg/l	520 mg/l
Chlorides		186 mg/l	117 mg/l	180 mg/l	95 mg/l
COD		411 mg/l	81 mg/l	256 mg/l	64 mg/l

Table 4.1 Results for Dhalli STP

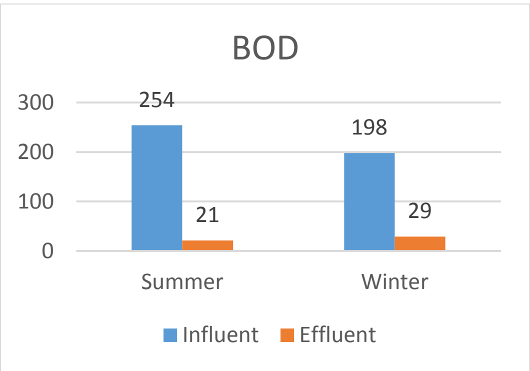


Fig. 4.1

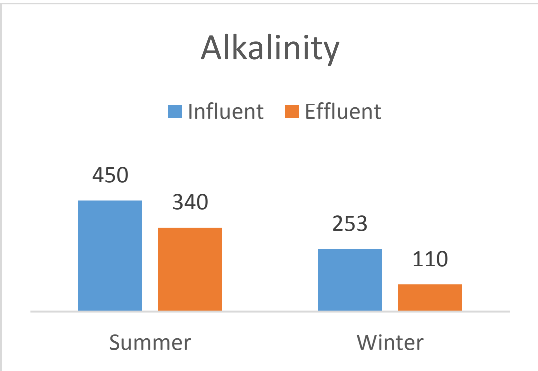


Fig. 4.2

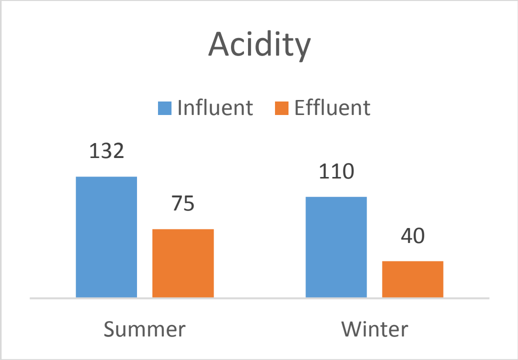


Fig. 4.3

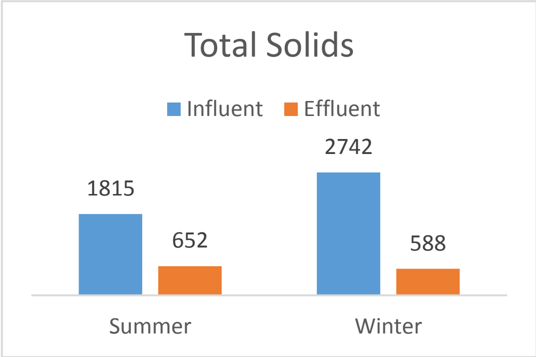


Fig. 4.4

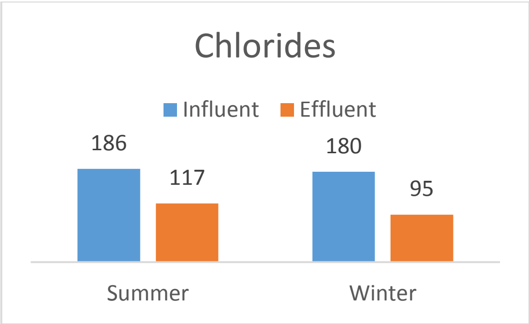


Fig. 4.5

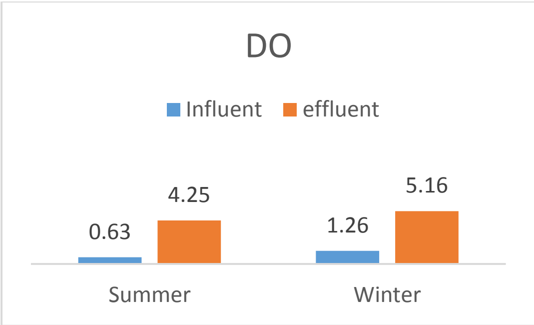


Fig. 4.6

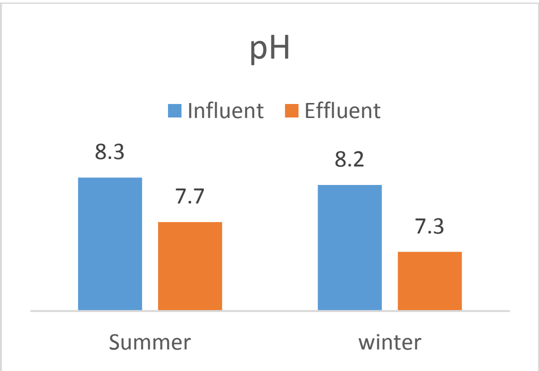


Fig. 4.7

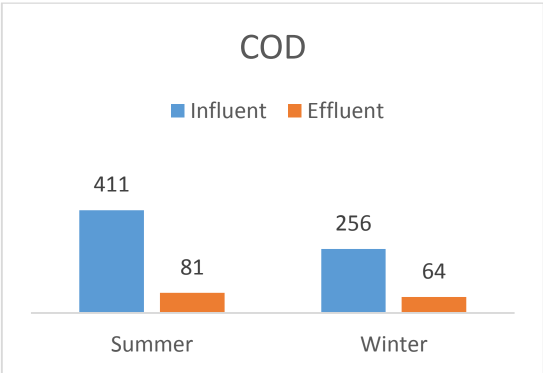


Fig. 4.8

From the above results we conclude that in summer the BOD removal efficiency was 91.73% and was 85.35% in winter which shows that the treatment plant was not working properly in winter because the bacterial action decreases due the decrease in temperature.

The effluent BOD, pH and COD of both summer and winter were within the standard limits given by Central Pollution Control Board for surface water discharge in river streams. The values are mentioned in Fig 4.1, 4.7, 4.8.

In summer the BOD concentration was more than that of in winter because Shimla experiences dry period during summer.

The above values show that the DO increases with decrease in temperature.

4.2 Results for Snowdon STP

The following table shows the influent and effluent characteristics of both summer and winter season.

Parameters		Summer		Winter	
		Influent	Effluent	Influent	Effluent
pH		8.2	7.8	8.1	7.1
BOD		247 mg/l	24 mg/l	200 mg/l	25 mg/l
DO		0.93 mg/l	4.88 mg/l	2.46 mg/l	4.56 mg/l
Alkalinity	HCO_3^-	363 mg/l	289 mg/l	310 mg/l	156 mg/l
	CO_3^{2-}	0	0	0	0
	OH^-	0	0	0	0
Acidity		188 mg/l	87 mg/l	135 mg/l	82 mg/l
Total Solids	TSS	353 mg/l	102 mg/l	270 mg/l	48 mg/l
	TDS	905 mg/l	313 mg/l	1270 mg/l	275 mg/l
Chlorides		176 mg/l	129 mg/l	203 mg/l	146 mg/l
COD		469 mg/l	70 mg/l	352 mg/l	50 mg/l

Table 4.2 Results for Snowdon STP

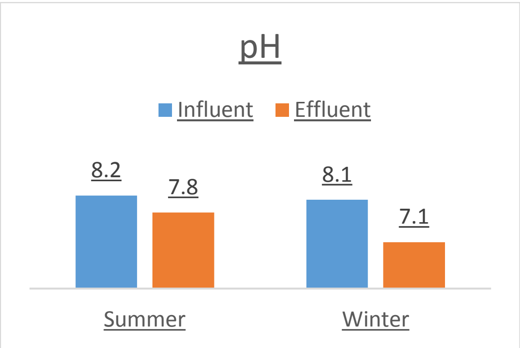


Fig. 4.9

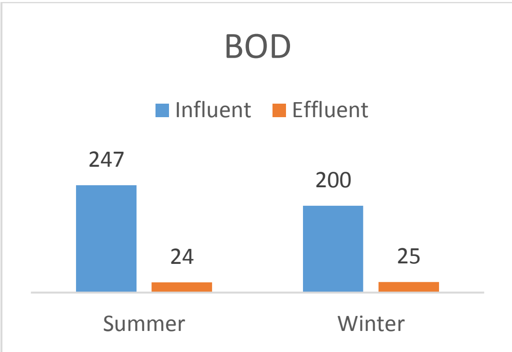


Fig. 4.10

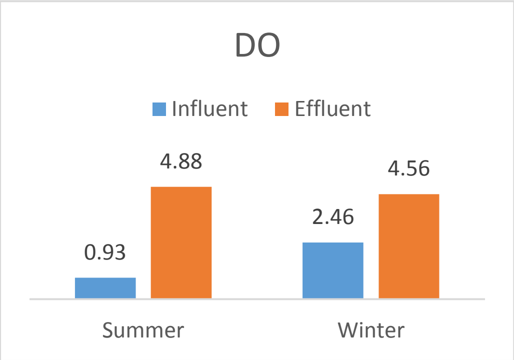


Fig. 4.11

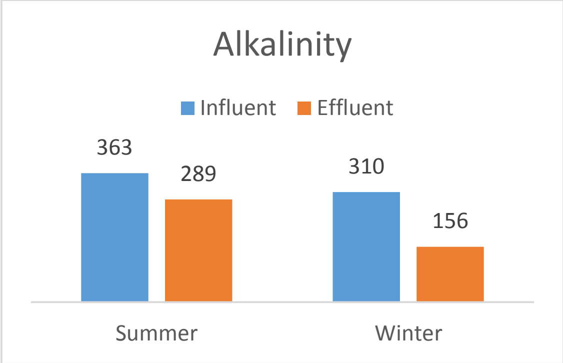


Fig. 4.12

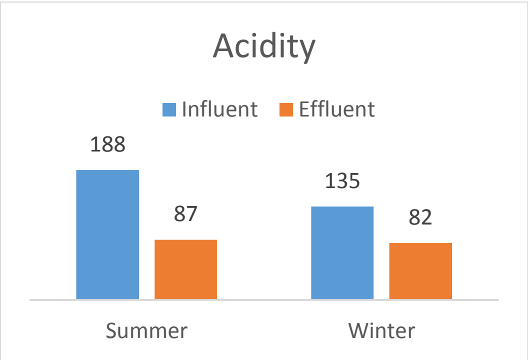


Fig. 4.13

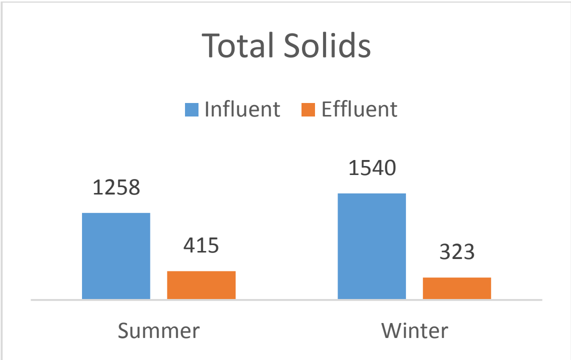


Fig. 4.14

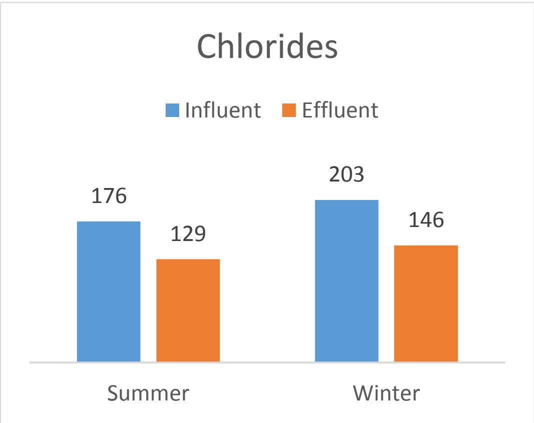


Fig. 4.15

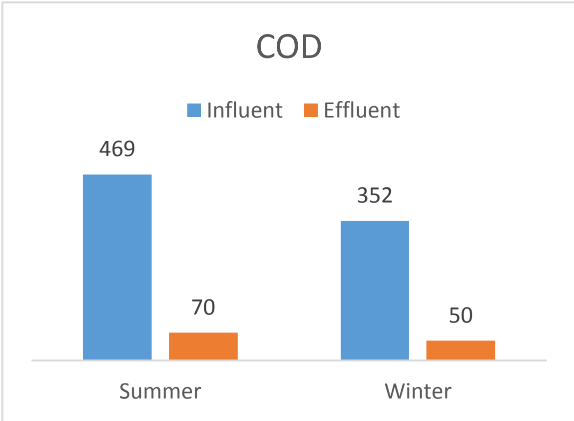


Fig. 4.16

From the above results we conclude that in summer the BOD removal efficiency was 90.28% and was 87.5% in winter which shows that the treatment plant was not working properly in winter because the bacterial action decreases due the decrease in temperature.

The effluent BOD, pH and COD of both summer and winter were within the standard limits given by Central Pollution Control Board for surface water discharge in river streams. The values are mentioned in Fig 4.9 , 4.10, 4.16.

In summer the BOD concentration was more than that of in winter because Shimla experiences dry period during summer.

The above values show that the DO increases with decrease in temperature.

4.3 Results for Lalpani STP

The following table shows the influent and effluent characteristics of both summer and winter season.

Parameters		Summer		Winter	
		Influent	Effluent	Influent	Effluent
pH		8.1	7.5	7.3	7.6
BOD		220 mg/l	40 mg/l	192 mg/l	35 mg/l
DO		1.44 mg/l	5.26 mg/l	0.87 mg/l	3.85 mg/l
Alkalinity	HCO_3^-	309 mg/l	281 mg/l	520 mg/l	319 mg/l
	CO_3^{2-}	0	0	0	0
	OH^-	0	0	0	0
Acidity		190 mg/l	82 mg/l	250 mg/l	93 mg/l
Total Solids	TSS	1177.5 mg/l	88.3 mg/l	1000 mg/l	350 mg/l
	TDS	737.5 mg/l	621.67 mg/l	2500 mg/l	1000 mg/l
Chlorides		190 mg/l	146 mg/l	143 mg/l	67 mg/l
COD		832 mg/l	320 mg/l	768 mg/l	64 mg/l

Table 4.3 Results for Lalpni STP

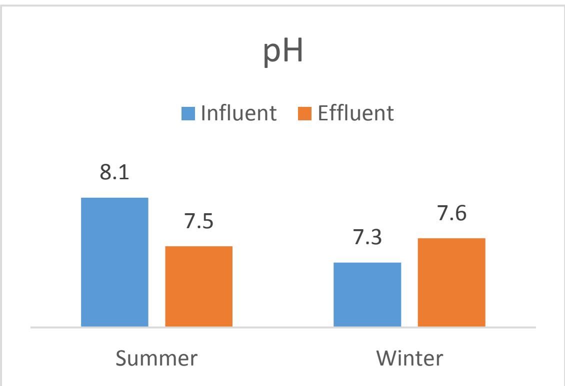


Fig. 4.17

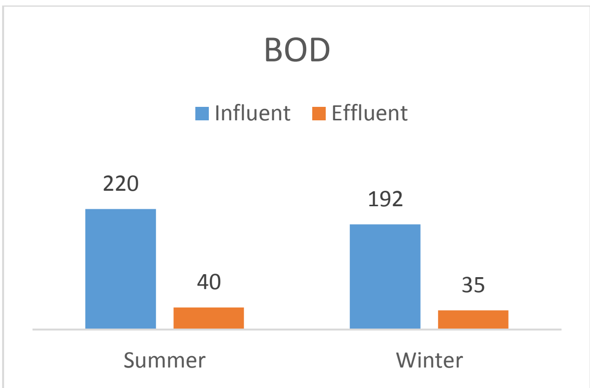


Fig. 4.18

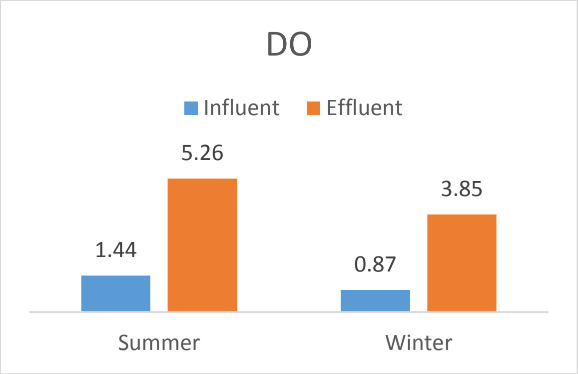


Fig. 4.19

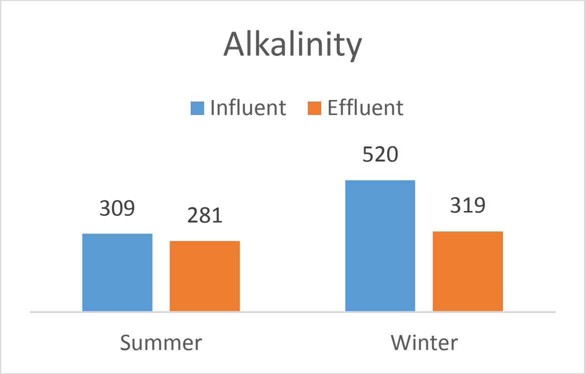


Fig. 4.20

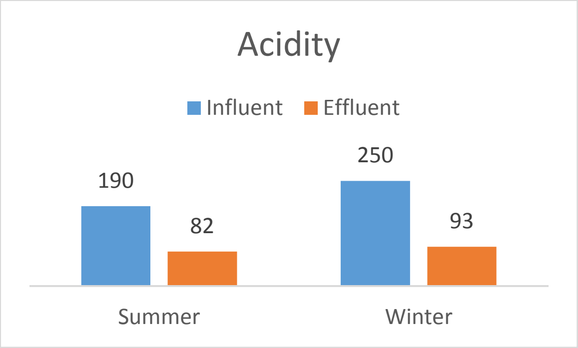


Fig. 4.21

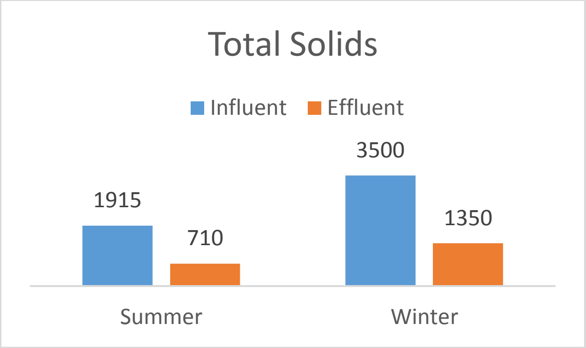


Fig. 4.22

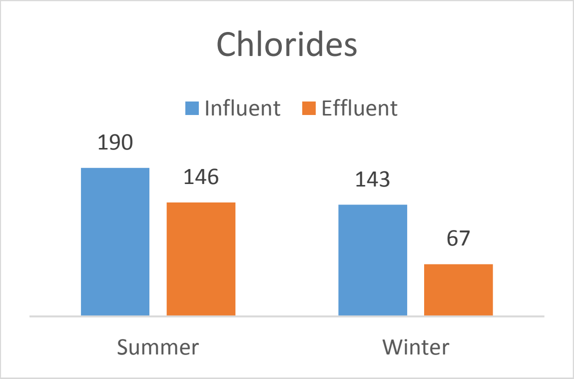


Fig. 4.23

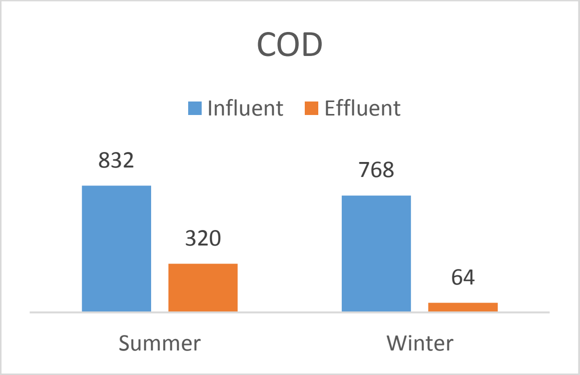


Fig. 4.24

From the above results we conclude that in summer the BOD removal efficiency was 91.73% and was 85.35% in winter which shows that the treatment plant was not working properly in winter because the bacterial action decreases due the decrease in temperature.

The effluent BOD, DO and COD obtained were not within the standard limits given by the Central Pollution Control Board. This may have been because of experimental errors or the plant was not working properly. The pH values obtained were within the limits. (Fig 4.17, 4.18,4.24).

In summer the BOD concentration was more than that of in winter because Shimla experiences dry period during summer.

4.4 Results for Malyana STP

The following table shows the influent and effluent characteristics of both summer and winter season.

Parameters		Summer		Winter	
		Influent	Effluent	Influent	Effluent
pH		7.8	7.5	8.1	7.5
BOD		320 mg/l	40 mg/l	267 mg/l	45 mg/l
DO		.97 mg/l	3.23 mg/l	1.38 mg/l	5.11 mg/l
Alkalinity	HCO_3^-	355 mg/l	212 mg/l	401 mg/l	317 mg/l
	CO_3^{2-}	0	0	0	0
	OH^-	0	0	0	0
Acidity		166 mg/l	77 mg/l	150 mg/l	83 mg/l
Total Solids	TSS	2159 mg/l	889 mg/l	2453 mg/l	657 mg/l
	TDS	917 mg/l	633 mg/l	963 mg/l	546 mg/l
Chlorides		191 mg/l	113 mg/l	168 mg/l	104 mg/l
COD		568 mg/l	76 mg/l	407 mg/l	80 mg/l

Table 4.4 Results for Malyana STP

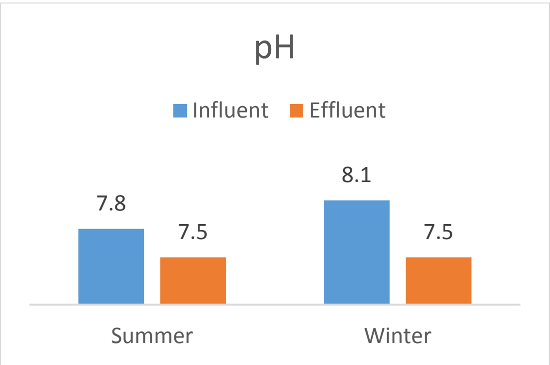


Fig. 4.25

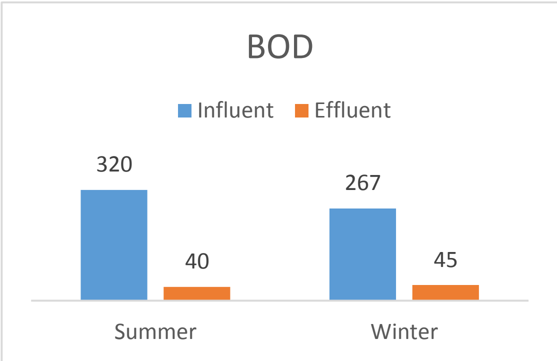


Fig. 4.26

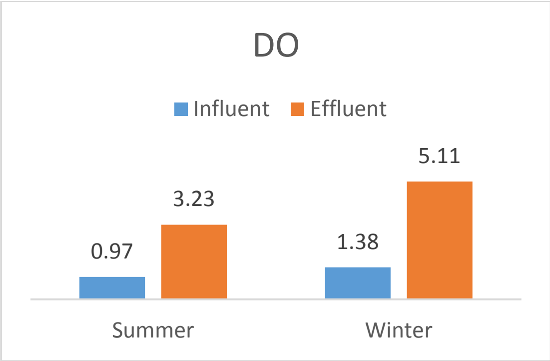


Fig. 4.27

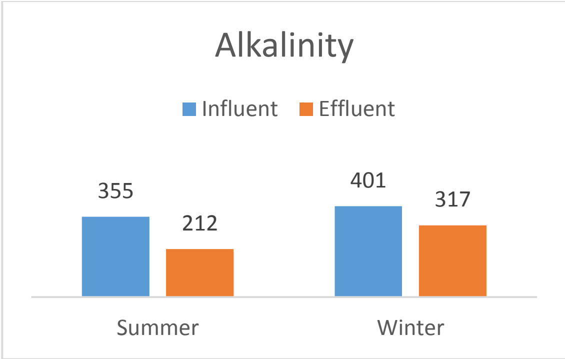


Fig. 4.28

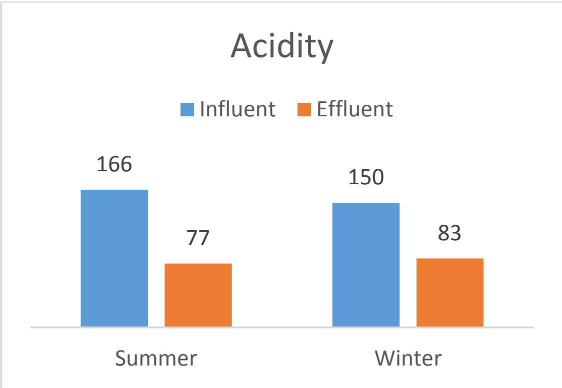


Fig. 4.29

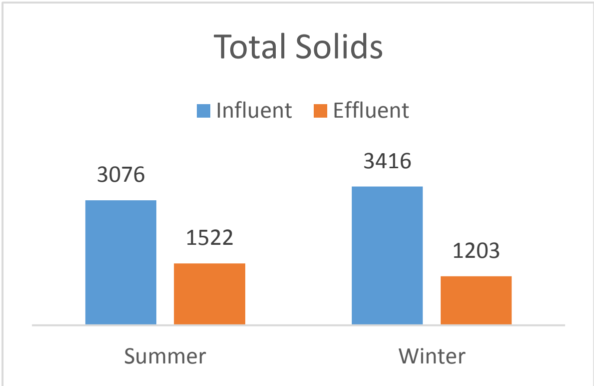


Fig. 4.30

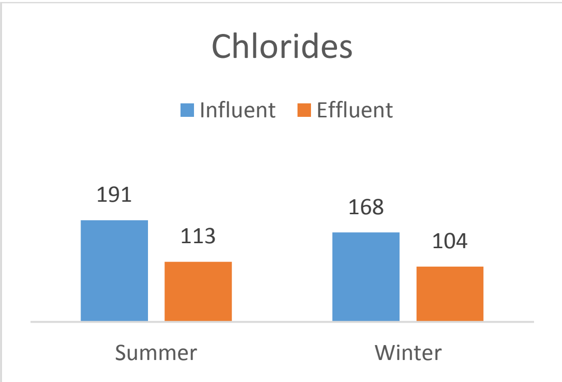


Fig. 4.31

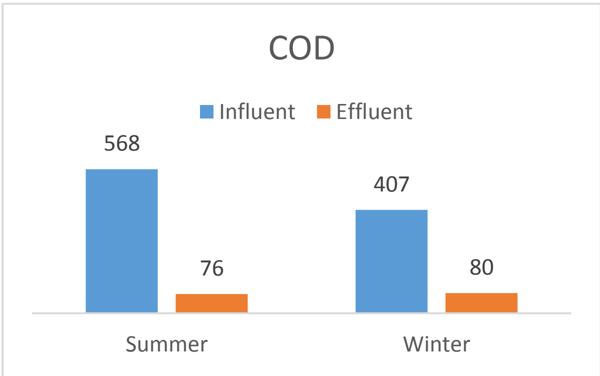


Fig. 4.32

From the above results we conclude that in summer the BOD removal efficiency was 87.5% and was 83% in winter which shows that the treatment plant was not working properly in winter because the bacterial action decreases due the decrease in temperature.

The effluent pH and COD of both summer and winter were within the standard limits given by Central Pollution Control Board for surface water discharge in river streams. The values are mentioned in Fig 4.25, 4.32.

In summer the BOD concentration was more than that of in winter because Shimla experiences dry period during summer.

The above values show that the DO increases with decrease in temperature.

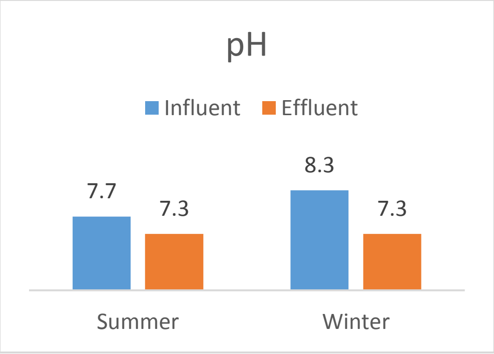
The effluent BOD of both summer and winter were not within the standard limits. It may have been due to experimental errors or the plant was not working properly (Fig 4.26)

4.5 Result for Summer Hill STP

The following table shows the influent and effluent characteristics of both summer and winter season.

Parameters		Summer		Winter	
		Influent	Effluent	Influent	Effluent
pH		7.7	7.3	8.3	7.3
BOD		220 mg/l	27 mg/l	183 mg/l	28 mg/l
DO		1.09 mg/l	3.93 mg/l	1.5 mg/l	4.4 mg/l
Alkalinity	HCO_3^-	383 mg/l	259 mg/l	320 mg/l	285 mg/l
	CO_3^{2-}	0	0	0	0
	OH^-	0	0	0	0
Acidity		215 mg/l	86 mg/l	197 mg/l	98 mg/l
Total Solids	TSS	909 mg/l	306 mg/l	756 mg/l	158 mg/l
	TDS	967 mg/l	663 mg/l	1113 mg/l	457 mg/l
Chlorides		187 mg/l	98 mg/l	175 mg/l	130 mg/l
COD		468 mg/l	59 mg/l	458 mg/l	65 mg/l

Table 4.5 Results for Summer Hill STP



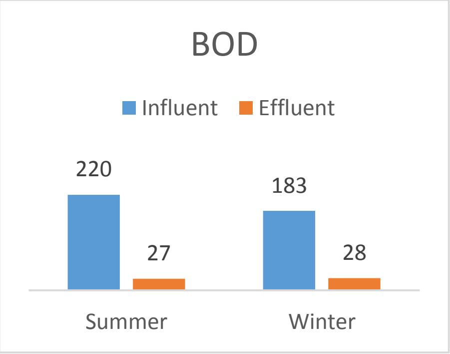


Fig. 4.33

Fig. 4.34

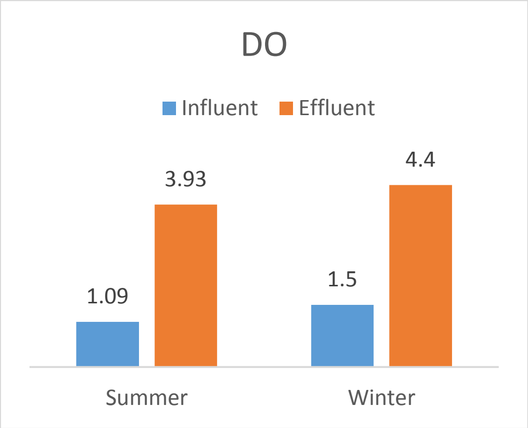


Fig. 4.35

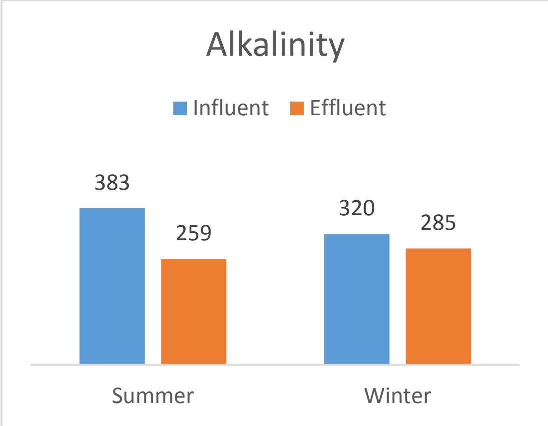


Fig. 4.36

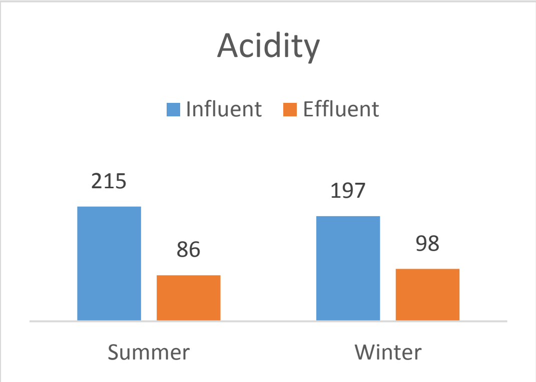


Fig. 4.37

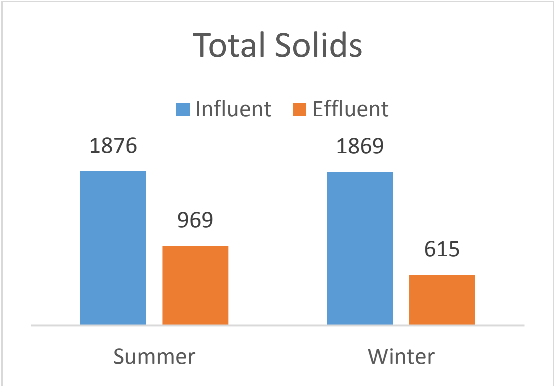


Fig. 4.38

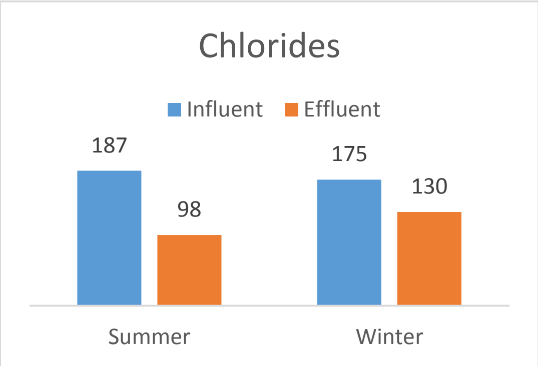


Fig. 4.39

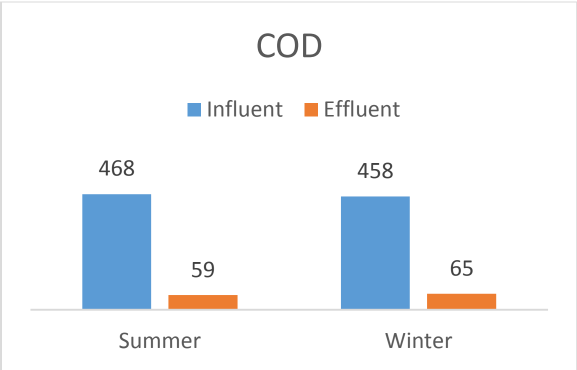


Fig. 4.40

From the above results we conclude that in summer the BOD removal efficiency was 87.84% and was 84.6% in winter which shows that the treatment plant was not working properly in winter because the bacterial action decreases due the decrease in temperature.

The effluent BOD, pH and COD of both summer and winter were within the standard limits given by Central Pollution Control Board for surface water discharge in river streams. The values are mentioned in Fig 4.33, 4.34, 4.40.

In summer the BOD concentration was more than that of in winter because Shimla experiences dry period during summer.

The above values show that the DO increases with decrease in temperature.

4.6 Results for North Disposal STP

The following table shows the influent and effluent characteristics of both summer and winter season.

Parameters		Summer		Winter	
		Influent	Effluent	Influent	Effluent
pH		7.6	7.4	8.1	7.4
BOD		353 mg/l	36 mg/l	196 mg/l	33 mg/l
DO		1.17 mg/l	4.12 mg/l	1.03 mg/l	2.83 mg/l
Alkalinity	HCO_3^-	449 mg/l	313 mg/l	357 mg/l	273 mg/l
	CO_3^{2-}	0	0	0	0
	OH^-	0	0	0	0
Acidity		151 mg/l	91 mg/l	165 mg/l	80 mg/l
Total Solids	TSS	703 mg/l	153 mg/l	417 mg/l	63 mg/l
	TDS	2153 mg/l	856 mg/l	1879 mg/l	588 mg/l
Chlorides		154 mg/l	79 mg/l	183 mg/l	128 mg/l
COD		472 mg/l	50 mg/l	475 mg/l	69 mg/l

Table 4.6 Results for North Disposal STP

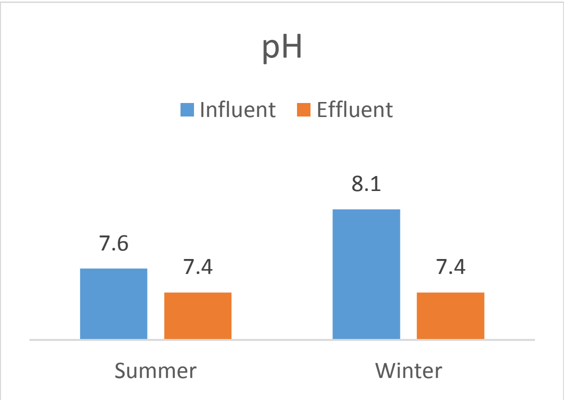


Fig. 4.41

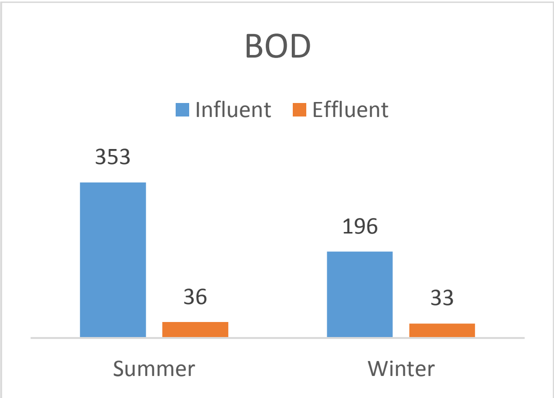


Fig. 4.42

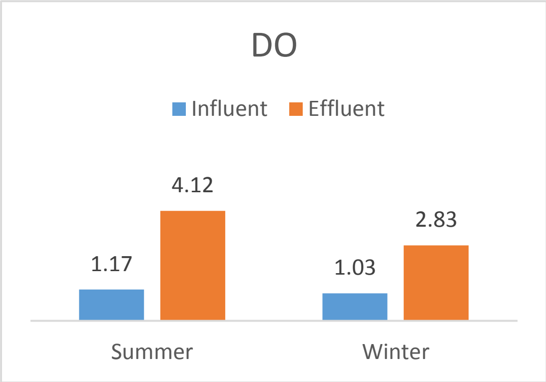


Fig. 4.43

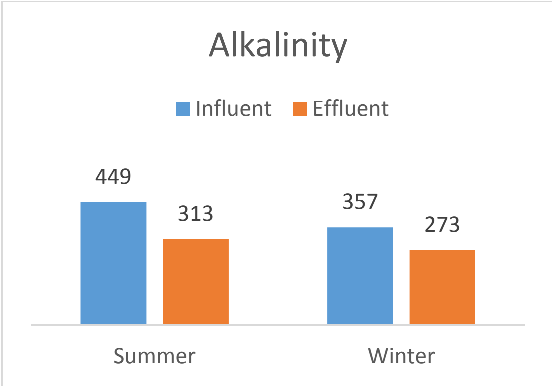


Fig. 4.44

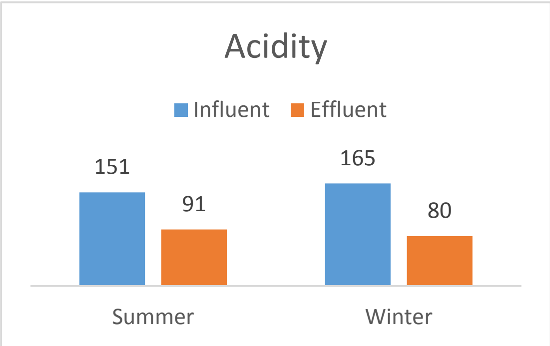


Fig. 4.45

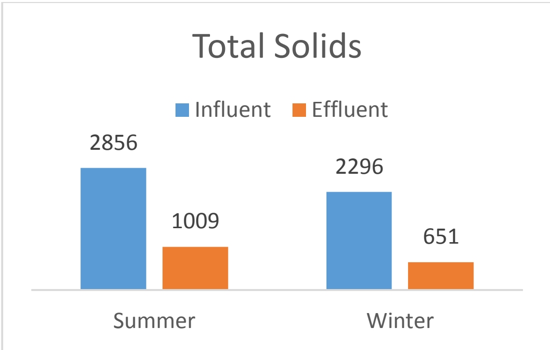


Fig. 4.46

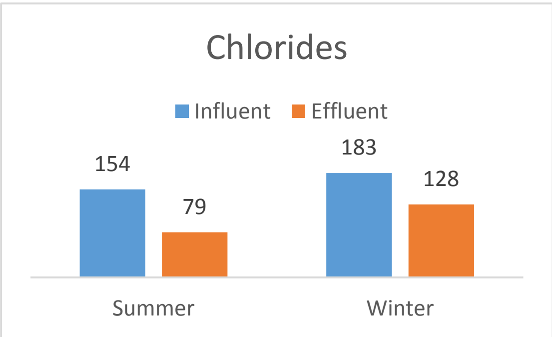


Fig. 4.47

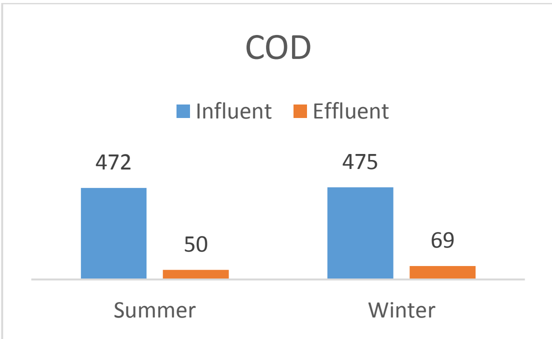


Fig. 4.48

From the above results we conclude that in summer the BOD removal efficiency was 90% and was 83.1% in winter which shows that the treatment plant was not working properly in winter because the bacterial action decreases due the decrease in temperature.

The effluent pH and COD of both summer and winter were within the standard limits given by Central Pollution Control Board for surface water discharge in river streams. The values are mentioned in Fig 4.41, 4.48.

In summer the BOD concentration was more than that of in winter because Shimla experiences dry period during summer.

The effluent BOD values were slightly greater than the prescribed limit.

Chapter 5 CONCLUSION

- Since BOD5 is about 68% of ultimate BOD we can easily state that the BOD5/COD ratio for fully biodegradable wastewater vary between 0.63 to 0.68. Any wastewater having BOD/COD ratio greater than 0.63 can hence be considered to be quite amenable for biological treatment.

- The BOD/COD ratio values of all six STP lie in range of 0.3-0.7 which indicates the presence non-biodegradable waste present in the influent. In certain cases BOD/COD was less than 0.3.

- As per the BOD values obtain from influent of six STPs we can conclude that sewage entering STPs was of medium to high strength which can be easily treated in the facilities available in STPs.

- Lower sewage would tend to increase viscosity and solubility of oxygen and decrease settling rate. Oxygen transfer rate, microbial growth and rate of all biological process. Effect of temperature is major factor affecting all physio-chemical and biological (aerobic and anaerobic) processes.

- Higher temperature of sewage in summer generally leads to an increase in metabolic activities. In Activates Sludge Process all biochemical reactions rates such as organic substrate utilisation, production of biomass cells (MLVSS) maintenance energy requirements, oxygen utilisation, BOD removal efficiency, nitrification follows Arrhenis relationship over temperature range 5-25° C. Consequently decrease in temperature during winter period would tend to have adverse effect on all above biochemical transformations.

- Activated Sludge MLSS in ASP/EA requires longer period to acclimatize to changes in temperature during cold weather operations. Temperature changes also have significant effect on the composition of bacterial biomass (MLSS) and its settling behaviour.

- Extended Aeration 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 therby eliminating sludge handling equipment.

- Extended Aeration requires higher HRT entailing higher aeration tank volume (3-5 times), higher MLSS (3000-5000 vs 2000-3000 mg/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 stabilised sludge as major considerations.

- Conventional Activated Sludge process will require smaller aeration tank compared to extended aeration, based on this criteria ASP would certainly be attractive in terms of lower land requirement compared to extended aeration process.

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

SCOPE FOR FUTURE WORK

In planning of any city sanitation plan is the most important according to the point of view of public health and other parameters for beautification of the city so the sanitation planning plays an important role in planning the 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 new phases in the city.

Our project is mainly based on collection of sewage sample from sewage treatment plants present in Shimla namely Lalpani, Malyana, Dhalli, North Disposal, Summer Hill, Snowdon.

In this project we have visited all six plants and collected the samples which is used to calculate the performance of plants and other parameters to evaluate and compare the performance of several STPs 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

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°C above the receiving water temperature	--	--	shall not exceed 5°C above the receiving water temperature

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

S. No.	Parameter	Standards			
		Inland surface water	Public Sewers	Land for irrigation	Marine coastal areas
1	2	3			
		(a)	(b)	(c)	(d)
19.	Total chromium (as Cr.) mg/l, Max.	2.0	2.0	--	2.0
20.	Copper (as Cu) mg/l, Max.	3.0	3.0	--	3.0
21.	Zinc (As Zn.) mg/l, Max.	5.0	15	--	15
22.	Selenium (as Se.) mg/l, Max.	0.05	0.05	--	0.05
23.	Nickel (as Ni) mg/l, Max.	3.0	3.0	--	5.0
[1]24.	* * *	*	*	*	*
[1]25.	* * *	*	*	*	*
[1]26.	* * *	*	*	*	*
27.	Cyanide (as CN) mg/l Max.	0.2	2.0	0.2	0.2
[1]28.	* * *	*	*	*	*
29.	Fluoride (as F) mg/l Max.	2.0	15	--	15
30.	Dissolved Phosphates (as P), mg/l Max.	5.0	--	--	--
[2]31.	* * *	*	*	*	*
32.	Sulphide (as S) mg/l Max.	2.0	--	--	5.0
33.	Phenoile compounds (as C_6H_5OH) mg/l, Max.	1.0	5.0	--	5.0

S. No.	Parameter	Standards			
		Inland surface water	Public Sewers	Land for irrigation	Marine coastal areas
1	2	3			
		(a)	(b)	(c)	(d)
34.	Radioactive materials :				
	(a) Alpha emitter micro curie/ml.	10^{-7}	10^{-7}	10^{-8}	10^{-7}
	(b) Beta emitter micro curie/ml.	10^{-6}	10^{-6}	10^{-7}	10^{-6}
35.	Bio-assay test	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent
36.	Manganese (as Mn)	2 mg/l	2 mg/l	--	2 mg/l
37.	Iron (as Fe)	3 mg/l	3 mg/l	--	3 mg/l
38.	Vanadium (as V)	0.2 mg/l	0.2 mg/l	--	0.2 mg/l
39.	Nitrate Nitrogen	10 mg/l	--	--	20 mg/l
[1]40.	* * *	*	*	*	*