Performance Analysis of Existing Sewage Treatment Plants in Himachal Pradesh

A Thesis

Submitted in the partial fulfillment of the requirements for the award of degree

of

MASTER OF TECHNOLOGY

IN

CIVIL ENGINEERING

With specialization in

ENVIRONMENTAL ENGINEERING

By

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WAKNAGHAT SOLAN – 173234 HIMACHAL PRADESH, INDIA, May, 2018

CERTIFICATE

This is to certify that the work which is being presented in the report title **"Performance Analysis of Existing Sewage Treatment Plants in Himachal Pradesh"** in the fulfillment of the award of degree of Master of Technology in Civil Engineering with specialization in **Environmental Engineering** and submitted in Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentication record of work carried by **Himanshu Dewan (162753)** during a period from August 2017 to May 2018 under the supervision of **Dr. Rajiv Ganguly**, Associate Professor, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

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

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ABSTRACT

Sewage is one of the most important factors for environment degradation as it contains variety of organic and inorganic constituents which degrade the environment. So, effective treatment of sewage is very crucial for healthy life. This study performed is based on the performance analysis of 30 existing domestic wastewater treatment plants in Himachal Pradesh. Extended aeration with mechanical aerators and diffused aeration system is the conventional technology used. Only physio-chemical parameters were tested and considered. Side by side, seasonal variation of STPs is also performed as temperature is one of the main factors which are very much responsible for the effective working of the micro-organisms. The study is based on two methods i.e. General efficiency method and Effluent Quality Index method. The objective of this project is to calculate the efficiencies of the STPs studied and provide with the ranking according to the most efficient plants. The analysis concludes that various plants treatment efficiency is not up to the level and needs urgent up gradation so as to meet the new effluent quality standards as per CPCB. According to General actual efficiency method, Kunihar ranks 1st with the removal efficiency of 90.69% and NIT Hamirpur lacks with the removal efficiency of 57.29%. As per Effluent quality method, Ghumarwin ranks 1st with the effluent quality index of 37.23 and can be used for recreational purposes. This study also concludes that Effluent quality index is one of the best methods to be used for effluent reuse.

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Himanshu Dewan

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LIST OF ABBREVIATIONS

STP	Sewage Treatment Plant
I&PH	Irrigation & Public Health Department
HPPCB	Himachal Pradesh Pollution Control Board
CPCB	Central Pollution Control Board
MLD	Million liters per day
LPCD	Liters per capita per day
DAF	Diffused Aeration System
ETP	Effluent Treatment Plant
DWT	Domestic Wastewater Treatment
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
TSS	Total Suspended Solids
DO	Dissolved Oxygen
ASP	Activated Sludge Process
MBBR	Moving Bed Biofilm Reactor
UASB	Upflow Anaerobic Sludge Blanket
°C	degree Celcius

CHAPTER 1

INTRODUCTION

1.1 Wastewater Treatment

Domestic wastewater coming from residual community includes toilet, bathing, laundry, sinks etc. It contains macrobiotic and inert constituents [1]. Domestic wastewater treatment (DWT) is used to remove these biological and inert constituents from the sewage to avoid human and environment health from pollution.

1.1.1 Primary Treatment

Primary treatment is used to remove coarse solids, large materials like plastics, scum like oil and grease from the wastewater as these materials can reduce the efficient working of the treatment system and the treatment units. These materials can create problems in operating and maintaining the subsequent treatment units. The primary treatment involves screening, grit elimination and flow measurement devices (partial flume) [2].

It also consist of holding sewage temporarily in an inactive basin to allow the heavy solids to settle the bottom and the scum and grease etc lighter than water can float and are removed.

1.1.2 Secondary Treatment

This process is the most important process in wastewater treatment as this process is involved in the removal of suspended and dissolved organic and inorganic matter. Most of the water-borne pathogens are removed by secondary treatment. Secondary treatment is well-known as biological treatment, as this process involves deterioration of biological matter with the help of bacteria. Biological process can opt aerobic or anaerobic process of treatment or combination of both. Conventional activated sludge process is mostly used but anaerobic process is achieving attractiveness in domestic sewage treatment as is responsible to remove large fraction of biological matter [3].

1.1.3 Tertiary Treatment

As the effluent from treatment plant is released into streams or river which can further be reused, the secondary treatment removes only 60 to 70 % of BOD, 55 to 65% of COD, more treatment is required to make is suitable for reuse. Disinfectants are added after secondary treatment to compose it suitable for reuse. Microfiltration, reverse osmosis, ultra filtration etc are some of the processes to be used if water is used for drinking.

1.2 Need of the Study

- Sewage is one of the most imperative factors for environment degradation, so more emphasis is laid for its treatment and proper discharge.
- Suggesting methods for increasing the efficiency of STPs.
- Determination of the best technology for providing effluent of good quality.
- Reuse of the effluent for different prospective depending upon the superiority of the effluent.
- The existing STPs needs up gradation as per the new CPCB effluent quality standards.

1.3 Objectives

The objective of the project is to draw the comparison between performances of sewage treatment schemes in Himachal Pradesh and other objectives are written below:

- To study the technologies adopted for Domestic Sewage Treatment in Himachal Pradesh and compare it with State-of –Art technologies.
- To access the performance of existing Domestic Wastewater Treatment Schemes in Himachal Pradesh through various techniques.
- To suggest appropriate methods/technologies for improvement in the performances of STPs.

CHAPTER 2

LITERATURE REVIEW

2.1 Wastewater Treatment History

Many things have been written about water supply system history, but there is lack of information regarding wastewater management. Lack of sanitation system affects the human and environment health to a greater extent. Back to 20,000 years, the first human race communities were stretch over wide areas of land and the waste they produce was straightaway returned to the earth and was decomposed due to natural digestion cycle. Back to 10,000 years, after the birth of first advance human civilization, the discarding of domestic waste was managed through digging holes in the land and covered after use, as is defined by Mosaic Law of Sanitation (Deuteronomy; chapter 23).

Due to insufficient earlier records, it was difficult to foretell the health of ancient communities [4],[5].

Wastewater treatment has followed a very troubling path to enter proper supervision, due to the reason of not understanding the economic benefits of wastewater management and practices. The developed nations are excelling in wastewater treatment and are advancing from basic wastewater treatment techniques. The future scope is of producing sufficient quality of effluent so that it can be reused directly as there will be scarcity of water. The studies show that the wastewater management practices, economic conditions and public health have improved so far [6].

2.2 Wastewater Treatment

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2.3 Aerobic Treatment

Aerobic wastewater treatment process involves deterioration of biological matter with the help of naturally occurring micro-organisms in the presence of oxygen. Oxygen is one of the chief components in aerobic treatment which helps in the abolition of biological matter. These bacteria, fungi and other micro-organisms feed on the biological material in the existence of oxygen to reduce the level of biochemical oxygen demand (BOD), chemically oxygen demand (COD) and total suspended (TSS) and dissolved solids (TDS). These reactors are highly engineered. Proper hydraulic retention time (HRT) helps in reducing the organic matter as it provides sufficient time for the micro-organisms to feed on the organic matter. Dissolved oxygen (DO), if found insufficient can be provided by means of mechanical aerators and diffused aeration system (DAS). These systems help in maintaining sufficient amount of oxygen in the tank for the micro-organisms to act as work horses for wastewater [7].

2.3.1 Extended Aeration

Extended aeration process is the up gradation of conventional activated sludge process which is based on deterioration of organic matter in the existence of aerobic environment. In this process the hydraulic retention time (HRT) is kept more as of conventional activated sludge system so that micro-organisms get enough time to feed on the organic matter. The aeration is implemented by mechanical way or compressed air so as to provide enough amount of dissolved oxygen to the microbes. pH is one of the most important factor in biological process, so it must be maintained to provide proper aerobic environment in the reactor for the working of the micro-organisms [2].

Extended aeration process consists of the following chambers:

1) Inlet Chamber
2) Screen Chamber
3) Grit Removal Chamber
4) Aeration Reactor
5) Secondary Sedimentation Tank

6) Recycle Sludge System
7) Sludge Digester
8) Sludge Drying Beds

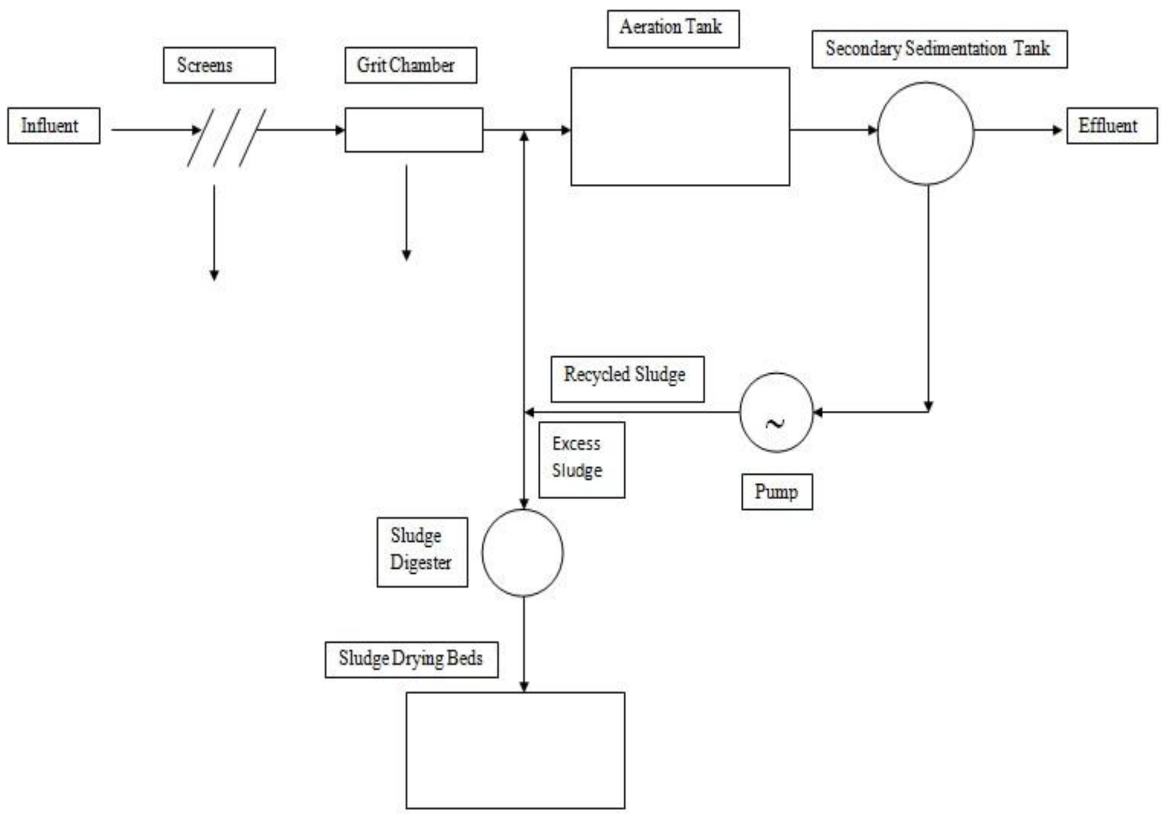

Figure 2.1 Flow Sheet of Extended Aeration Process

2.3.2 Diffused Aeration System

Diffused aeration system is the process of releasing air or oxygen into aeration tank. Diffused aeration system serves two purposes:

1) Transfer of oxygen into liquid phase from gaseous phase thus providing sufficient Dissolved oxygen [8].
2) Keeping the micro-organisms in suspension and prevent them from settling.

The most common diffused aeration system is matrix of perforated pipes. These openings can be coarse or fine. The effectiveness of fine bubble aeration process is more as compared to coarse bubble aeration system but one of the drawbacks of fine bubble aeration process is clogging of pores and thus requires regular maintenance [9], [10].

2.4 Anaerobic Process

Anaerobic process is the elimination of biological stuff in the dearth of oxygen. Anaerobic Digestion (AD) has gained importance since 1980s and has been implemented to various types of wastes such as solid, liquid and gases. Septic tanks are one of the basic examples of anaerobic digestion. But alone anaerobic digestion does not work efficiently. In combination, another technology, mostly aerobic is used to make it work efficiently [3].

Anaerobic digesters focus on renewable environmental protection and resource conservation (EPRC). Anaerobic processes of biological treatment have been proved useful in removing organic load and sludge management. Anaerobic process of organic waste result in the formation of biogas out of which methane can extensively used as source of energy. Up flow anaerobic sludge blanket (UASB) is the main common technology used as anaerobic process of treatment [3].

2.4.1 Upflow Anaerobic Sludge Blanket (UASB)

Many anaerobic technologies such as anaerobic contact reactor, UASB etc. are used for wastewater treatment. But UASB has excelled in all the anaerobic technologies and is used in treating variety of effluents from dairy, pulp and paper, coffee processing, chemical and sugar industries [12].

Influent wastewater after passing from primary treatment such as screening and grit deletion is permitted to bypass throughout the bottom of the cylindrical tank and flows upward and passes through biological suspended sludge blanket which acts as filter to treat influent wastewater, in the structure of granules of diameter 1mm to 3 mm.

Under anaerobic conditions, the organic matter being degraded produce biogas (particularly methane and carbon dioxide). These gases are responsible to maintain biological granules.

There is gas-liquid-solid separator at the crown of the reactor which separates gaseous, liquid and solid part present in wastewater.

The biogas gets stored in the inverted-cone and the solids retain back in the reactor system. The unsoiled effluent is discharged from the crown of the reactor and is passes to aerobic treatment (if required) for further treatment. Some portion of the treated effluent is used as recycle to maintain bacteria in the reactor.

After use for several weeks, larger particles of sludge act as filter for slighter particles as effluent rises. There is accumulation of granule-forming-micro-organisms due to the upward flow and the rest is washed away. The granule formation is affected by serviceable and ecological conditions of the reactor. The lack of optimum temperature conditions results in the disintegration of the granules [13].

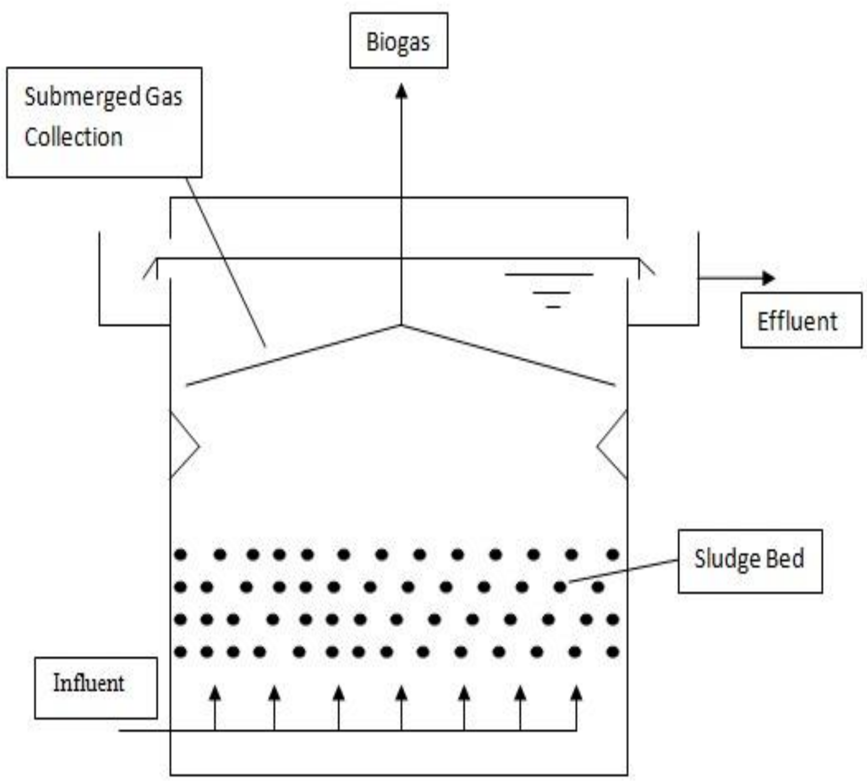

Figure 2.2 Flow scheme of UASB

2.5 Performance Analysis

The objective of the study is to determine performance of existing sewage treatment plants so that proper measures can be taken for the upgradation of the treatment systems to improve the superiority of effluent as per the effluent quality standards. Various studies have been implemented to estimate the treating effectiveness of wastewater treatment plants.

M.F. Colmenarejo et. al (2006) considered eight domestic wastewater treatment plants of small scale at Las Rozas, Madrid (Spain). These plants operated on different technologies. These plants were studied for a period of nineteen months. The technologies used are compact extended aeration, conventional activated sludge, conventional extended aeration, rotary biodisc reactor and peat bed reactor. The results concluded that the plants operating on conventional technologies of activated sludge process and extended aeration process had superior elimination efficiencies of the parameters such as BOD_5, COD, TSS and ammonia. The general efficiency of plants with conventional treatment was recorded more than 80%. The plant with peat filter bed was inadequate in treating the domestic sewage. So there is need for up gradation of such plants [14].

Jie-Chung Lou et. al (2007) conducted study on wastewater treatment plant situated along Cheng-Ching Lake in Taiwan. The author focuses on the upgradation of the treatment units to produce effluent of good quality as there is scarceness of water in Taiwan. So there is a need for water recycle and reuse. The treatment units considered are wastewater tank, sedimentation tank, sludge thickener unit and sludge dewatering unit. The removal efficiency of suspended solids and turbidity was found to be between 48.35% to 99.68% and 24.15% to 99.36% which shows there is significant removal through wastewater treatment process. Wastewater treatment units are not effective in removal of NH_3-N, total organic solids and chemical oxygen demand. Tertiary treatment like ozonation is required to remove these parameters efficiently. The reuse of supernatant is practicable during wastewater treatment process [15].

Priyanka Jamwal et. al (2009) evaluated seventeen sewage treatment plants in Delhi operated with different technologies. These STPs were examined for the period of twelve months. The technologies used are conventional activated sludge process, conventional extended aeration process and oxidation ponds. Physical, chemical and biological parameters are required to calculate the integrated efficiency of the plants. Actual and standard integrated efficiencies of the plants were compared. The results concluded that plants with extended aeration performed well except Mehrauli. The actual integrated efficiency (IG_a) of extended aeration plants were more than 98%. This also concludes that proper concern should be taken while testing and operation and maintenance of the plants should be conducted on regular basis to achieve high efficiency to meet up the effluent discharge standards. There is urgent necessitate of up gradation of treatment schemes [16].

Ravi Kumar et. al (2010) considered two treatment plants in Bangalore city with activated sludge process. Wastewater treatment plant is designed to aim elimination of biological and inorganic constituents in wastewater which pollute the human and environment health. The results concluded that both the treatment plant were incapable to treat total dissolved solids in comparison to BOD, COD and TSS. The order of removal of both the plants were TDS<COD<TSS<BOD in case of Mailasandra and TDS<COD<BOD<TSS in case of Nagasandra. Further the problems related to working and continuation of the treatment plants was also discussed [17].

Prerna Sharma et. al (2013) did comparison analysis of three existing sewage treatment plants operating on different technologies in Chandigarh city. As described by the author, Chandigarh has well planned and developed sewerage network for the transportation of domestic wastewater generated to the treatment plants. The technologies compared are Moving Bed Biofilm Reactor (MBBR), Activated Sludge Process and Upflow Anaerobic Sludge Blanket (UASB). The results concluded that the effluent parameters of STP with MBBR technology were under permissible limits and the effluent water is used for irrigation purpose in different sector gardens in Chandigarh. The effluent parameters of other two STPs were not under permissible limits. The order of removal efficiency of STP with UASB is TDS<COD<TSS<BOD, in case of ASP is TDS<TSS<BOD<COD and in MBBR is TDS<COD<TSS<BOD. The order of the preference of the technologies are MBBR>UASB>ASP [18].

Prachi N. Wakode et. al (2014) conducted a study on 25MLD domestic wastewater treatment plant situated at Kalyan, Thane working on Sequential Batch Reactor (SBR) technology. The study is performed to monitor the effluent parameters as effluent is released into Ulhas River. The STP was studied for a time interval of three months. An on-site questionnaire was conducted to study the STP. A total of thirty six samples were tested. The collections of the testing samples were obtained from inlet, circulation chamber and outlet. The results concluded that the elimination efficiency of BOD is 96%, TSS is 92.74% and total nitrogen is 75.67% and for phosphate is 71.79%. The author concluded that the higher elimination efficiency is due to the habitual maintenance of the aeration equipments [19].

Kavita N. Choksi et. al (2015) considered the STP at Surat with Activated Sludge Process as biological process for treatment. The total of six parameters was considered for the evaluation of the treatment plant. The study was conducted for two seasons i.e. winter and summer sessions. Author also determined a correlation between two of the parameters i.e. BOD and TSS with the help of regression analysis. The results concluded that the elimination efficiency for BOD was 94.84% and TSS 92.68% during winter season and 93.08% and 88.68% during summers. Individual treatment units efficiency was also studied which was found to be satisfactory. The correlation was developed between BOD and TSS for influent and removal efficiencies to study the variation in the removal of the parameters [20].

Lledo Castellet et. al (2016) found out that there is very much need to find out the efficiency of the sewage treatment plants for the betterment of the human and environment health. Performance analysis is very helpful in comparison of the technologies of the treatment and opt the best technologies so that the effluent of desired standards can be achieved. Nearly all the studies performed focus on the removal efficiencies and the operational parameters. So, this paper focuses on the environmental effects caused by the removal parameters on the environment. Weightage is assigned to the input and output parameters. The operational parameters come under input and the pollutants removed come under output. DEA technology is used to evaluate the performance of the treatment plants. The sample from Spanish STP was studied which concluded pollutant's shadow prices are good quality proxy to allot weightage to outputs. WWTPs are acknowledged as efficient and inefficient (with efficiency score not more than 0.6). The efficiency score is independent of the energy cost's weightage. The major potential cost-effective savings are allied to staff and energy costs [21].

P. Rajasulochana et. al (2016) focus on the environmental laws which have become strict for health of both human and environment, economy and pollution elimination. The pollution is caused as a result of release of inorganic and organic constituents. So these constituents are to be treated before the discharge of wastewater into any water source. Conventional technologies of treating water and wastewater such as chemical precipitation, ion exchange, evaporation, carbon absorption and membrane processes are found to be successful. Microbiological treatments are gaining popularity to eliminate toxic and other unsafe constituents. The author with the help of this paper focuses on the performance of all the techniques used for treatment. It is found that microalgae are helpful in removal of toxic wastes. It has also been studied that the conventional technologies are no more effective in eliminating heavy metals, phosphorous, nitrogen etc. Algae are very much useful in removal of BOD, nitrogen, phosphorous, fecal coli forms and heavy metals. The algal biomass is useful for production of methane, composting, liquid fuels, animal feed and fine chemicals production [22].

Abd El-Motaleb M Ramadan et. al (2017) studied the comparison of wastewater treatment schemes in El-Gharbia governorate in Egypt. The plants were operated on different biological treatment such as conventional activated sludge process, oxidation ditch, extended aeration process, rotating biological contractors and aerated lagoons. These plants were analysed for the period of twelve months. Theoretical correlations determined between the influent and effluent parameters prove useful in for proper control of treatment plant and its operation. The plant with oxidation ditch excels in performance while the one with activated sludge process lack in elimination of parameters. Some of the plants effluent parameters were beyond the permissible limits. So there is need for improving the technology adopted for the plants [23].

Most of the sewage treatment plants are evaluated on the basis of general efficiency method which considered influent and effluent biological, physical and chemical parameters. More work has been done by the authors for introducing new methods to determine the quality of the effluent of the treatment plant so that reuse of effluent as per the respective needs can take place.

Mohammad Karamouz et. al (2003) Due to the too much demand of water for domestic, industrial and agricultural, there is exhaustion of water. Similarly, there is pollution of water in extreme. The author presents his work in using Multiple Criteria Decision Making (MCDM) technique to develop different methods to control water pollution. Different water source systems were identified and effects due to each source of pollution on water sources were reviewed in Iran. Simple Additive Weighting (SAW) and Analytical Hierarchy Structure (AHS) were two of the MCDM tools used. These techniques identify the share of each type of pollution source. Expert opinions and engineering judgments were performed to analyse the deficiency in data. Based on the discussions, various projects for reducing pollution were categorized. After categorization, there was identification of several projects. During discussion, the total costs for the implementation of the projects were also calculated and each of the projects was prioritized depending on its impact to control water pollution [24].

Chitu Okoli et. al (2004) explained that Delphi method is proving a popular and useful tool to identify and prioritize the factors on the basis of personal decisions. This study explains the process to select the experts of the field for the study and give their views on the process. A detailed Delphi survey has been done to identify the foremost factors affecting the e-commerce diffusion in Africa's Sub-Saharan region. Many benefits are obtained after this detailed study. Firstly, it helps in determining the most crucial and important factors affecting the process on the basis of personal decisions. Secondly, as this method is performed by the experts who have ample range of experience, researchers can extend their information and observations and provide their opinions which can strengthen the theory. Thirdly, the researchers can be asked to justify their points with proper reasoning for understanding the informal relations among the factors and understanding the necessity of building the theory. Lastly, validification of the statements can be done to ensure that the researchers have properly understood the items submitted by them to reach their main goal [25].

M.D. Gomez-Lopez et. al (2009) decision making TOPSIS approach for applying disinfection technologies to treated wastewater for its reuse. Due to the scarceness of water, wastewater treatment and its reuse is gaining a lot of importance in various parts of the world. The author applies TOPSIS method to 6 various methods for disinfecting the treated wastewater for its reuse. The results from the analysis of data with TOPSIS approach show that chlorinating the wastewater with 4ppm was the best technique due to the lower cost and environment friendly. This technique is best if wastewater is to be reused for domestic, industrial and agriculture use. If the water is to be reused for other environmental uses and for recreational purposes, for which cost factor is given less importance and environmental factors are given more importance, Ultraviolet (UV) light was given more importance. The conclusion can be withdrawn that depending upon our needs and expectations, different technologies can be used to disinfect wastewater to make it fit for reuse [26].

Yury Avramenko et. al (2010) used multiple criteria technique to select the best technology for treating the wastewater. Environmental indicators and economic indicators are evaluated using fuzzy logic formulation. Environmental indicator contains set of contaminants with their removal efficiency and economic indicators consist of factors such as energy requirement, land requirement, capital cost, operational cost and the potential of technology to make it fit for reuse. The environmental and economic indicators are transformed to ratings according to fuzzy performance level from excellent to very poor. The indicators are provided with appropriate weightage on the basis of importance of application in area of treatment. The data was verified on the basis of decision making criteria. Comparison was made on this basis for various technologies to be used for wastewater treatment. The results show that the best technology to be used for wastewater treatment must be affordable, sustainable and acceptable by environment and society. Further social aspect is also an important factor which can also be considered for multiple decisions to obtain best results [27].

A.R. Karimi et. al (2011) used TOPSIS and AHP methods of fuzzy approach to select appropriate and best method to be used for wastewater treatment. These tools are proving best for the selection of best technology as the decision is based on the validification of the expert's opinion and the results obtained. The author compares 5 different processes in Iran with the help of these methods. The technologies compared are upflow anaerobic fixed-bed reactor (UAFB), contact process, upflow anaerobic sludge blanket (UASB), anaerobic baffled reactor (ABR) and anaerobic lagoons. The factors selected on the basis of which comparison is to be done are technical, environmental, administrative, economic and general condition of the industry. According to TOPSIS fuzzy logic the order of preference was UAFB > ABR > Contact Process > UASB > Anaerobic lagoons. According to AHP fuzzy logic the order of preference was ABR > UAFB > UASB > Contact Process > Anaerobic lagoon. Both the two methods results in using ABR and UAFB as best anaerobic technologies [28].

Pradip P. Kalbar et. al (2012) focused on using advance wastewater treatment technologies as alternate to conventional type treatment technologies. It was very complicated to select appropriate technique to use as wastewater treatment process. So he used Multiple attribute decision making (MADM) for selecting the best alternative process to be used for wastewater treatment. TOPSIS technique has been used to assign weightage to 7 criteria with 12 parameters on the basis of which results are to be produced. Each parameter is assigned weight depending upon its importance and is prioritized. For different scenarios, different weightage is assigned depending upon its importance in that scenario. It is noted that for no scenario condition, it is very difficult to prioritize the parameters as equal weightage is assigned to each parameter. On the basis of the weightage to the parameters, the technologies are given ranking from best to the least in different conditions. It is to be noted that the scenario matters the most in selecting the best alternative [29].

Yeonjoo Kim et. al (2013) gave prioritization to the treated wastewater sites on the basis of decision making tool using TOPSIS fuzzy logic method. The author considered economic, social, technical and environmental scenarios for evaluating the best treated wastewater sites. Questionnaire study was performed to assign weightage to the parameters. 10 sites were selected in South Korea in the watershed region. Water quality and quantity tests were performed to check the values of the influent and effluent of the treatment sites. Side by side on the basis of survey weightage was assigned to the parameters. On the basis of these, ranking was provided to the treated wastewater sites. This is one of the best tools to find out the best technology for wastewater treatment. Various decision making tools can be used to calculate the performance of the sites and compared. There can be variation in results as each method has its criteria for evaluation [30].

Maliheh Falah Nezhad et. al (2015) considered water scarceness as one of the major problem in Iran. So the author applied decision making tool on treatment plant to calculate its water quality index which can be used to determine different areas or wastewater effluent reuse depending on the effluent quality index of the effluent. This study will help in reusing the wastewater in different areas which can help in saving the drinking water from being wasted. Weightage is assigned to 8 parameters by using Delphi technique. Effluent quality index of the wastewater effluent is calculated and compared with the standard effluent quality index. The results shows that lower the effluent quality index more it is fit to reuse. This type of study is beneficial for wastewater reuse and helps in saving pollution in water bodies which serves as purpose for drinking [31].

Sheetal Jaisingh Kamble et. al (2017) discussed that multiple criteria decision making tool is proving beneficial for accessing environmental, social and economic decision making problems in selecting best technology for wastewater treatment. More and more research is being carried out in this field. Questionnaire survey is performed by using expert opinions and decisions. Life cycle assessment based on fuzzy logic is developed for estimating and assortment of domestic wastewater treatment plants. Four-phase procedure is being adopted for evaluation. This approach was applied to 6 domestic sewage treatment processes were considered for evaluation i.e. soil biotechnology, membrane bioreactor, sequential batch reactor, moving bed biofilm reactor, activated sludge process and facultative aerated lagoons. The results conclude that MBR is the best option for wastewater treatment with the order of sequence MBR > SBR > MBBR > soil biotechnology > facultative aerated lagoon > ASP. ASP has the least water effluent quality, so its effluent needs further treatment to make it fir for reuse [32].

2.6 Summary

After reviewing all the literature on performance analyses of wastewater treatment plants, it can be concluded that the conventional technology for wastewater i.e. activated sludge process is evergreen and best technology for wastewater treatment. Side by side it is also concluded that for attaining effluent of high quality, alternative technologies such as moving bed biofilm reactor, sequential batch reactor, upflow anaerobic sludge blanket can be used for domestic wastewater treatment. Performance analysis of sewage treatment plants helps us in knowing the treatment efficiency of treatment plants and helps us to identify the fields in which the plants need upgradation. Similarly, water scarceness is one of the major problems in today's world. So there is a need to reuse wastewater. For reusing wastewater, the effluent from the treatment plants should be of good quality to make it fit for reuse. Multiple-criteria decision making is also one of the best approach in identifying the effluent quality index of the effluents from the treatment plants and the identifying the fields in which the effluents can be reused. Multiple decision making approach can help us in selecting the best technology to be opted for effluent treatment before the construction of treatment plant hence saving cost and time.

CHAPTER 3

MATERIAL AND METHODS

3.1 Introduction

In this chapter, the methods followed for the study are discussed. For achieving the objectives, the study work planned as follows:

1. Selection of STPs on the basis of capacity.
2. Analyze the influent and effluent data collected from the sites.
3. Evaluate the efficiency of STPs on the basis of physical and chemical parameters.
4. Compare the seasonal variation of the STPs.
5. Evaluate the Effluent Quality Index of the influent and effluent data.
6. Rank the STPs according to the best results obtained from both the methods.
7. Compare the ranking of both the methods.

3.2 Site Information

3.2.1 Description of Himachal Pradesh

The name Himachal was framed from the Sanskrit word with Him meaning ‘snow’ and achal meaning ‘land’ with the combination snowy land, by the most outstanding scholars of the region, Acharya Diwakar Datt Sharma.

Himachal Pradesh is legendary for its attractive natural environment, snow fed mountains, hill stations, and the most important, the temples for which it has been named ‘Devbhoomi’ Himachal means Abode of Gods.

Out of the entire population, about 90% inhabit in the rural areas while the remaining 10% in the urban areas. As most of the populations reside in rural areas, sill more than 98% hygiene is achieved as most of the households have toilets.

Himachal Pradesh is subdivided into twelve districts out of which Kangra is the largest district population-wise covering 22% of the total population and area-wise, Lahual-Spiti wrapping 24.84% of the total land [33], [34], [35].

3.2.2 Location

The state Himachal Pradesh is positioned in the north-west division of the Himalayas, covering land area of about 55,673 sq. km. It is encircled on north by Jammu and Kashmir, on west by Punjab, on south-west by Haryana, south-east by Uttrakhand, on east by Tibet Autonomous Region and finally Uttar Pradesh on south face. The latitude ranges between thirty degrees twenty-two minutes and forty-four seconds to thirty-three degrees twelve minutes and forty seconds north while the longitude ranges from seventy-five degrees forty-five minutes and fifty-five seconds to seventy-nine degrees four minutes and twenty seconds east.

3.2.3 Topography

Situated into north-western Himalayas, Himachal Pradesh is grouped into three topographical regions, firstly Shiwalik Hills, secondly Mountains – Lesser Himalayas, Greater Himalayas and Trans Himalayas, thirdly Valleys – Shiwalik dun , fluvial and glacial-fluvial valleys and finally Mountain Passes.

As being highland state, maximum of the state portion lies on Dhauladhar Range. The utmost peak of the mountain is Shilla, which is at 7025 m.

3.2.4 Climate

Because of elevation and steep geography of the state, there is unusual fluctuation in temperature in the state. As the altitude increases from the western part towards the northern and eastern parts, the high latitude of temperature start shifting from its high value to the lower range of temperature, signifying the higher we go the cooler is the air. Una as well as Bilaspur districts being on low altitude have annual temperature ranging more than 20 and 25 °C. Sometimes in summer, it rises above 32°C. As the altitude rises, the temperature drops even below – 4 °C in winters in some areas of state.

As far rainfall is considered, it hails from southwestern monsoons, from early June to late September. During winters, considerable amount of rainfall and snowfall is received as of western disturbances all over the state, increasing from plains to hills. Dharamshala is the region of uppermost rainfall in the state to the lowest in Lahaul-spiti as well as Kinnaur districts.

3.2.5 Existing Sewage Treatment and Disposal Facilities

As water supply system is important to provide hygienic drinking water society, sewerage system is also important for the effective transport of sewage to the treatment plants before its disposal to the water bodies. The sewage treatment facilities of Himachal Pradesh have improved so far from the activated sludge process and oxidation ditches to extended aeration. The sewerage system is maintained by Irrigation & Public Health (I&PH) Department. There are 66 STPs in the region out of which 30 are in construction and planning phase and are non-operational. Out of 36 operational STPs, 1 is working on anaerobic technology i.e. UASB process and the rest are working on aerobic technology i.e. extended aeration process. There is combined sewerage system which carries both domestic sewage wastewater and storm water. More and more emphasis is laid by government to connect more and more households to the sewerage network as 90% of the entirety population inhabit in rural areas. All the treatment facilities discharge indirectly or directly into Beas, Satluj, Ravi, Chenab and Yamuna which are also drinking source for the state. So before discharging the domestic wastewater, it has to be treated to maintain hygiene.

3.2.6 Policy, Regulation and Institutional Framework

Irrigational and Public Health (I&PH) Department of Himachal Pradesh [36] and Himachal Pradesh Pollution Control Board (HPPCB) with the help from Central Pollution Control Board (CPCB) [37] is responsible for the provision and planning of the sewerage systems, treatment facilities, disposal facilities and to put off water pollution due to domestic wastewater. I&PH department is properly involved in its work to provide safe treatment of domestic sewage and to produce effluent as per the discharge standards.

3.2.7 Zone-wise details of STPs

The region of Himachal Pradesh is branched into four zones by I&PH Department namely Dharamshala, Mandi, Hamirpur and Shimla.

3.2.7.1 Dharamshala Zone

Dharamshala Zone has the total population of 20,23,067 persons (Census of India, 2011). This zone covers the whole of Kangra district and Chamba district with the total portion of 12,267 sq. km. The total domestic wastewater generation from this zone is 218.49 MLD (considering per capita water demand of 135 lpcd, CPCB, 2013). There are 10 STPs considered for evaluation with the treatment design capacity of 15.539 MLD. More treatment plants are to be installed to meet the desired generation and more and more households are to be linked to the sewerage transportation network.

All the plants work on extended aeration using two formats, extended aeration with mechanical aerators and extended aeration with diffused aeration system.

3.2.7.2 Mandi Zone

Mandi Zone has the total inhabitant of 14,36,992 persons (Census of India, 2011). This zone covers Mandi district and Kullu district with the total area of 9453 sq. km. The total domestic wastewater generated from this zone is 155.195 MLD (considering per capita water demand of 135 lpcd, CPCB, 2013, [4]). There are 11 STPs out of which 9 are considered for evaluation with treatment design capacity of 16.885 MLD. The government is laying emphasis on the up gradation of the STPs so as to meet the present domestic sewage generation.

3.2.7.3 Hamirpur Zone

Hamirpur Zone has the total population of 13,57,406 persons (Census of India, 2011). This zone covers Bilaspur, Hamirpur and Una districts with the total area of 3825 sq. km. The total domestic wastewater generated is 146.56 MLD (considering per capita water demand of 135 lpcd, CPCB, 2013). There are 9 STPs with the treatment design capacity of 12.66 MLD out of which 6 STPs with the design capacity of 8.13 MLD are considered for evaluation. More efforts are to be made to meet the present sewage generation demand. More and more households are to be connected to the sewerage network.

3.2.7.4 Shimla Zone

Shimla Zone has the total population of 20,54,044 persons (Census of India, 2011). This zone covers Kinnaur, Lahaul and Spiti, Shimla, Sirmaur and Solan districts with the entire land of 30,128 sq. km. The total domestic sewage generated is 211.84 MLD (considering per capita water demand of 135 lpcd, CPCB, 2013). There are 18 STPs with the treatment design capacity of 48.58 MLD out of which 5 STPs with design capacity of 9.70 MLD are considered for evaluation. The topography of this zone is such that more small scale treatment plants needs to be designed at different places to meet the present demand of sewage generation as due to high change in elevation the is difficulty in connecting the households to sewerage network.

3.2.8 Sewage Generation

The population of the state is 68,64,602 persons (Census of India, 2011). The per capita water supply is 135 lpcd (CPCB, 2013). The total water requirement in the state is 926.72 MLD. The total sewage generation is taken as 80% of water required. So in the state, total sewage generation is 741.38 MLD. The collection efficiency of sewage is 60 to 70%. At some places it is 40 to 50%. Taking an average of 55 %, approx 410.76 MLD of sewage wastewater is transported to the sewage treatment schemes.

Table 3.1 Contribution of Himachal Pradesh as per water demand and sewage generation

FACTORS	INDIA	HIMACHAL PRADESH
1. Population (Census 2011)	1,210,854,977	6,864,602 (0.56%)
2. Population (2016)	1,324,171,354	7,123,184 (0.54%)
3. Area (km^2)	3,287,263	55,673 (1.69%)
4. Water Demand (MLD)(2011)	163,465	926.72 (0.57%)

5. Water Demand (MLD)(2016)	178,763	961.63 (0.54%)
6. Sewage Generation (MLD)(2016)	143,010.40	769.304 (0.56%)
7. Sewage Treatment Capacity(MLD)(2016)	21,120.36	95.00 (0.45%)

Source: Inventorization of Sewage Treatment Plants, SERIES : CUPS/2015

Table 3.2 Zonal distribution of sewage treatment plants

Zone	**STPs**	**Population**	**Wastewater Generated (MLD)**	**Treatment Capacity Design (MLD)**
Dharamshala	Kangra Zone III	15,07,223	162.78	12.931
	Palampur			
	Tanda Medical College			
	Kangra Zone I			
	Nagrota Bagwan			
	Dharamshala			
	Jwalamukhi			
Hamirpur	NIT Hamirpur	4,54,293	49.06	8.13
	Ghumarwin			
	Sujanpur			
	Hamirpur Zone I			
	Hamirpur Zone II			
	Hamirpur Zone III			
Shimla	Dhalli	1,40,580	15.18	9.70
	Kunihar			
	Solan			
	Arki			
	Sanjauli Malyana			

Mandi	Sundernagar	1,79,604	19.40	14.655
	Ragunath ka Padhar			
	Khaliyar			
	Jogindernagar			
	Bhootnath			
	Lankabaker			

Figure 3.1 Location of STPs in Himachal Pradesh

3.3 Selection of STPs

The sites are selected on the ground of capacity. There are 66 STPs in Himachal Pradesh out of which 36 are operational. From the 36 STPs, 30 sites are selected for evaluation. Out of 30 sites, thirteen sites are under 1 MLD, sixteen sites are in the domain of 1 to 5 MLD and one site is above 5 MLD. The selected sites are evaluated by considering the physical and chemical parameters.

The technologies used in the sewage treatment plants are conventional extended aeration using mechanical aerators and diffused aeration system.

Table 3.3 Classification of Sewage Treatment Plants (STPs)

S.No	**STP**	**Capacity (< 1 MLD)**
1	Chamba Zone III	0.2
2	NIT Hamirpur	0.27
3	Palampur	0.351
4	Khaliyar	0.4
5	Sharabai	0.46
6	Kangra Zone III	0.63
7	Hamirpur Zone III	0.68
8	Arki	0.7
9	Dhalli	0.76
10	Jarad	0.87
11	Chamba Zone II	0.9
12	Kunihar	0.9
13	Bhuntar	0.99
		1 to 5 MLD
14	Sujanpur	1.2
15	Ghumarwin	1.2
16	Nagrota Bagwan	1.34
17	Hamirpur Zone II	1.35
18	Tanda Medical College	1.4
19	Chamba Zone I	1.51
20	Kangra Zone I	1.68

21	Jogindernagar	1.74
22	Jwalamukhi	2.38
23	Bhootnath	2.5
24	Lankabaker	2.57
25	Solan	2.90
26	Hamirpur Zone I	3.13
27	Sundernagar	3.55
28	Ragunath ka Padhar	3.83
29	Sanjauli Malyana	4.44
		>5 MLD
30	Dharamshala	5.15

3.4 Collection of the Samples

The sample results are collected from the 30 sites by visiting each STP and studying it. The sample results for 12 months were grabbed from each site to study the performance of each STP. The seasonal variation of STPs is also analyzed. On site, for testing, the sample location is decided for taking the grab sample. The types of samplings are:

1. Grab sampling: Grab sampling is defined as taking the samples from influent and effluent sites at a particular time.
2. Composite sampling: Composite sampling is defined as combining of grab samples taken at a particular time at regular intervals from influent and effluent.

Parameters are taken as selected by the department. The listing of parameters to be tested is explained further. The collection sites of the sample for testing are:

1. Influent zone of the STP.
2. Effluent zone of STP.

3.5 Selection of Parameters

The parameters selected to check the performance of STPs are:

1. pH
2. Dissolved Oxygen (DO)

3. Biochemical Oxygen Demand (BOD)
4. Chemical Oxygen Demand (COD)
5. Total Suspended Solids (TSS)

3.6 Measurement of Parameters

The selected physical and chemical parameters of the wastewater are measured with the help of analytical methods as follows [38]:

Table 3.4 Methods for measuring parameters

S. No.	Parameters	Methods
1	pH	Digital pH meter
2	Dissolved Oxygen	Winkler test/Digital DO meter
3	Biochemical Oxygen Demand	3 Day BOD test
4	Chemical Oxygen Demand	Open Reflux
5	Total Suspended Solids	Filtration

3.6.1 pH

3.6.1.1 Procedure

1. Collect the influent/effluent sample in the container.
2. Calibrate the Digital pH meter using buffer solution with pH values 4.0, 7.0 and 9.2.
3. Take reading by inserting pH meter in sample.

3.6.1.2 Significance

pH has a very important role and is one of the mainly essential parameter in treatment and testing of wastewater. The wastewater has various problems related to increase in pH, lethal chemicals, presence of other harmful matter and sometimes it is seen that alkalinity increases. This creates severe issues regarding its discharge, so treatment of all types of wastewater is necessary before its discharge. The micro-organisms only survive and work if optimum pH condition prevails in the aeration tank. For maintaining pH level, equalization tank is provided before aeration tank. The most recommended level of pH in the aeration reactor ranges from 6.5 to 9 (CPCB, 2005).

3.6.2 Dissolved Oxygen (DO)

3.6.2.1 Procedure

1. Collect the sample in the container.
2. Insert the digital DO meter in the influent/effluent sample and note the reading.

3.6.2.2 Significance

Dissolved oxygen is also one of the important factors in the process of breakdown of biological matter inflowing into the aeration reactor. The biological matter is kept in suspension by mechanical means and the microorganisms use the dissolved oxygen existent in the wastewater to breakdown the suspended organic matter so that there is settlement of the remaining matter. The air is equally distributed in the aeration tank with the help of mechanical means. The effluent should be rich in DO level. The DO in the effluent should be more than 4 mg/L.

3.6.3 Biochemical Oxygen Demand (BOD)

3.6.3.1 Procedure

1. Take two 300 ml BOD bottle and fill one with dilute mixture (wastewater 2% and distilled water 98%) and the other with full distilled water (blank).
2. Note down the DO of the both sets immediately.
3. Keep the samples in BOD incubation for 3 days at 27°C.
4. Note down the DO of both the sets.
5. BOD_3 can be calculated as:

$$BOD_3\ (mg/L) = (D_1 - D_2) - (B_1 - B_2) * \text{Dilution Factor}\ [38]$$

Where, D_1 is initial DO of blank sample

D_2 is final DO of blank sample (3 Day)

B_1 is initial DO of mixture sample

B_2 is final DO of mixture sample (3 Day)

3.6.3.2 Significance

Biochemical oxygen demand is the extent of quantity of dissolved oxygen (DO) required by the micro-organisms in an aerobic biological process for the breakdown of the organic components kept in suspension. These organic solid components are kept in suspension by means of mechanical methods. The measurement of BOD in influent and effluent wastewater is very much important as its index has huge impact on the environment and water sources.

It is noted that higher the value of BOD measured in the wastewater, more the amount of organic material present in the wastewater. So its treatment is very much necessary before discharging it into any water source, as these water sources can be used for any domestic purposes. As per the old effluent limits, the amount of BOD in wastewater should not exceed 30 mg/L (CPCB, 2005).

3.6.4 Chemical Oxygen Demand (COD)

3.6.4.1 Procedure

1. Two 50 ml tubes are taken with one tube is filled with 2.5 ml sample and the other with 2.5 ml distilled water.
2. Both the test tubes are filled with 1.5 ml potassium dichromate solution and 3.5 ml of sulphuric acid reagent and mix carefully.
3. Place both the tubes in open Reflux COD apparatus at 150°C for 2 hours.
4. Let the test tubes cool down.
5. Put one drop of ferron as indicator.
6. Titrate with 0.1 N FAS solution till the colour changes from blue-green to wine red.
7. COD is calculated as

$$\text{COD (mg/L)} = ((B-S)*N*8000)/\text{ml of Sample taken} \ [38]$$

Where, B = ml of FAS used for blank solution

S = ml of FAS used for sample

N = Normality of FAS

3.6.4.2 Significance

In the wastewater, not only organic materials are present, but lethal components are also present, which are harmful for aquatic life if released into the water sources. So for removing these chemical components, measurement of chemical oxygen demand is very important. Chemical oxygen demand (COD) is the extent of oxygen required to reduce the chemicals present in wastewater. It is noted that more the value of COD, more is the extent of chemical materials present in wastewater. As per the old effluent limits, the value of COD in wastewater should not exceed 250 mg/L (CPCB, 2005).

3.6.5 Total Suspended Solids (TSS)

3.6.5.1 Procedure

1. Take 50 ml crucible and weigh it. Now pour 50 ml sample in the crucible and keep it in oven at 103°C.
2. Take another crucible of 50 ml and weigh it. Again pour 50 ml sample in the crucible.
3. Take Whatmann filter paper No. 42 and weigh it. Now filter the sample through the filter paper and keep it for oven drying at 103°C.
4. TSS can be calculated as:

   TDS (mg/L) = ml of residue / ml of sample taken * 1000 [38]

   TSS (mg/L) = TS (mg/L) – TDS (mg/L)

3.6.5.2 Significance

Total suspended solids are the part of total solids which are present in wastewater and are present in suspension that are detained by filtration. The estimation of total suspended solids is very much important as it alter the operation of wastewater treatment and the environment health. If large extent of suspended solids is present in wastewater, they restrict the entry of light into the water creating anaerobic conditions into the water bodies. Entry of light is very important for the aquatic life to sustain life. Dissolved oxygen is also an important parameter. The suspended solids increases turbidity of the wastewater and destroy its aesthetic look. As per the old effluent limits, the amount of TSS in wastewater should not exceed 250 mg/L (CPCB, 2005).

3.7 Methods for Performance Analysis

Performance analysis is used for evaluating the efficiency of wastewater treatment plants. The following methods are used for the evaluation of performance of STPs:

1. General overall efficiency method
2. Effluent Quality Index method

3.7.1 General overall efficiency method

The general overall efficiency is defined as the overall efficiency of the plant calculated from the values of the influent and effluent parameters. The parameters considered are physical and chemical in nature i.e. BOD, COD, TSS and NH_4.

$$E_G = \frac{1}{4}\left[E_{BOD_3} + E_{COD} + E_{NH_4} + E_{TSS} \right] \qquad [14]$$

Where E_G is the overall general efficiency (%)

E_{BOD_3} is the average efficiency removal after 3-Day BOD test (%)

E_{COD} is the average efficiency removal of COD (%)

E_{TSS} is the average efficiency removal of TSS (%)

E_{NH_4} is the average efficiency removal of NH_4 (%)

Actual general overall efficiency (EG_a) is illustrated as the calculation of the removal efficiency of the parameters with respect to the actual influent statistics values and the actual effluent data values. The parameters tested by the department are only taken. The formulation is given as:

$$EG_a = \frac{1}{3}\left[E_{BOD_3} + E_{COD} + E_{TSS} \right] \qquad [14]$$

Where EG_a is the actual overall general efficiency (%)

E_{BOD_3} is the actual average efficiency removal after 3-Day BOD test

E_{COD} is the actual average efficiency removal of COD (%)

E_{TSS} is the actual average efficiency removal of TSS (%)

E_{BOD_3} = (BOD_{IN} – BOD_{EFF}) / BOD_{IN} * 100 %

Where BOD_{IN} = actual influent BOD; BOD_{EFF} = actual effluent BOD

E_{COD} = (COD_{IN} – COD_{EFF}) / COD_{IN} * 100 %

Where COD_{IN} = actual influent COD; COD_{EFF} = actual effluent COD

E_{TSS} = (TSS_{IN} – TSS_{EFF}) / TSS_{IN} * 100 %

Where TSS_{IN} = actual influent TSS; TSS_{EFF} = actual effluent TSS

3.7.1.1 Standard General overall efficiency method

Standard general overall efficiency (EG_s) is defined as the calculation of removal efficiency of the parameters with respect to the actual influent statistics values and the standard effluent data values as per the CPCB, 2005.

$$EG_s = \frac{1}{3} [E_{BOD_3} + E_{COD} + E_{TSS}] \qquad [14]$$

Where EG_s is the standard overall general efficiency (%)

E_{BOD_3} is the standard average efficiency removal after 3-Day BOD test

E_{COD} is the standard average efficiency removal of COD (%)

E_{TSS} is the standard average efficiency removal of TSS (%)

E_{BOD_3} = (BOD_{IN} – BOD_{EFF}) / BOD_{IN} * 100 %

Where, BOD_{IN} = actual influent BOD; BOD_{EFF} = standard effluent BOD

E_{COD} = (COD_{IN} – COD_{EFF}) / COD_{IN} * 100 %

Where, COD_{IN} = actual influent COD; COD_{EFF} = standard effluent COD

E_{TSS} = (TSS_{IN} – TSS_{EFF}) / TSS_{IN} * 100 %

Where, TSS_{IN} = actual influent TSS; TSS_{EFF} = standard effluent TSS

3.8 Effluent Quality Index

Water scarceness is one of the foremost problems now-a-days. So, only option left is either using less amount of water or reusing the effluent from the treatment plants. For reusing the effluent, concern has to be taken that after treatment, the effluent is fit for reuse. So, one of the methods for checking the effluent quality is used known as Effluent Quality Index (EQI).

Effluent quality index is based on Delphi and TOPSIS method in which all the parameter influent and effluent values are converted into an index by assigning weightage to the parameters. Effluent quality index is very useful in determining the quality of the effluent and the area where the effluent can be reused. The effluent quality index of the sites are calculated and compared with the effluent quality index obtained from the standard parameters [31].

Effluent Quality index is based on two parameters:

1. Effluent Quality Index (influent)
2. Effluent Quality Index (effluent)

The value of EQI is obtained from the expression:

$$EQI = \sum (0.767 * I_{BOD} + 0.0767 * I_{COD} + 0.0885 * I_{TSS} + 0.1344 * I_{pH}) / 0.3763 \quad [31]$$

Where, EQI is the effluent quality index of influent and effluent.

I_{BOD} is the sub-index of BOD obtained from rating curves

I_{COD} is the sub-index of COD obtained from rating curves

$\boldsymbol{I_{TSS}}$ is the sub-index of TSS obtained from rating curves

$\boldsymbol{I_{pH}}$ is the sub-index of pH obtained from rating curves

The weightage ascribed to the parameters are:

Table 3.5 Weightage ascribed to parameters [31]

S.No.	Parameter	Weightage
1	BOD	0.0767
2	COD	0.0767
3	TSS	0.0885
4	pH	0.1344
	Total	0.3763

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

In the territory of Himachal Pradesh, out of 66 STPs, 36 STPs are in operational phase. Out of 36 STPs, 30 STPs are considered for evaluation depending upon different capacities. The performance analysis is done on the source of two methods whose results are being discussed.

4.2 Performance Evaluation

Performance analysis is performed to check to efficient working of the sewage treatment plants. The wastewater contains huge quantity of macrobiotic, inorganic and toxic matter which are dangerous for aquatic, human and environment life. So before discharging the wastewater to the streams, rivers and other water bodies, it is to be treated. The effluent discharged by the treatment plant should be under the permissible limits as per CPCB. The purpose of wastewater treatment plant is to produce such quality of effluent that it is fit for reuse. For obtaining such kind of effluent, performance analysis is being performed.

4.2.1 General overall efficiency approach (EG)

4.2.1.1 Results

According to the basis of general overall efficiency approach, “STP Kunihar” with 0.9 MLD capacity is ranked 1st with the actual general removal efficiency of 90.78%. The ranking to the STPs is provided on the basis of general removal efficiency obtained from the actual influent and effluent data sets. “NIT Hamirpur” having capacity 0.27 MLD has the lowest actual removal efficiency of 57.29%. Both the plants are working on the same technology i.e. Extended aeration process. The difference being the aerators in “STP Kunihar” aerators provided with vertical mechanical surface aerators and at “NIT Hamirpur”, inclined surface aerators are provided at the sides of the tank.

Table 4.1 Ranking to the STPs on the basis of Actual General Overall Efficiency (EG_a)

STP	Actual general overall efficiency (EG_a)	Ranking
Kunihar	90.78	1
Jogindernagar	88.61	2
Dharamshala	88.09	3
Nagrota Bagwan	87.42	4
Ghumarwin	86.88	5
Lankabaker	86.49	6
Sujanpur	84.39	7
Tanda Medical College	84.21	8
Khaliyar	84.13	9
Kangra Zone II	83.41	10
Dhalli	81.52	11
Ragunath ka Padhar	81.52	12
Bhootnath	81.32	13
Sundernagar	80.96	14
Palampur	80.94	15
Hamirpur Zone I	80.67	16
Solan	78.89	17
Jwalamukhi	76.25	18
Hamirpur Zone III	76.08	19
Kangra Zone I	75.13	20
Arki	74.15	21
Hamirpur Zone II	73.27	22
Sanjauli Malyana	69.76	23
NIT Hamirpur	57.29	24

Table 4.2 Comparison of Standard and Actual general overall efficiencies.

STP	Standard general overall efficiency (EG_s)	Actual general overall efficiency (EG_a)
NIT Hamirpur	49.94	57.29
Palampur	61.00	80.94
Khaliyar	54.07	84.13
Kangra Zone II	52.23	83.41
Hamirpur Zone III	49.45	76.08
Arki	60.60	74.15
Dhalli	72.61	81.52
Kunihar	71.76	90.96
Ghumarwin	55.06	86.88
Sujanpur	54.27	84.39
Nagrota Bagwan	64.57	87.42
Hamirpur Zone II	50.07	73.27
Tanda Medical College	58.09	84.21
Kangra Zone I	-23.17	75.13
Jogindernagar	66.68	88.61
Jwalamukhi	50.16	76.25
Bhootnath	61.60	81.32
Lankabaker	69.44	86.49
Solan	56.00	78.89
Hamirpur Zone I	45.35	80.67
Sundernagar	55.28	80.96
Ragunath ka Padhar	65.43	81.52
Sanjauli Malyana	80.71	69.76
Dharamshala	63.77	88.09

The overall actual efficiency should always be greater than the overall standard efficiency. The maximum EG_a was observed for “Kunihar” i.e. 90.78%. “Palampur”, “Khaliyar”, “Kangra Zone III”, “Dhalli”, “Ghumarwin”, “Nagrota Bagwan”, “Jogindernagar”, “Bhootnath”, “Lankabaker”, “Dharamshala” shows actual efficiency of more than 80%. The general standard efficiency of “Kangra Zone I” is found to be negative value of 23.17. This is because the characteristics of the influent sewage feeding the STP are less than the effluent standards. "Sanjauli Malyana" shows the EG_s more than EG_a. This indicates the effluent produced by the STP is not meeting the discharge standards.

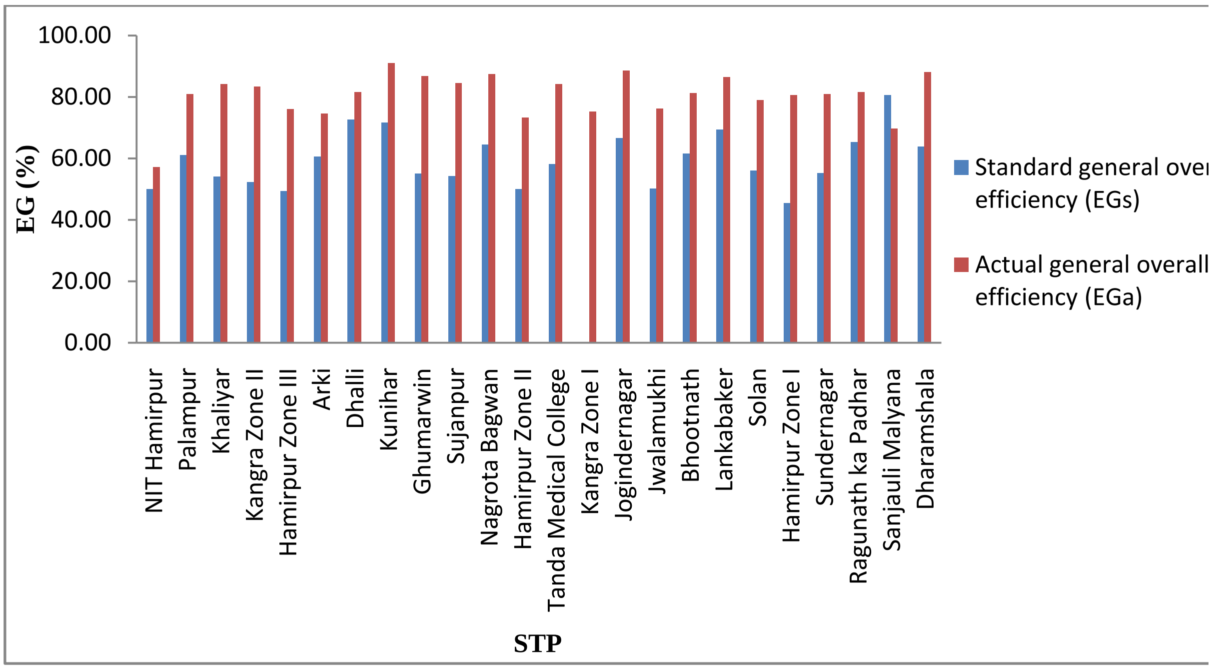

Figure 4.1 Comparison of Standard and Actual general overall efficiencies.

4.2.1.2 Characteristics of the influent wastewater

Influent sewage of the twenty four STPs was studied for the phase of twelve months. The BOD_3/COD ratio for untreated municipal wastewater varies from 0.3 to 0.8. The BOD_3/COD ratio of 0.5 or more indicates high biodegradability of the influent sewage by biological treatment.

As the drainage pattern is combined sewer system, the precipitation water is also discharged to STPs with wastewater. For "NIT Hamirpur", the BOD_3 varies from minimum 90 mg/L to maximum of 190 mg/L, COD varies from minimum 100 mg/L to maximum 480 mg/L, TSS varies from minimum 195 mg/L to maximum of 365 mg/L.

The values of BOD_3 at "Palampur" ranges from 190 mg/L to 360 mg/L, COD ranges from 280 mg/L to 430 mg/L and TSS ranges from 224 mg/L to 304 mg/L. At "Khaliyar", BOD_3 ranges from 134 mg/L to 459 mg/L, COD ranges from 164 mg/L to 1056 mg/L and TSS ranges from 150 mg/L to 186 mg/L. “Dhalli” and “Sanjauli Malyana” has high amount of COD values ranging from 620 mg/L to 960 mg/L and 640 mg/L to 2667 mg/L. High COD indicates the presence of toxic substances. TSS at “Sanjauli Malyana” is also high ranging 200mg/L to 1450 mg/L.

“Tanda medical college” receives influent from the Rajiv Gandhi Medical College and Hospital. Hospital and residential waste with storm water feeds the treatment plant. The COD ranges 440 mg/L to 596 mg/L.

4.2.1.3 Physical and Chemical Removal Efficiency

All the STPs in Himachal Pradesh were designed to generate the effluent with BOD_3, COD and TSS values less than 30mg/L, 250 mg/L and 100mg/L (CPHEEO, 1993). Overall actual efficiency is generally measured with the help of these parameters.

High physical removal efficiency of 93.94% is observed at “Dharamshala” with extended aeration process followed by “Nagrota Bagwan” with the physical removal efficiency of 93.47%. “Jwalamukhi”, “Arki” and “NIT Hamirpur” has low physical removal efficiency of 69.53%, 61.36% and 57.64%. All other treatment plants, except these three, show good and moderate physical removal efficiencies. Physical removal efficiencies from “Palampur” to “Jogindernagar” vary from 86.80% to 90.62%. As all the plants employ extended aeration process, the total suspended solids removal efficiency varies from 57.64% at “NIT Hamirpur” to 93.94% at “Dharamshala”.

The chemical removal efficiencies consist of BOD_3 removal efficiency and COD removal efficiency. STP “Bhootnath” shows the highest BOD_3 removal efficiency of 95.44% followed by “Lankabaker” with 92.97% removal efficiency. The extended aeration proves best as most of the STPs are working well in removing BOD_3. The BOD_3 removal efficiency ranges from 95.44% at “Bhootnath” followed by “Jwalamukhi” with 92.58% and the least at NIT Hamirpur with 61.13%

Extended aeration shows good COD removal efficiency ranging from 89.24% at “Kunihar” followed by 77.12% at “Kangra Zone III”. “Tanda Medical College” has more removal efficiency of 79.03% than “Sanjauli Malyana” with 66.61%. Most of the STPs have removal efficiency ranging 70% to 85%. “NIT Hamirpur”, “Kangra Zone I” and “Hamirpur Zone II” shows relatively less removal efficiency of 52.29%, 59.09% and 59.67%.

4.2.1.4 Seasonal Variation

The seasonal variation of STPs in Automn season is shown below:

Table 4.3 Comparison of Standard and Actual efficiencies in Automn Season

STP	Standard general overall efficiency (EG_s)	Actual general overall efficiency (EG_a)
NIT Hamirpur	61.60	53.94
Palampur	59.81	78.09
Khaliyar	0.00	0.00
Kangra Zone II	53.32	78.64
Hamirpur Zone III	63.35	81.06
Arki	59.35	74.43
Dhalli	72.62	81.39
Kunihar	0.00	0.00
Ghumarwin	52.27	87.42
Sujanpur	52.13	82.65
Nagrota Bagwan	65.20	87.00
Hamirpur Zone II	63.46	80.04
Tanda Medical College	58.79	83.73
Kangra Zone I	-46.33	75.45
Jogindernagar	65.55	89.82
Jwalamukhi	51.05	76.37
Bhootnath	58.35	88.46
Lankabaker	69.44	86.49
Solan	0.00	0.00
Hamirpur Zone I	63.14	82.08
Sundernagar	53.19	80.10
Ragunath ka Padhar	62.59	83.02
Sanjauli Malyana	75.89	75.28
Dharamshala	64.67	89.12

Automn season starts from September to November. The temperature ranges between 15 to 25°C. The treatment efficiency is quite well noted in this season. The highest actual efficiency is noted as 89.82% in Jogindernagar.

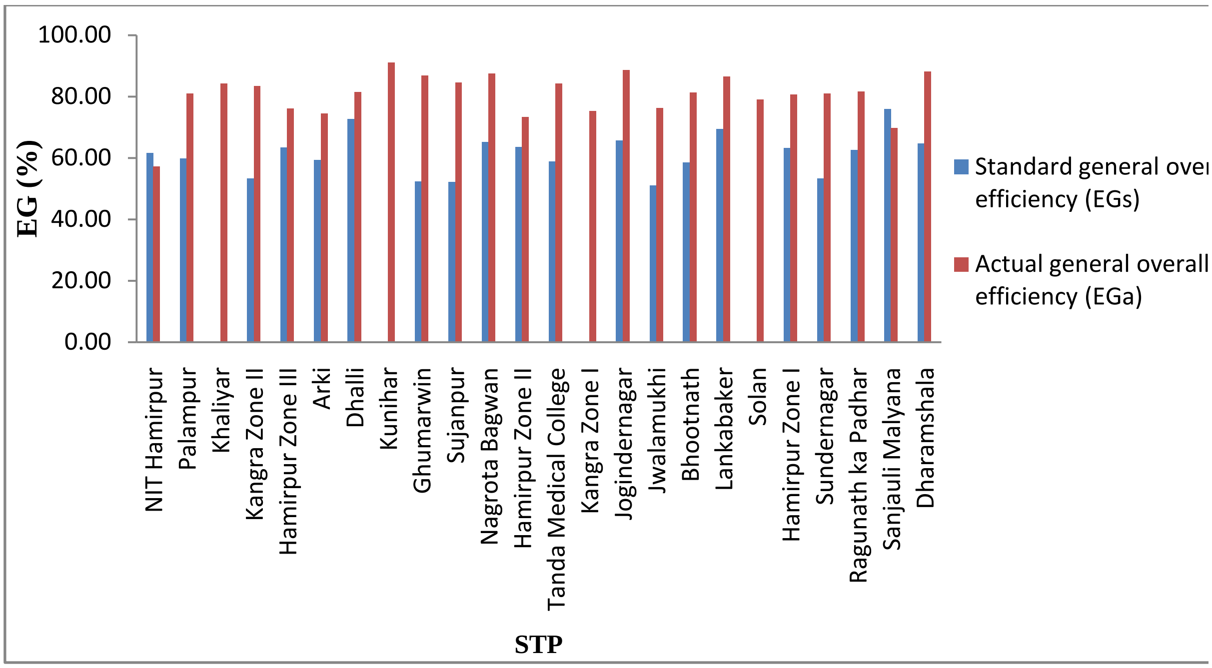

Figure 4.2 Comparison of efficiencies in Automn Season

Table 4.4 Comparison of efficiencies in Winter Season

STP	Standard general overall efficiency (EG_s)	Actual general overall efficiency (EG_a)
NIT Hamirpur	60.22	53.00
Palampur	60.77	80.77
Khaliyar	50.99	79.20
Kangra Zone II	52.00	84.22
Hamirpur Zone III	61.03	79.28
Arki	61.59	71.86
Dhalli	72.03	76.92
Kunihar	0.00	0.00
Ghumarwin	64.17	37.03
Sujanpur	64.67	88.82
Nagrota Bagwan	64.53	87.38

Hamirpur Zone II	60.25	71.81
Tanda Medical College	57.35	83.87
Kangra Zone I	-24.72	75.85
Jogindernagar	65.74	88.72
Jwalamukhi	50.94	75.94
Bhootnath	57.98	91.09
Lankabaker	65.00	87.75
Solan	56.61	78.93
Hamirpur Zone I	60.99	85.20
Sundernagar	53.35	80.63
Ragunath ka Padhar	65.55	82.41
Sanjauli Malyana	83.93	72.26
Dharamshala	65.81	87.05

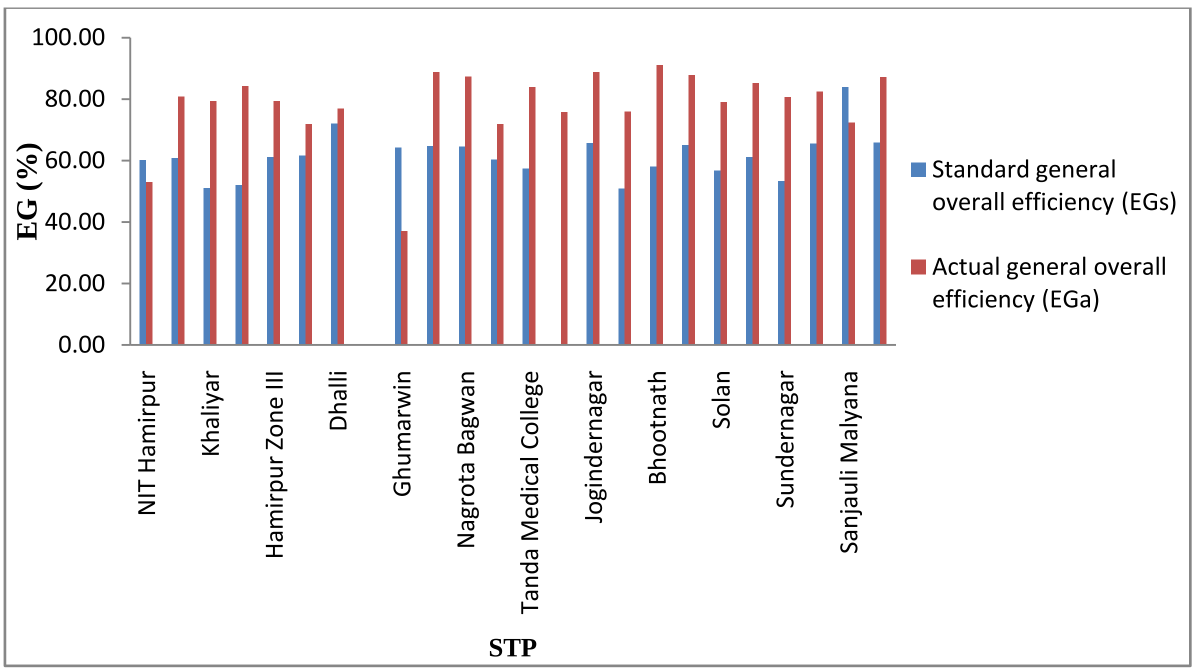

Figure 4.3 Comparison of standard and actual efficiencies in Winter Season

It is noted that in the region of Himachal Pradesh, during winters, the average temperature ranges between 10 to 15°C. Some regions in the area have temperature less than 0°C. So it is difficult for the aerobic bacteria to work in such conditions. The uppermost exclusion efficiency noted is 91.09% in Bhootnath.

Shimla region has low temperature during winters. The removal efficiency of Dhalli and Sanjauli Malyana is 76.92% and 72.26%.

Table 4.5 Comparison of efficiencies in Summer Season

STP	Standard general overall efficiency (EG_s)	Actual general overall efficiency (EG_a)
NIT Hamirpur	57.99	54.35
Palampur	60.10	80.26
Khaliyar	60.94	82.99
Kangra Zone II	52.27	86.30
Hamirpur Zone III	50.42	74.19
Arki	60.15	74.59
Dhalli	0.00	0.00
Kunihar	70.94	90.80
Ghumarwin	56.17	86.15
Sujanpur	64.67	88.82
Nagrota Bagwan	63.69	86.35
Hamirpur Zone II	57.87	72.76
Tanda Medical College	58.63	85.73
Kangra Zone I	-11.34	74.65
Jogindernagar	67.24	87.40
Jwalamukhi	49.77	75.92
Bhootnath	63.00	89.59
Lankabaker	70.20	87.27
Solan	55.79	78.59
Hamirpur Zone I	44.77	84.45
Sundernagar	58.38	81.55
Ragunath ka Padhar	66.73	80.74
Sanjauli Malyana	87.86	66.43
Dharamshala	66.71	88.58

The summer season has the temperature range between 30 to 40°C. The uppermost exclusion efficiency is noted as 90.80% in Kunihar. This temperature is best for the micro-organisms to work. Optimum temperature is to be maintained in the reactor to the micro-organisms to feed on the organic matter to breakdown it.

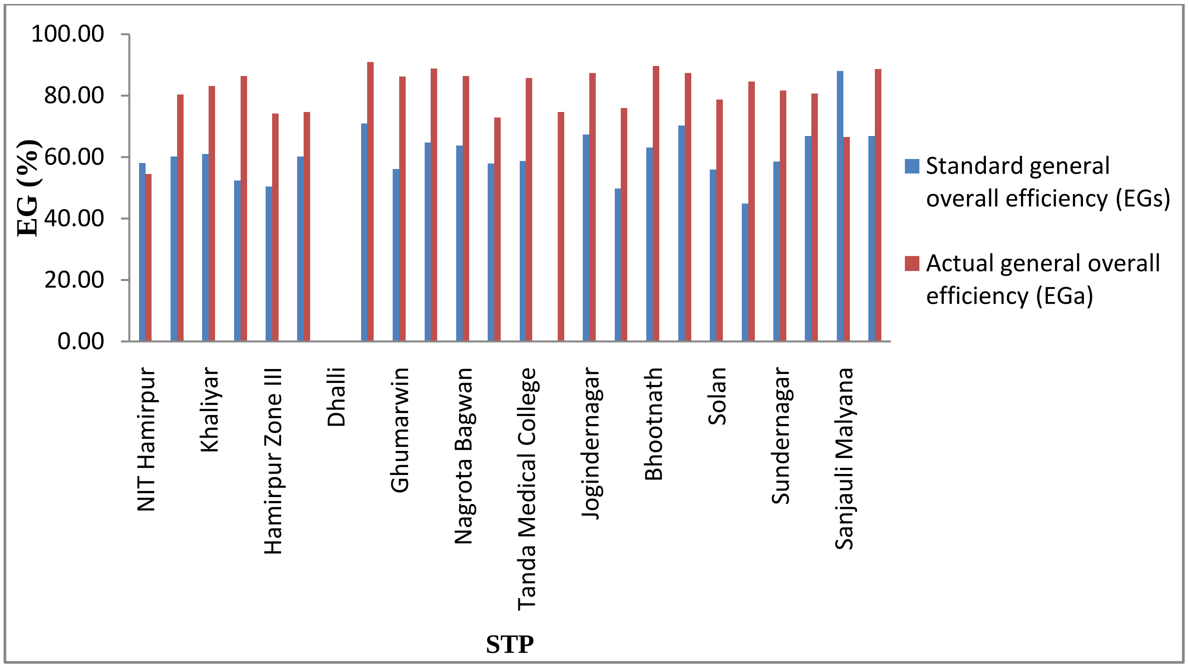

Figure 4.4 Comparison of efficiencies in Summer Season

Table 4.6 Comparison of efficiencies in Monsoon Season

STP	Standard general overall efficiency (EG_s)	Actual general overall efficiency (EG_a)
NIT Hamirpur	19.17	68.16
Palampur	61.89	82.76
Khaliyar	49.17	87.49
Kangra Zone II	51.89	85.64
Hamirpur Zone III	22.67	69.73
Arki	61.09	74.82
Dhalli	0.00	0.00
Kunihar	72.33	91.10
Ghumarwin	58.05	86.82

Sujanpur	0.00	0.00
Nagrota Bagwan	64.86	88.91
Hamirpur Zone II	23.47	66.99
Tanda Medical College	58.15	84.45
Kangra Zone I	-10.99	74.58
Jogindernagar	67.40	88.36
Jwalamukhi	48.90	76.02
Bhootnath	66.69	87.22
Lankabaker	73.23	82.95
Solan	55.83	79.15
Hamirpur Zone I	13.99	71.21
Sundernagar	56.15	81.52
Ragunath ka Padhar	66.24	80.26
Sanjauli Malyana	0.00	0.00
Dharamshala	58.79	88.03

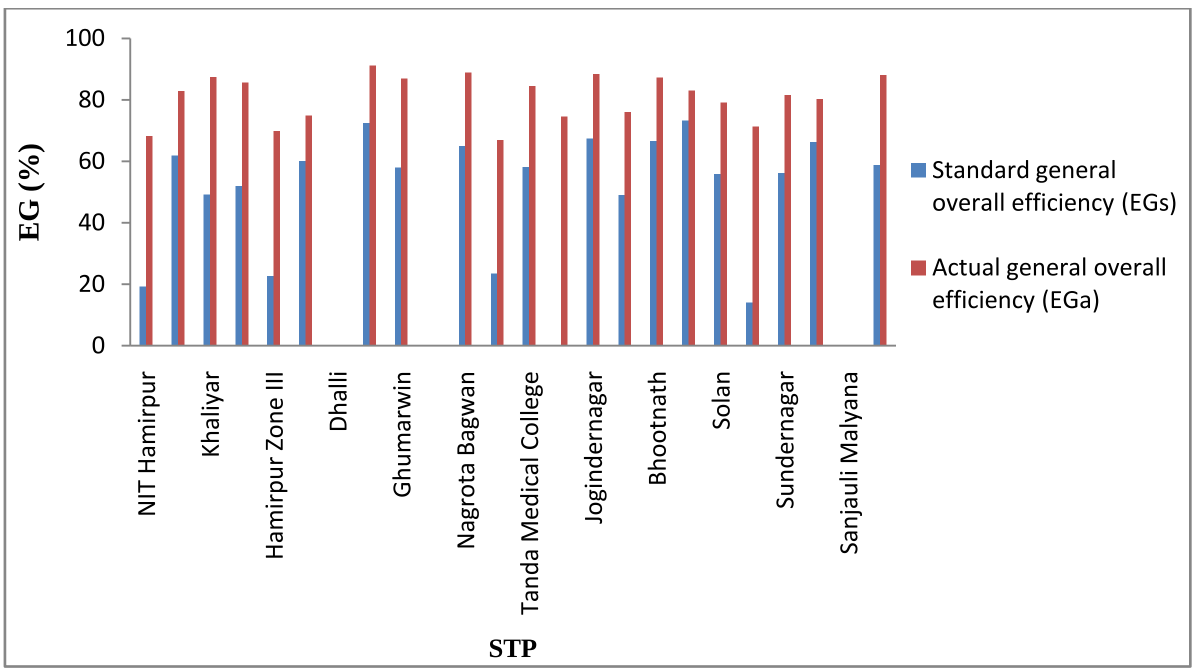

Figure 4.5 Comparison of efficiencies in Monsoon Season

4.2.1.5 Factors affecting the working of STPs

Factors affecting the general efficiency of STPs are aeration, temperature, pH, flow treated. The present study shows that extended aeration is performing best. STP at "Kunihar" is the best overall performer with the overall efficiency of 90.78%. "Nagrota Bagwan" with Diffused Aeration System is better in removing total suspended solids with efficiency of 93.47% than "Solan" and "Dhalli" using the same technology with 71.77% and 75.74%. This implies that "Nagrota Bagwan" performs better in removing the TSS than all other STPs studied. One of the key problems with "Dhalli" and "Solan" using Diffused Aeration Process is foam formation, and hence resulting in average removal of TSS.

In STPs where mechanical aerators are use as extended aeration process, "Dharamshala" performs better with the overall TSS removal of 93.94%. "Jwalamukhi" proves best in removing BOD_3 with 92.58% while COD and TSS removal efficiency is quite low i.e.65.90% and 69.53%.

As there is combined sewer system, the storm water drains into these STPs resulting in low performance of the STPs studied as the sometimes during rains, certain STPs gets flooded and overloaded and the aeration system is not able to provide sufficient amount of oxygen as required. The Hydraulic retention time (HRT) also gets reduced due to the overflow condition resulting in the effluents of low quality and hence the low TSS removal is observed due to low Sludge Retention Time (SRT) [19].

4.2.2 Effluent Quality Index approach

4.2.2.1 Results

Effluent Quality Index is the best method for estimating the superiority of the effluent discharging from the treatment plant. The estimation helps in understanding the field in with the effluent from the treatment plant can be reused to save water sources.

It is seen that pH has more weightage than BOD, COD and TSS. pH is considered as the most essential factor because the value of pH shows the nature of the wastewater. As wastewater contains organic and inorganic components, the wastewater can be acidic or alkaline in nature. The proper pH must be maintained for the proper working of the micro-organisms.

Out of thirty STPs considered, “STP Ghumarwin” shows the best results, means its effluent water can be used for recreational use. The least EQI value is obtained for “STP Tanda Medical College” as 54.43 means its effluent wastewater can be used for agricultural purposes.

The effluent quality index of the STPs lies from 37.23 to 54.43. This shows that the quality of the effluent is good and can be re-used for various purposes like recreational purposes, industrial reuse, groundwater disposal, surface water disposal and agricultural reuse. The effluent can be recirculated for drinking also on applying tertiary treatment.

Table 4.7 Ranking of STPs on basis of EQI

STP	Effluent Quality Index (EQI)	Ranking
Ghumarwin	37.23	1
Kunihar	37.6	2
Dharamshala	37.92	3
Sharabai	38.27	4
Bhuntar	38.31	5
Jarad	39.29	6
Jogindernagar	39.34	7
Sujanpur	39.68	8
Palampur	39.75	9
Khaliyar	39.75	10
Jawalamukhi	39.97	11
Dhalli	40.06	12
Sundernagar	40.53	13
Sanjauli Malyana	40.64	14
Lankabaker	40.64	15
Solan	41.39	16
Arki	42.22	17

Ragunath ka Padhar	42.57	18
Chamba Zone II	42.60	19
Chamba Zone I	42.73	20
Chamba Zone III	42.85	21
NIT Hamirpur	44.59	22
Kangra Zone I	45.88	23
Hamirpur Zone II	45.57	24
Bhootnath	46.35	25
Hamirpur Zone III	46.63	26
Kangra Zone II	51.46	27
Hamirpur Zone I	52.51	28
Nagrota Bagwan	54.03	29
Tanda Medical College	54.43	30

Table 4.8 Comparison of IQI and EQI

STP	Influent Quality Index (IQI)	Effluent Quality Index (EQI)
Chamba Zone III	0.00	42.85
NIT Hamirpur	67.86	44.59
Palampur	64.15	39.75
Khaliyar	64.56	39.75
Sharabai	0.00	38.27
Kangra	64.13	51.46
Hamirpur Zone III	67.86	46.63
Arki	64.15	42.22
Dhalli	64.42	40.06
Jarad	0.00	39.29
Chamba Zone II	0.00	42.60
Kunihar	65.64	37.60
Bhuntar	0.00	38.31
Sujanpur	64.44	39.68
Ghumarwin	64.12	37.23
Nagrota Bagwan	64.02	54.03

Hamirpur Zone II	67.86	45.57
Tanda Medical College	64.02	54.43
Chamba Zone I	0.00	42.73
Kangra Zone I	38.10	45.88
Jogindernagar	64.60	39.34
Jawalamukhi	64.03	39.97
Bhootnath	64.06	46.35
Lankabaker	64.09	40.64
Solan	64.03	41.39
Hamirpur Zone I	67.86	52.51
Sundernagar	64.03	40.53
Ragunath ka Padhar	64.02	42.57
Sanjauli Malyana	65.00	40.64
Dharamshala	64.09	37.92

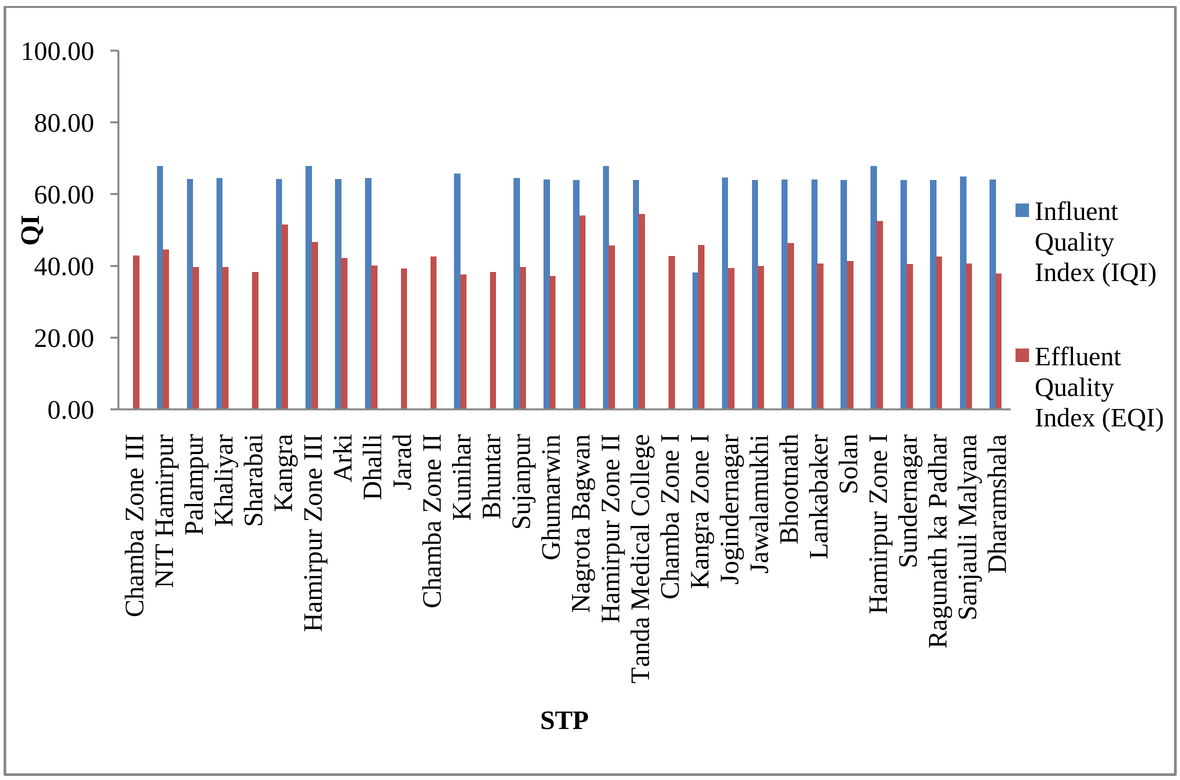

Figure 4.6 Comparison of IQI and EQI

4.2.2.2 Seasonal Variation

Seasonal variation is very important as it tells us the quality of effluent in different seasons. On the basis of results, we can judge the best season in which best quality of effluent can be attained. Side by side, we can judge that which plant is working best in which season.

Table 4.9 Comparison of IQI and EQI in Automn Season

STP	Influent Quality Index (IQI)	Effluent Quality Index (EQI)
Chamba Zone III	0.00	42.11
NIT Hamirpur	67.86	43.75
Palampur	64.02	40.41
Khaliyar	0.00	0.00
Sharabai	0.00	0.00
Kangra	64.10	41.25
Hamirpur Zone III	67.86	57.44
Arki	64.04	42.06
Dhalli	64.02	41.83
Jarad	0.00	0.00
Chamba Zone II	0.00	42.01
Kunihar	0.00	0.00
Bhuntar	0.00	0.00
Sujanpur	64.58	40.38
Ghumarwin	64.09	36.52
Nagrota Bagwan	64.02	40.64
Hamirpur Zone II	67.86	43.01
Tanda Medical College	64.07	39.96
Chamba Zone I	0.00	42.53
Kangra Zone I	37.13	45.56
Jogindernagar	64.37	38.63
Jawalamukhi	64.02	40.26
Bhootnath	64.03	47.28
Lankabaker	64.02	40.43

Solan	0.00	0.00
Hamirpur Zone I	67.86	52.93
Sundernagar	64.20	40.36
Ragunath ka Padhar	64.07	41.63
Sanjauli Malyana	64.33	42.76
Dharamshala	64.06	36.55

It is seen that the seasonal variation does not have much impact on the domestic wastewater treatment plant as the results obtained of each STP in different seasons is nearly same. However, it is noted that the results obtained in monsoon and winter seasons are more as compared to summer and autumn season due to the reason during monsoon and winter the rainfall is more and the flow in the treatment plants increases and hence the time required for each slot of wastewater is not sufficient to provide effluent of good quality. So, more measures are taken to deal such situations.

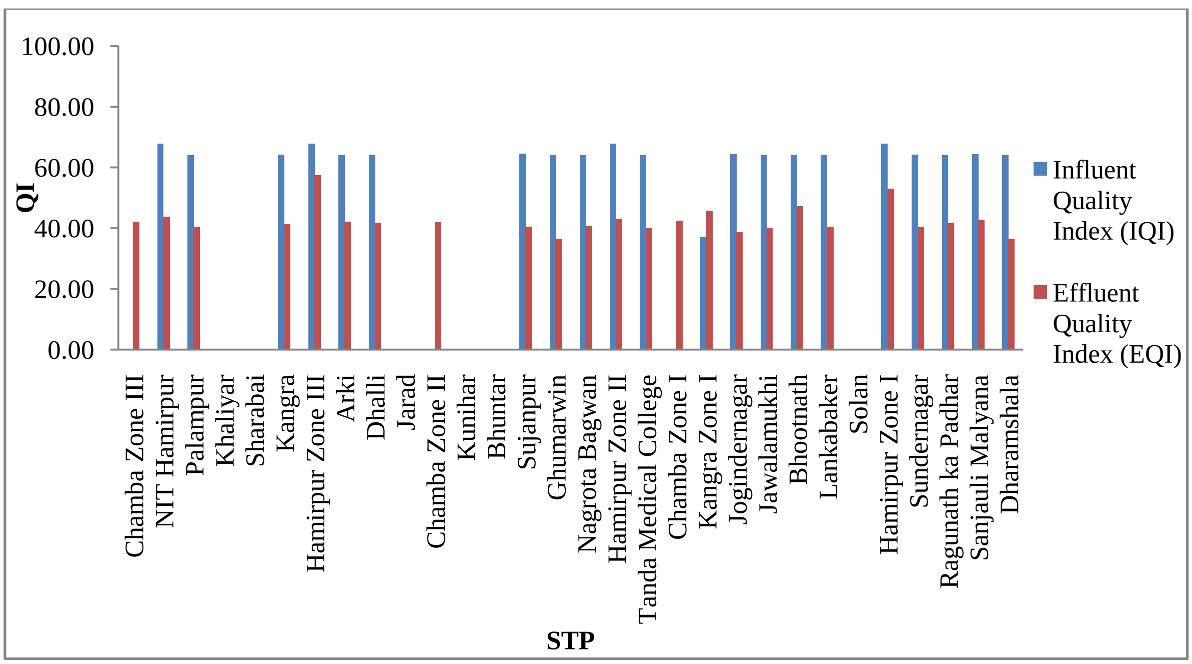

Figure 4.7 Comparison of IQI and EQI in Automn Season

Table 4.10 Comparison of IQI and EQI in Winter Season

STP	Influent Quality Index (IQI)	Effluent Quality Index (EQI)
Chamba Zone III	0.00	43.72
NIT Hamirpur	67.86	44.26
Palampur	65.48	39.14
Khaliyar	64.29	41.27
Sharabai	0.00	37.65
Kangra	64.24	50.35
Hamirpur Zone III	67.86	45.81
Arki	64.05	43.11
Dhalli	65.01	42.68
Jarad	0.00	38.32
Chamba Zone II	0.00	42.78
Kunihar	0.00	0.00
Bhuntar	0.00	39.05
Sujanpur	64.59	40.51
Ghumarwin	64.17	37.03
Nagrota Bagwan	64.02	39.49
Hamirpur Zone II	67.86	44.14
Tanda Medical College	64.03	39.00
Chamba Zone I	0.00	42.93
Kangra Zone I	38.19	45.30
Jogindernagar	64.22	39.33
Jawalamukhi	64.02	40.38
Bhootnath	64.13	42.49
Lankabaker	64.03	53.18
Solan	64.04	40.71
Hamirpur Zone I	67.86	39.72
Sundernagar	64.17	40.54
Ragunath ka Padhar	64.03	42.45
Sanjauli Malyana	67.86	41.97
Dharamshala	64.07	37.97

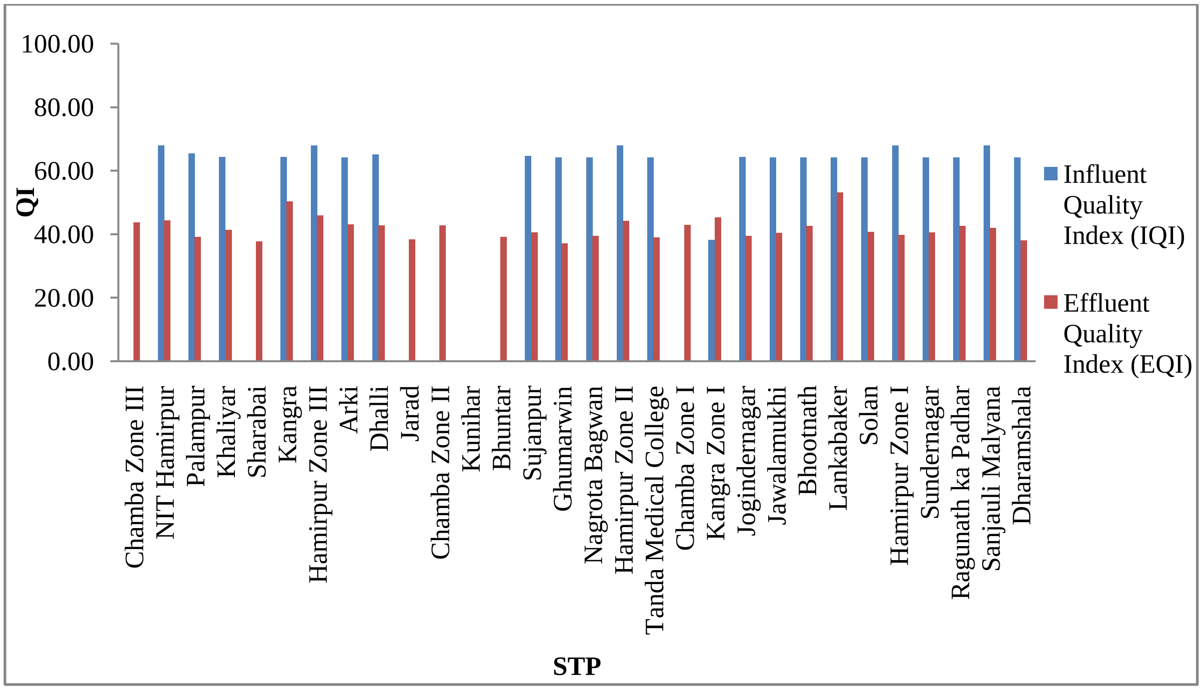

Figure 4.8 Comparison of IQI and EQI in Winter Season

Table 4.11 Comparison of IQI and EQI in Summer Season

STP	Influent Quality Index (IQI)	Effluent Quality Index (EQI)
Chamba Zone III	0.00	42.87
NIT Hamirpur	67.86	44.32
Palampur	64.16	39.60
Khaliyar	64.64	40.30
Sharabai	0.00	37.69
Kangra	64.13	48.96
Hamirpur Zone III	67.86	45.74
Arki	64.08	41.88
Dhalli	21.63	17.49
Jarad	0.00	39.41
Chamba Zone II	0.00	42.43
Kunihar	65.55	37.31

Bhuntar	0.00	38.74
Sujanpur	64.66	49.92
Ghumarwin	64.13	37.43
Nagrota Bagwan	64.03	39.05
Hamirpur Zone II	67.86	44.48
Tanda Medical College	64.06	38.81
Chamba Zone I	0.00	42.88
Kangra Zone I	38.28	46.68
Jogindernagar	64.21	39.32
Jawalamukhi	64.08	39.95
Bhootnath	64.08	46.32
Lankabaker	64.84	40.90
Solan	64.02	41.56
Hamirpur Zone I	43.31	49.60
Sundernagar	64.08	40.65
Ragunath ka Padhar	64.02	43.71
Sanjauli Malyana	64.74	64.86
Dharamshala	64.10	38.60

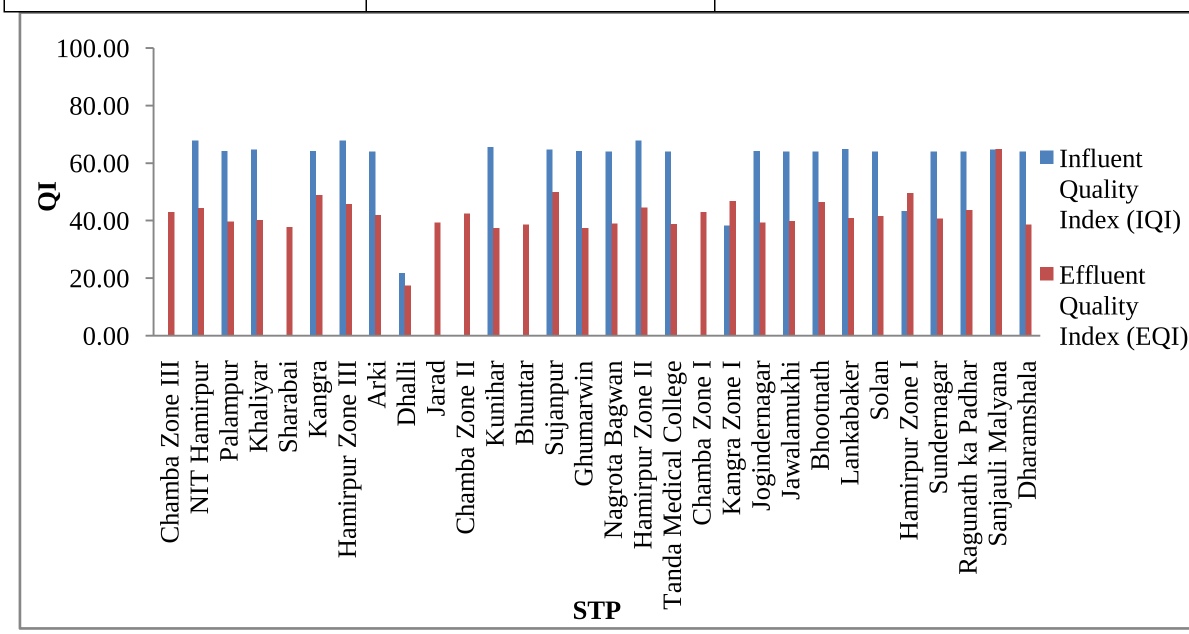

Figure 4.9 Comparison of IQI and EQI in Summer Season

Table 4.12 Comparison of IQI and EQI in Monsoon Season

STP	Influent Quality Index (IQI)	Effluent Quality Index (EQI)
Chamba Zone III	0.00	43.16
NIT Hamirpur	44.01	46.50
Palampur	64.06	40.09
Khaliyar	64.70	37.56
Sharabai	0.00	39.10
Kangra	64.07	49.32
Hamirpur Zone III	43.11	45.80
Arki	64.70	41.73
Dhalli	0.00	-3.27
Jarad	0.00	39.71
Chamba Zone II	0.00	43.19
Kunihar	65.73	39.33
Bhuntar	0.00	38.14
Sujanpur	43.69	32.51
Ghumarwin	64.12	37.78
Nagrota Bagwan	64.03	40.48
Hamirpur Zone II	44.86	46.60
Tanda Medical College	64.03	40.14
Chamba Zone I	0.00	42.86
Kangra Zone I	38.34	46.29
Jogindernagar	66.08	39.59
Jawalamukhi	64.02	39.29
Bhootnath	64.04	48.48
Lankabaker	64.07	40.91
Solan	64.02	41.70
Hamirpur Zone I	42.97	51.76
Sundernagar	64.07	40.50
Ragunath ka Padhar	64.03	42.52
Sanjauli Malyana	44.02	19.85
Dharamshala	64.12	38.36

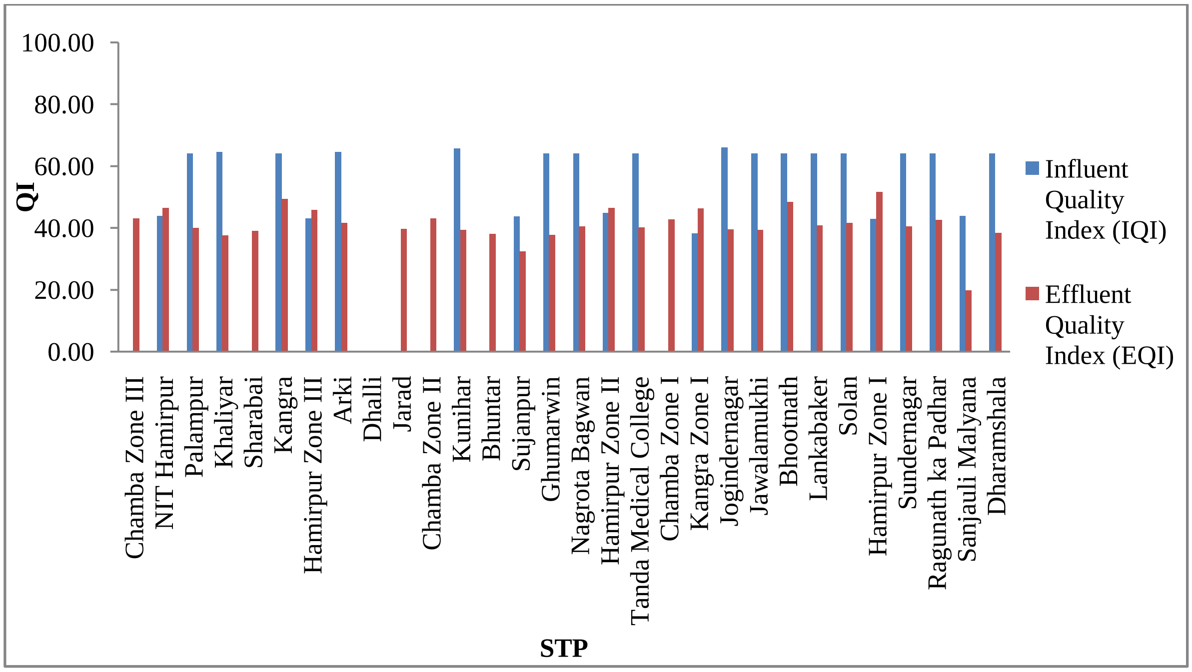

Figure 4.10 Comparison of IQI and EQI in Monsoon Season

CHAPTER 5

CONCLUSION

Performance analysis was carried out on 30 of Existing STP's in Himachal Pradesh in order to comment on the efficiency of sewage treatment plants (STP) for treating sewage water. The treated effluent of some plants was not up to the prescribed standards of the Centre Pollution Control Board (CPCB) and Himachal Pradesh Pollution Control Board (HPPCB). As per the new norms of CPCB, all the STP's studied needs up gradation to meet the new effluent standards. There is a need of strict provision to check the tests performed and apparatus used as the results are not suitable. As mostly 5-6 effluent parameters are tested which are not sufficient enough to meet the ambient effluent quality, so there is a requirement of testing more parameters which enables us to discharge wastewater effluent into the stream, river and other water bodies, as there water bodies are home for aquatic life and its water is worn in a lot of fields.

Mostly designed treatment plants do not meet their design capacity because maximum households have septic tanks which are not linked with the sever lines caring sewage to treatment plants. So Irrigation and Public Health department needs to keep a check on linking each and every house with the sewage line.

Also in the upper regions of Himachal Pradesh where there are treatment plants, the temperature in winter falls below 0 degrees and in such conditions, the microorganisms die. So installation of heaters or blowers in the aeration tanks to maintain the temperature is required as temperature is very important factor for microorganisms to decompose the organic matter and to produce the satisfactory effluent.

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