PERFORMANCE EVALUATION OF SEWAGE TREATMENT PLANTS

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree
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in
CONSERVATION OF RIVERS AND LAKES

By
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CANDIDATE'S DECLARATION

I hereby declare that the work which has been presented in the dissertation entitled **"PERFORMANCE EVALUATION OF SEWAGE TREATMENT PLANTS"** in partial fulfillment of the requirements for the award of the degree of **Master of Technology in Conservation of Rivers and Lakes**, submitted in Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee, is an authentic record of my own work carried out during the period from July 2011 to June 2012 under the supervision of **Dr.M.P.Sharma**, Associate Professor , Alternate Hydro Energy Centre , Indian Institute of Technology Roorkee.

The matter embodied in the dissertation has not been submitted by me for the award of any other degree or diploma.

Place: Roorkee

Date: June,13, 2012

Priyanka

(PRIYANKA SIDDHARTH)

CERTIFICATE

This is to certify that the above statement made by the candidate is correct to the best of my knowledge and belief.

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ABSTRACT

Sewage is correctly the subset of wastewater that is contaminated with feces or urine, but is often used to mean any waste water. "Sewage" includes domestic, municipal, or industrial liquid waste products disposed of, usually through a pipe or sewer.

Sewage treatment, or domestic wastewater treatment, is the process of removing contaminants from wastewater and household sewage, both runoff (effluents) and domestic. It includes physical, chemical, and biological processes to remove physical, chemical and biological contaminants.

Since 1985, more than 70 sewage treatment plants have been constructed under the GAP and Yamuna Action Plan (YAP). These plants are based on a range of technologies involving varying levels of mechanization, energy inputs, land requirement, skilled manpower, etc. In the early stages, the selection of technology was based on past experience and its perceived performance efficiency. Moreover, at different stages of these Action Plans a number of technologies have been tried out on pilot scale and some of them have been scaled up for larger capacity plants. Over the last 20 years a considerable experience and expertise has been developed within the country in this sector. However, the level of performance of these plants with regard to effluent quality, energy consumption, process stability, resource recovery, capital and O&M costs, etc.

There are many Sewage Treatment technologies available for the treatment and reuse of sewage in India. Sometimes, it is difficult to select a technology that is appropriate for the desired treatment in the specific region such as rural, urban or metropolitan area. The important factors affecting the selection of STP technology are the volume of daily flow, sewage characteristics, degree of treatment needed, disposal of the effluent, area of land required for the plant, capital cost of installation, power required for the treatment, annual operation and maintenance cost.

Actual performance of the STP can differ from that of design mainly due to differences in sewage characteristics & local conditions. Thus knowing actual performance and capacity of the STP becomes very important. The current study is an attempt in this direction. After evaluating the performance of different technologies based sewage treatment plant in term of different parameter, From life cycle cost analysis it is conclude that the Waste Stabilization Pond is the most economical and cost effective technology to treat sewage where the cost of land is low i.e. approx.

in the range upto Rs. 200 Lacs per ha. In WSP daily power requirement is also very low so in villages where power is not available WSP is only suitable. Where land cost is high and land is not available the UASB and ASP both are suitable.

In ASP treated effluent quality is best among UASB & WSP. The average BOD & TSS removal efficiency of ASP are more than 90% which is very high in comparison to UASB & WSP. Where land cost is high, land scarcity areas where huge area is not available, ASP are found to be economical in order, a suitable option in Mega & Metropolitan areas.

The revenue generation potential from UASB with FPU is the highest among ASP & WSP, its projected energy production capacity of 56 MLD STP is 11.08 MWh/day which very high in comparison to ASP & WSP, the cost of electricity saving per MLD ASP STP is 072 lakhs/year and the UASB STP is 2.88 lakhs/year which very high in comparison to ASP, in WSP energy generation through biogas is not available.

PERFORMANCE EVALUATION OF SEWAGE TREATMENT PLANTS

CONTENTS

LIST OF ABBREVIATIONS/NOTATIONS

SL. NO	ABBREVIATIONS/ NOTATIONS	DESCRIPTION
1	AM	Annual Maintenance
2	STP	Sewage Treatment Plant
3	BOD	Bio-chemical Oxygen Demand
4	COD	Chemical Oxygen Demand
5	TSS	Total suspended solids
6	TS	Total solids
7	VSS	Volatile suspended solids
8	CH_4	Methane
9	CO_2	Carbon dioxide
10	H_2S	Hydrogen sulfide
11	m.c	Moisture content
12	vol %	Volume percentage
13	MLD	Million liter per day
14	MFL	Madras Fertilizers Limited
15	MPL	Madras Pesticides Limited
16	mg/l	Milligram per liter
17	kg	Kilogram
18	cum.	Cubic meter
19	m3	Cubic meter
20	m2	Square meter
21	C.V	Calorific Value
22	kWh	Kilo watt hour
23	MWh	Mega watt hour
24	kJ	Kilo joule
25	MJ	Mega joule
26	kl / hr	Kilo liter per hour
27	TTP	Tertiary Treatment Plant
28	HRT	Hydraulic Retention Time
29	ASP	Activated Sludge Process
30	FAB	Fluidized Aerobic Bed Bioreactor
31	UASB	Upflow Anaerobic Sludge Blanket

32	WSP	Waste Stabilization Pond
33	SWD	Sewage Water Depth
34	MPN	Most Probable Number
35	MLSS	Mixed Liquid Suspended Solid
36	MLVSS	Mixed Liquid Volatile Suspended Solid
37	SVI	sludge volume index
38	F/M ratio	Food / Micro-organism Ratio
39	E-coli	Escherichia coliform
40	YAP	Yamuna Action Plan
41	sq. km	Square Kilometer

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CHAPTER – 1

INTRODUCTION

1.1 GENERAL

Urbanization has encouraged the migration of people from villages to the urban areas in India. With exponential growth in urbanization, a number of environmental problems have emerged. For improving standards of life, running water-supply has been established in most of the cities/towns and even in some villages over the past three decades in India. This has, in turn, led to flush-latrines and much large use of water in homes for bathing, washing of clothes utensils etc, generating significant amount of wastewater. Use of soaps, detergents and amounts of various food materials going to the sink have also grown with improved life standards. Unfortunately, due to paucity of resources sewerage or improved sanitation did not get much attention. Hence sewerage has lagged far behind water supply. A large number of the cities/towns either do not have any sewerage system or the sewerage system is overloaded or defunct. Even where sewers exist, they often leak or overflow, releasing their contents to storm water or other surface drains or percolate in to soil to reach ground-water [2]. Thus a bulk of pollution gets retained on land to percolate, leach or get washed-off to streams or groundwater. The performance of a sewage treatment plant may be defined as its efficiency to remove/reduce the potential harmful contaminants or pollutants from raw sewage and to discharge the treated effluent into the natural environment with compliance to specific discharge limits.

The main biological parameters which are used to classify the pollutant load in the municipal raw sewage are Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS). The other parameters, considered are Chemical Oxygen Demand (COD), Feacal Coliform, Nutrients like Nitrogen (N) and Phosphorous (P) etc. Physical parameters like pH and Temperature may also be important in some cases. Therefore the performance of a Sewage Treatment Plants is associated with the efficient removal of the aforesaid parameters from the raw sewage [15].

The treatment technology, involved in the treatment process also plays an important role in the overall performance of the STP because the selection of appropriate technology depends upon many factors like quantity and quality of the raw sewage, availability of space, cost criteria, environmental status of the receiving body, existence of proper operation and maintenance facilities, availability of energy, utilization of treated effluent and sludge byproducts etc.

A successful project must satisfy certain criteria like economic viability, social responsibility, environmental reliability etc. especially after its implementation. In this aspect the performance of a Sewage Treatment Plant can be considered as a measure of the sustainability of the sewage treatment project. The better is the performance of a plant, more is its useful life, more is the project sustainability. Therefore nowadays, the performance of a STP has become a very important factor in taking part in the overall development of the community as well as the development of the country [10].

The one important aspect associated with the performance of Sewage Treatment Plant is its regular operation and maintenance (O&M). The level of O&M actually determines the efficiencies of the different treatment units of the plant. More is the regularity and quality of O&M, more will be the efficiencies of the treatment units and consequently better is the performance of the treatment plant. Again in order to maintain the level of O&M to the desired extent , factors like regular flow of fund, plant management, laboratory and training facilities, plant personnel, co-ordination amongst the implementing authorities, reputation of O&M agencies etc. are also necessary[3].

1.2 WATER SUPPLY, WASTEWATER GENERATION AND TREATMENT IN INDIA

In India, water quality has deteriorated steadily with time. With increase in population, the demand of fresh water also increased which in turn, led to the increased generation of wastewater. Rapid urbanization in the last century has led to the Metropolitan and other bigger cities getting choked with myriad environmental problems such as water supply, wastewater and solid waste generation and their collection, treatment and disposal. A study conducted by the Central Pollution Control Board in 2003-04 indicates that about 26,254 million liters per day of waste water are generated in the 921 Class I cities and Class II towns in India (having more than 70% of urban population) with treatment facilities available for about 7044 million litres per day only [11]. Table 1.3 below shows the trend of water supply, waste water generation and treatment available in Class I cities and Class II towns in India.

Table: 1.1: Trend of water supply, waste water generation and treatment in Class I Cities/ II Towns

Parameters	Year 1988				Year 1999				Year 2008			
	Metro Cities	Class-I Cities	Class-II Towns	Total	Metro Cities	Class-I Cities	Class-II Towns	Total	Metro Cities	Class-I Cities	Class-II Towns	Total
Number of Cities	3	37	22	59	6	50	37	87	6	53	35	88
Population Projected	18744666	29147026	1877185	31024211	35971972	45561552	2605818	48167370	31287816	45101133	2424340	4752543
Total Water Supply (in MLD)	3369.1	4710.57	260.25	4970.82	5722.5	6689.25	265.53	6954.78	6128.48	8512.12	270.07	8782.19
Per Capita Water Supply (lpcd)	179.7	161.61	138.64	160.22	159.08	146.82	101.9	144.39	195.87	188.73	111.39	184.79
Sewage Generation (in MLD)	2694.4	3771.26	208.38	3979.64	4334.9	5389	171.99	5560.99	4308.64	6215.84	216.03	6431.87
Treatment Capacity (in MLD)	81.07	193.9	-	193.9	402	483.01	38.5	521.51	2768	3025.14	-	3025.14

Source: [Ministry Water Resource Govt. of India]

1.3 WATER POLLUTION

Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater). Water pollution occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds [12].

Water pollution affects plants and organisms living in these bodies of water. In almost all cases the effect is damaging not only to individual species and populations, but also to the natural biological communities.

1.4 REUSE OF WASTEWATER

Water scarcity and water pollution pose a critical challenge in many developing countries. In urban areas, it is becoming difficult for the authorities to manage water supply and wastewater. Strategies for water and wastewater reuse can improve urban water management. The important aspects to minimize public health risks are identified [15].

Wastewater Reuse:

1. Wastewater Reuse for Agriculture
2. Wastewater Reuse for Industry
3. Urban Applications
4. Wastewater Reuse for Environmental Water Enhancement
5. Groundwater Recharge

The capacity building policy-making, institutional strengthening, financial mechanisms, and awareness rising and stakeholder participation are vital to implement these strategies for wastewater reuse.

1.5 ZERO DISCHARGE TECHNOLOGY

Zero discharge' means that no wastes are discharged, that everything is recycled and no pollutants are being discharged into the environment. Another term for this is Totally Effluent Free(TEF)

Evolution of treated wastewater discharge standards is a complex process requiring thorough expertise. Zero Discharge is one such standard / requirement of pollution control authorities

1.6 IMPORTANCE AND USEFULNESS WASTEWATER TREATMENT

The purpose of wastewater treatment is to remove the organic and inorganic solids. The organic solids are decomposed by microorganisms and inorganic solids that are inert are removed by sedimentation. The treatment of sewage consists of primary, secondary and tertiary treatment. The primary treatment units are screen chamber, grit chamber, and primary settling tank. The secondary treatment units are aeration tank and secondary settling tank. The tertiary treatment units are rapid sand filtration or slow sand filtration and nutrient removal by various methods. The domestic sewage is the major source of pollution for surface as well as ground water [14]. The water becomes unfit for various uses and causing waterborne diseases. There are frequent outbreaks of diseases due to unsanitary living conditions. The discharge of untreated wastewater into the aquatic environment is the main cause of diarrhea diseases. As the quantity of wastewater discharged into the rivers/water bodies exceeds the self cleansing capacity of rivers the dissolved oxygen in the water reduces and the aquatic life will starts disappearing. As the rivers are the major sources of drinking water needs, the treatment of wastewater becomes necessary.

The waste water treatment systems are very essential for the following reasons

- To reduce human disease and to promote public health,
- To eliminate gross water pollution effects and
- To achieve levels of water quality that allows native marine organisms / aquatic life to return to normal growth patterns and allows full human recreational use.
- Removal of Suspended Solids by Clarification (In Sedimentation Tank) & Decomposition (By providing Suitable conditions for bacteria)
- Removal of Organics by Decomposition (By providing Suitable conditions for bacteria) & Provide conditions for separation of the wastewater from the Bacteria.
- Removal of Residual bacteria present in separated wastewater by adding powerful oxidants such as Chlorine.

1.7 STANDARDS FOR TREATED WASTEWATER:

The standards for treatment of wastewater decided by the regulatory authorities [which in the case of India is the Central Pollution Control Board (CPCB) along with the various State Pollution Control Boards (SPCB's)] and the application for which the final effluent from the treatment plant is to be utilized/ disposal method used for the final effluent.

Table 1.2 Treated Quality Standards

Parameters	To Discharge in Water bodies	On Land discharge
BOD_5 AT 20^oC (mg/l)	30	100
TSS (mg/l)	50	200
Feacal Coliform (MPN/100ML)	1000 (Desirable) 10000 (Maximum)	-

Source: [CPCB]

TABLE 1.3: Primary water quality criteria for designated-best-use classes

Sr. No.	Designated-Best-Use	Class of water	Criteria
1	Drinking Water Source without conventional treatment but after disinfection	A	1.Total Coliforms Organism MPN/100ml shall be 50 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 6mg/l or more 4. Biochemical Oxygen Demand 5 days 20°C 2mg/l or less
2	Outdoor bathing (Organized)	B	1. Total Coliforms Organism MPN/100ml shall be 500 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 5mg/l or more 4. Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
3	Drinking water source after conventional treatment and disinfection	C	1. Total Coliforms Organism MPN/100ml shall be 5000 or less 2. pH between 6 to 9 3. Dissolved Oxygen 4mg/l or more 4. Biochemical Oxygen Demand 5 days 20°C 3mg/l or less
4	Propagation of Wildlife and Fisheries	D	1. pH between 6.5 to 8.5 2. Dissolved Oxygen 4mg/l or more 3. Free Ammonia (as N) 1.2 mg/l or less

5	Irrigation, Industrial Cooling, Controlled Waste disposal	E	1. pH between 6.0 to 8.5 2. Electrical Conductivity at 25°C µmhos/cm Max. 2250 3. Sodium absorption Ratio Max. 26 4. Boron Max. 2mg/l
6	Not for any use	Below E	Not meeting A B C D,E Criteria

Source: [CPCB]

1.8 NATIONAL RIVER CONSERVATION PLAN (NRCP)

The Ministry of Environment and Forests, Government of India, started a programme for cleaning up of rivers in the country with the implementation of the Ganga Action Plan (GAP) in 1985. A Central Ganga Authority (CGA) was set up under the Prime Minister with the members being the Chief Ministers of the concerned states, Union Ministers and Secretaries of the concerned Central Ministries along with experts in the field of water quality. GAP was extended to GAP Phase – II in 1993 and then to NRCP in 1995. GAP Phase – II was merged into NRCP in 1996. The objective of the NRCP was to improve the water quality of major rivers as the major fresh water source in the country, through the implementation of pollution abatement schemes. Since then, a single scheme of NRCP is under implementation as a Centrally Sponsored Scheme. The CGA was renamed as National River Conservation Authority (NRCA) with a larger mandate to cover all the programmes supported by the National River Conservation Directorate (NRCD).

The functions of the NRCA are as follows:

(1) To lay down, promote and approve appropriate policies and programmes (long and short-term) to achieve the objectives.
(2) To examine and approve the priorities of the NRCP.
(3) To mobilize necessary financial resources.
(4) To review the progress of implementation of approved programmes and give necessary directions to the Steering Committee, and

(5) To make all such measures as may be necessary to achieve the objectives.

GAP Phase – I was started in 1985 as a 100% centrally funded scheme. The main objective was to improve the water quality of the River Ganga to acceptable standards by preventing the pollution load from reaching the river. Under GAP Phase– I pollution abatement works were taken up in 21 Class – I towns in Uttar Pradesh, Bihar and West Bengal. GAP Phase – I was extended to GAP Phase – II, approved in stages between 1993 and 1996. It covered the River Ganga and its major tributaries, viz. Yamuna, Gomati and Damodar. This plan covered pollution abatement works in 95 towns along the polluted stretches of these 4 rivers spread over 7 states. The total approved cost of this action plan was approved on 50:50 cost sharing basis between the Centre and the State Governments.

It was later felt that the river conservation activity needed to be extended to other rivers in the country as well. Accordingly, GAP was merged into a National River Conservation Plan (NRCP) in 1995 on 50:50 cost sharing basis between Centre and State Governments. The Ganga Project Directorate was converted into the National River Conservation Directorate (NRCD) for servicing the National River Conservation Authority and the Steering Committee. It covered pollution abatement works in 46 towns along the polluted stretches of 18 rivers spread over 10 states. The GAP Phase –II was merged with NRCP in 1996.

NRCP was converted into a 100% centrally funded scheme in November 1998 with only the land cost to be borne by the States. However, in March 2001, it was decided to adopt an integrated approach for the river cleaning programme and that all future programmes will be shared on a 70:30 cost sharing basis between the Centre and State Governments respectively.

The activities covered under the NRCP include the following:

(1) Interception and Diversion works to capture the sewage flowing into the river through open drains and divert them for treatment.
(2) Sewage Treatment Plants for treating the diverted sewage.
(3) Low Cost Sanitation works to prevent open defecation on river banks.
(4) Electric Crematoria and Improved Wood Crematoria to conserve the use of wood and help in ensuring proper cremation of bodies brought to the burning ghats.
(5) River Front Development works such as improvement of bathing ghats.
(6) Public awareness and public participation.

(7) HRD, capacity building, training and research in the area of River Conservation.

(8) Other miscellaneous works depend upon location specific conditions including the interface with human population.

1.9 OBJECTIVES OF THE STUDY

The present study has been taken for evaluating the performance of selected sewage treatment plants in term of different parameter like quality of treated sewage, performance stability, recourse requirement, potential of resource generation and impact of STP. The purposed study has the following objectives:

1. To review the literature on the performance evaluation of STPs.
2. To study the different technologies used sewage treatment.
3. To identify the main parameter used for performance evaluation.
4. To review the criteria for selection of STPs.
5. To develop the methodology for performance evaluation of STPs.
6. To identify the location of four different STP and collect samples for generating the data for Performance evaluation.
7. To evaluate the performance in term of energy utilization.
8. To identify the major problems responsible for failure of STPs.
9. To study the sustainability issues of STPs.

1.10 ORGANIZATION OF THESIS

The entire thesis has been divided into five chapters. The first chapter highlights the waste water generation and treatment capacity of the India, water pollution, need and importance of the waste water treatment, standard for treated waste water, National river conservation plan and objectives of the study. The second chapter deals with the identification of the parameter for performance evaluation of the sewage treatment plants and the literature review available for performance evaluation of STP. The third chapter deals with selection of the plant for performance evaluation and explaining the different methods of wastewater treatment and benefits of sewage treatment plants. The four chapter explaining the selected sewage treatment plant details and performance evaluation results. The fifth chapter gives the conclusions and future scope of the present study.

CHAPTER – 2

LITERATURE REVIEW

2.1 GENERAL

One of the most pervasive problems afflicting people throughout the world is inadequat access to clean water and sanitation. Problems with water are expected to grow worse in th coming decades, with water scarcity occurring globally, even in regions currently considere water-rich. Addressing these problems calls out for a tremendous amount of research to b conducted to identify robust new methods of purifying water at lower cost and with less energ while at the same time minimizing the use of chemicals and impact on the environment.

Physical, chemical and biological methods are used to remove contaminants from waste-wate In order to achieve different levels of contaminant removal, individual waste-water treatmer procedures are combined into a variety of systems, classified as primary, secondary, and tertiar waste-water treatment. More rigorous treatment of waste-water includes the removal of specifi contaminants as well as the removal and control of nutrients. Natural systems are also used for th treatment of waste-water in land-based applications. Sludge resulting from waste-water treatmer operations is treated by various methods in order to reduce its water and organic content and mak it suitable for final disposal and reuse. **[12]**

To prevent the pollution of river Ganga and to improve its water quality, an Action Pla known as the Ganga Action Plan was formulated in the year 1984 on the basis of a comprehensiv survey of Ganga Basin carried out by the Central Pollution Control Board under Assessment an Development Study of River Basin (ADSORB). The objective, at the time of launching the Gang Action Plan in 1985, was to improve the water quality of the river Ganga to acceptable standard b preventing the pollution load from reaching the river. Various schemes of interceptions & diversion and treatment of sewage have been undertaken under the Ganga Action Plan (GAP).

Since 1985, more than 70 sewage treatment plants have been constructed under the GAP an Yamuna Action Plan (YAP). Over the last 20 years a considerable experience and expertise ha been developed within the country in this sector. However, the level of performance of these plant with regard to effluent quality, energy consumption, process stability, resource recovery, capita and O&M costs, etc. has varied considerably.

With the help of Table 2.1 we are presenting the performance work of various STPs based o literature all over the world.

Table 2.1:Performance evaluation of STP based on literature.

STP	Technology	Capacity	DO (mg/l)	pH I	pH E	Turbidity I (NTU)	Turbidity E (NTU)	SS I (mg/l)	SS E (mg/l)	BOD I (mg/l)	BOD E (mg/l)	COD I (mg/l)	COD E (mg/l)	TKN (mg/l)	FC log I (MPN/ 100 ml)	FC log E (MPN/ 100 ml)	FS log I (MPN/ 100 ml)	FS log E (MPN/ 100 ml)	Reffrence
Solvak Republic	AN-ANAco	-	-	7.7	7.5	-	-	267	29	292	16	557	83	-	-	-	-	-	E.gasparikova 2004
HID, Nepal		-	-			-	-	1527	595	984	252	3234	1226	-	-	-	-	-	sushil kumar, 2008
James town, Accra,Ghana	UASB	-	4.24	8.96	7.45	1926	122	-	-	1206	23	3173	146	-	-	-	-	-	E.Awuah, 2008
Kondali Delhi	ASP	204.3	-	6.8	7.1	426	6	-	-	250	9	300	24	64	7.9	4.2	6.62	3.89	priyanka jamal, 2008
Yamuna Vihar Delhi	ASP	90.8	-	6.7	7.4	231	39	-	-	225	10	285	64		6.72	5.1	6.05	4.7	priyanka jamal, 2008
Rithala I Delhi	ASP	181.6	-	7.1	7.7	308	51	-	-	329	72	464	112	46	6	5.36	4.2	5.39	priyanka jamal, 2008
Coronation pillar II & III Delhi	ASP	136.2	-	6.6	6.8	50	91	-	-	264	40	320	48	46	6	4.52	4.17	2.65	priyanka jamal, 2008
Okhla Delhi	ASP	635.6	-	7.3	7.5	281	5	-	-	250	25	356	25	51	6.91	5.27	6.44	4.5	priyanka jamal, 2008
Nilothi Delhi	ASP	181.6	-	6.9	7.5	419	33	-	-	230	32	363	40	34	7	4.2	6.33	4.24	priyanka jamal, 2008
Keshopur Delhi	ASP	326.8	-	6.9	7.4	337	60	-	-	307	63	496	170	67	7.18	5.19	6.81	5.94	priyanka jamal, 2008

Papankallan Delhi	ASP	90.8	-	7	7.5	401	11	-	-	316	40	505	48	56	6.32	5.4	6.35	5.24	priyanka jamal, 2008
vasant kunj I Delhi	Ex Aeration	13.6	-	7.2	7.5	646	3	-	-	450	3	632	28	54	7.2	4.6	7.05	4.11	priyanka jamal, 2008
Vasant kunj II Delhi	Ex Aeration	9.9	-	7.2	7.5	646	12	-	-	450	3	632	42	54	7.2	5.8	7.05	5.28	priyanka jamal, 2008
Mehrauli Delhi	Ex Aeration	22.7	-	7.5	7.5	226	3	-	-	322	5	533	32	79	7.1	3.02	5.99	2.92	priyanka jamal, 2008
Nazafgarh Delhi	Ex Aeration	22.7	-	7.3	8.3	120	31	-	-	119	37	172	72	44	6.35	3.88	5.7	3.41	priyanka jamal, 2008
Delhi Gate	BIOFORE	9.9	-	7.3	7.2	304	4	-	-	350	2	666	21	64	6.97	4.95	7.14	4.71	priyanka jamal, 2008
Sen nursing home Delhi	BIOFORE	9.9	-	7.3	7.1	291	7	-	-	317	17	552	53	58	6.87	4.49	6.85	4.19	priyanka jamal, 2008
Cornation pillar I	Tricling Filtration	45.4	-	6.6	7.2	50	14	-	-	264	18	320	40	46	6	4.85	4.17	2.61	priyanka jamal, 2008
Rithala II Delhi	ASP+(High rate aeration process)	181.6	-	7.1	7.1	308	226	-	-	329	90	464	146	46	6	5.64	4.2	5.53	priyanka jamal, 2008
Oxidation pond Timarpur Delhi	Oxidation pond	27.2	-	6.4	7.7	252	5	-	-	252	6	320	21	42	5.54	2.08	5.94	1.86	priyanka jamal, 2008
Allahabad	ASP	60	3	-	-	-	-	-	40-44	-	29-33	-	280	-	-	-	-	-	CPCB, 2009
Varanasi	ASP	80	3	-	-	-	-	-	25-121	-	13-77	-	98-168		-	-	-	--	CPCB, 2009

Vrindavan	**WSP**	**4**									**30-60**								**CPCB, 2009**
Karnal		**8**							**44-70**		**70-100**								**CPCB, 2009**
Mathura		**12.5**									**20-30**								**CPCB, 2009**
Howrah		**30**							**39**		**13**								**CPCB, 2009**
Faridabad	**UASB**	**20**							**25-45**		**27-30**		**99-170**						**CPCB, 2009**
Ghaziabad	**UASB**	**56**									**28-33**		**280**						**CPCB, 2009**
Brazil	ST+AF	**0.205**							165	665	292	1398	730						**silvia.c 2011**
Brazil	**FP**	**0.4**							216	553	136	1187	525						**silvia.c 2011**
Brazil	**AP+FP**	**1.625**							**153**	510	**89**	1095	**309**						**silvia.c 2011**
Brazil	**ASP**	**64.5**							**57**	315	**35**	575	**92**						**silvia.c 2011**
Brazil	**UASB**	**3.04**							**85**	371	**98**	715	**251**						**silvia.c 2011**
Brazil	UASB+Post	**0.3**							**51**	362	**42**	713	**141**						**silvia.c 2011**

In Table 2.1 presented the performance evaluation of various STPs of india and other countries, through this we observed that the parameter selected by the many persons for performance evolutions in term of treated effluent quality are DO, TSS ,BOD, COD, pH, Turbidity, Fecal coliform and Total coliform in india and other country of the world. With the help of this review we have selected parameter for performance evaluation of STPs are pH, TSS, BOD and COD.

2.2 PERFORMANCE EVALUATION WORK OF STPs BASED ON LITERATURE

A great variability was noticed in the effluent concentrations and in the removal efficiencie: considering all analyzed constituents and all treatment technologies. The septic tank + anaerobi filter (ST+AF) process presented a performance below that reported in the literature.

The performance of the facultative ponds (FP) was lower than expected, considering COD TSS and TN removal efficiencies. However, good TP and FC removal efficiencies were achieved.

The anaerobic ponds + facultative ponds (AP + FP) showed a good performance in terms c BOD, COD, TP and FC removal, with a significant percentage of WWTPs with efficiencies withi and even above the values reported by the literature.

The performance presented by the activated sludge (AS) plants, considering organic matte removal, was the highest among the evaluated systems, although it was below the expected one.

The UASB reactors showed good BOD and COD removal efficiencies and a poor performanc regarding TSS, FC and nutrients, in terms of the reference ranges reported in the literature. Th performance achieved by the UASB reactors followed by post treatment (UASB + POST) was th closest one with the expected values from the literature.[7]

Sudasinghe et al. [6], presented that only 2 out of 8 STPs studied are performing well. I general the physical and technical (hardware) aspects are found to be satisfactory whilst personne and operation and maintenance aspects (software) are poor. This indicates that the construction o technically sound STPs does not necessarily guarantee its success. Recruitment of traine personnel and providing them with responsibilities are required for better performance of STPs The private sector appears to be performing well in managing the STP compared to governmen and NGO sectors. The study has provided insights into many aspects which require furthe research. Among them institutional arrangements, regulation for proper sewerage management an cost recovery from the beneficiary communities are found as priority areas.

Sushil et al. [1], presented the performance of central wastewater treatment plant (CWWTP of Hetauda Industrial District (HID).Which is used to treat industrial as well as sanitar wastewater. Brewery, dairy, vegetable ghee and soap factories are major sources of high strengtl wastewater in HID. The overall performance of CWWTP was not good as it did not treat th wastewater to meet the effluent standards of BOD5, COD and TSS. Large fluctuation in influen BOD5 (from 144 mg/l to 1556 mg/l) and lower volumetric BOD5 loading (avg. volumetric loadin of 56.34 g BOD/m3 d) compared to the design volumetric loading (111 g BOD/m3 d) were mai reasons for poor performance. To overcome the large fluctuation in characteristics of influen equalization tank should be added and wastewater from factories should be treated to mee pretreatment criteria before discharging to CWWTP. To overcome the problem of under BOD loading, other factory sewerage systems should be connected to CWWTP.

Bassim Eid Abbassi. et al.[4], presented the performance of compact decentralized sma scale activated sludge treatment plant, which receiving domestic wastewater was monitored ove 12 month period. The plant was constructed, so that carbonaceous and nitrogenous bioreactions ar to take place. The plant was operated at different hydraulic loadings (15, 20, 30 and 40 m3/d) i order to investigate the plant performance at varying conditions and to check for its absorbanc capacity for possible shock loadings as a result of fluctuating influent quality. Carbonaceou kinetic coefficients based on Monod kinetics were determined. It has been found, that the plar was operated properly under different hydraulic loadings and produced a water quality tha complies with the lowest Jordanian Standard 893-2006, which set an allowable maximum level c 30 mg-BOD /L and 100 mg-COD/L for irrigating cooked vegetables, 5 parks, playgrounds an sides of roads within city limits. The results showed clearly, that the plant is sufficiently capable t absorb the organic chock loadings, which is not unexpected in small treatment systems. Nutrier (nitrogen and phosphorous) removals were found to be very efficient, so that maximur ammonium and phosphorous removals were found to be 90 and 70 % respectively. The obtaine kinetic coefficients showed clearly, that this treatment facility is able to biodegrade this type o wastewater with low excess sludge production.

An integrated system originated from the combination of anaerobic and aerobic technologies operational experiences it can be said that the properly operated two stage technology is effectiv for the removal of organic pollution and suspended solids, while under optimal conditions evei nutrient removal can be achieved. Energy consumption decreased at about 25- 40% compared t the small WWTP working on aerobic principles **[5].**

2.3 SEWAGE GENERATION AND EXISTING TREATMENT CAPACITY IN INDIA.

In India, out of the total population of 1027 million in the year 2001, about 285 million live i urban areas. The percentage of urban population to the total population of the country, which in th year 1991 was 25.7 percent, stands at 27.8 percent in the year 2001. The percentage decada growth of population in rural and urban areas during the decade 1991-2001 was 17.9 and 31.1 percent, respectively.

Problem of pollution of water bodies and that of ground water is more related to cities and towns and their surroundings as pollution caused by villages and very small towns is either assimilated by or has negligible effect on the surrounding environment. However, there is possibility of bacteriological impacts on smaller communities that come in direct contact of sewage. In India, cities having more than hundred thousand population are classified as Class I cities and towns having fifty to hundred thousand population as Class II towns. This report assesses pollution caused by sewage generated from these two classes of cities/towns. According to the Census figure of 2001, the number of class I cities is 414 and class II towns is around 489.

There are 211 sewage treatment plants (STPs) in 112 of the 414 Class I cities and 31 STPs in 22 of the 489 Class II towns. Besides, 27 STPs are in 26 other smaller towns. Of these, 186, 24 and 21 STPs are operational and 25, 7 and 6 are under construction in Class I cities, Class II towns and other smaller towns, respectively. Thus, in all there are 269 STPs, including 231 operational and 38 under construction. All Class I cities and Class II towns together generate an estimated 29129 MLD sewage. Against this, installed sewage treatment capacity is only 6190 MLD. There remains a gap of 22939 MLD between sewage generation and installed capacity. In percentage this gap is 78.7% of the sewage generation. Another 1743 MLD (equal to 6%) capacity is under planning or construction stage. If this is also added to existing capacity, we are left with a 21196 MLD (equal to 72.7% of the sewage generation) gap in sewage treatment capacity that has not even planned yet.

Estimation of sewage generation is primarily based on 2001 census population, the average water supply figures for respective states as given in CPCB's status reports on Class I cities (CUPS/44/1999-2000) and Class II towns CUPS/49/1999-2000) and assuming sewage to be 80% of the water supply. In few cases estimation is based on 2001 census population and the sewage generation factors wherever given in these two reports. Capacity of the STPs have been taken form "MIS Report of Programmes under NRCP-Volume-II, November, 2004" of Ministry of Environment & Forests, Govt. of India, as most of the STPs have been installed under various National River Action Plans of Govt. of India.

An estimated 14652 MLD sewage is generated from 112 Class I cities having STPs. The combined treatment capacity of the STPs in these Class I cities is 6047 MLD. Therefore, a capacity gap of 8605 MLD exists in 112 Class I cities having STPs.

An estimated 143 MLD sewage is generated from 22 Class II towns having STPs whereas the combined treatment capacity of the STPs in these 22 Class II towns is 234 MLD.

There remain 302 Class I cities and 467 Class II towns having no sewage treatment facilities. An estimated 11512 MLD sewage is generated from 302 Class I cities not having STPs and 2822 MLD sewage is generated from 467 Class II towns not having STPs.

So we can say that based on this review 72.7% gap is exit in between sewage generation and its treatment in india which is very large. Many cities and towns do not have sewage treatment plants even they are Class I. In future water crisis will increased so we need to require not waste a single drop of water and treat waste water and reuse it for non potable purposes.

2.4 PRESENT STATUS OF SEWAGE TREATMENT IN INDIA.

Large number of technological & managerial problems in operation of these STPs. Out of 175 total identified STPs spread over 15 States, the present 84 STPs of 13 different technologies spread over 9 States of India . The overall performance of 45 STPs has been found poor or very poor. Out of 84, performance of only 8 STPs has been rated good, while that of 30 of these have been rated satisfactory . Capacity utilization in general was inadequate.

Sludge handing appears to be most neglected area in STPs operation. Alternate power supply facility is not available in most of the cases. Utilization of biogas generated from UASB reactors or sludge digesters is also not adequate in most of the cases.

Total scenario of STPs performance is dismal, as overall performance of 46 STPs has been found Poor or Very Poor. Performance of only 8 STPs has been rated Good while that of 30 other has been rated Satisfactory.

Capacity utilization of the STPs observed is in general inadequate. Information on capacity utilization was collected from 55 STPs. Out of 55 STPs only 18 STPs (i.e 33%) were operating at normal flow (90 to 110% design flow) whereas rest 37 (i.e.67%) were either under-loaded or over-loaded.Sludge removal / treatment / handling appears to be the most neglected area in STPs operation.

In 43 STPs based on ASP technology or other high rate aeration systems, sludge-handling facilities were found mostly out of order. Similarly, in 28 STPs based on Waste Stabilization Pond or where Ponds have been employed in treatment schemes, cleaning of accumulated sludge was not regularly done in 24 cases.

Utilization of biogas generated from UASB reactors or sludge digesters is also not adequate in most of the cases.It was observed that there was no gas generation and utilization in 13 plants in spite Of having anaerobic reactors/digesters. In 14 STPs the gas generated is being flared and not being utilized.In 8 STPs the gas generated is only partly utilized mostly flared. Only in 12 STPs the gas generated was being utilized as domestic fuel (5 STPs) or as fuel for gas engine (4 STPs) or duel fuel generator, DFG (3 STPs)

Alternate power supply facility is not available in most of the cases. Out of 84 STPs, Only 13 STPs were having operational alternate power supply facility, 12 having DFG and 1 having DG Set. Six other STPs were also having alternate power supply facility but were not able to utilize this due to funds constraints.

Fund shortage is an important factor in poor operation and maintenance of STPs and has been reported in 26 cases. The problem of fund shortage is mostly reported from States of Bihar, Haryana, U.P., and West Bengal. This trend shows that the root of problem lies in less priority being given to sewage treatment.

Lack of proper laboratories at site is another area that needs attention. In case of 42 STPs the testing is reportedly done at common departmental laboratories. In case of another 16 STPs the testing is done through contract with some laboratory. In all these cases, day-today testing is normally not done that could enable proper control on plant's performance. Samples are collected and analyzed by departmental/ external labs once in a month or week.

In majority of the cases, operation of the STPs is looked after by contractors. These contractors generally depute unqualified or less qualified staff at site, which is also an important factor responsible for poor operation of STPs. This indicates that terms and condition of operation contracts are not adequately framed to check this situation.

2.5 WORKING PRINCIPLE OF SEWAGE TREATMENT PLANT

Treatment of sewage is essential to ensure that the receiving water into which the effluent is ultimately discharged is not significantly polluted. However, the degree of treatment required will vary according to the type of receiving water. Thus, a very high degree of treatment will be required if the effluent discharges to a fishery or upstream of an abstraction point for water supply. A lower level of treatment may be acceptable for discharges to coastal waters where there is rapid dilution and dispersion.

A Sewage Treatment Plant consists of all the operational units where proper collection, treatment and disposal of sewage are undertaken with respect to the characteristics of influent sewage and the status of the water bodies receiving the treated effluent.

2.6 UNIT OPERATION AND PROCESS OF SEWAGE TREATMENT

Waste water is a complex matrix of physical, chemical and biological contaminants and therefore the treatment can also be classified as physical unit operations, chemical unit processes, and biological unit processes, Although these operations and processes occur in a variety of combinations in treatment systems, but the basic principles involved in the treatment do not change.

2.6.1 PHYSICAL UNIT OPERATIONS

These are the treatment methods in which the application of physical forces predominates. Screening, mixing, flocculation, sedimentation, floatation, filtration, and gas transfer are examples of physical unit operations.

2.6.2 CHEMICAL UNIT PROCESSES

In these treatment methods the removal or conversion of contaminants is brought about by the addition of chemicals or by other chemical reactions. Coagulation, ion exchange and pH adjustment are examples of typical chemical processes.

2.6.3 BIOLOGICAL UNIT PROCESSES

These treatment methods are associated with the removal of contaminants which is brought about by biological activities. Biological treatment is used primarily to remove the biodegradable organic substances (colloidal or dissolved) in wastewater. Basically, these substances are converted into gases that can escape to the atmosphere and into biological cell tissue that can be removed by settling. Biological treatment is also used to remove nutrients (nitrogen and phosphorus) in wastewater.

2.7 CLASSIFICATION OF SEWAGE TREATMENT METHODS

The unit operations and unit processes mentioned above are grouped together to provide various levels of treatment which are described in the following sub-sections. A generalized processes diagram has been shown in the figure-2.1.

2.7.1 PRELIMINARY WASTEWATER TREATMENT

It is the removal of such wastewater constituents that may cause maintenance or operational problems in the treatment operations, processes, and ancillary systems. It consists solely of separating the floating materials (like dead animals, tree branches, papers, pieces of rags, wood etc.) and the heavy settleable inorganic solids. It also helps in removing the oils and greases, etc. from the sewage. This treatment reduces the BOD of the wastewater, by about 15 to 30%. Examples of preliminary operations are:

• Screening and communition for the removal of debris and rags.

• Grit removal for the elimination of coarse suspended matter that may cause wear or clogging of equipment.

• Floatation / skimming for the removal of oil and grease.

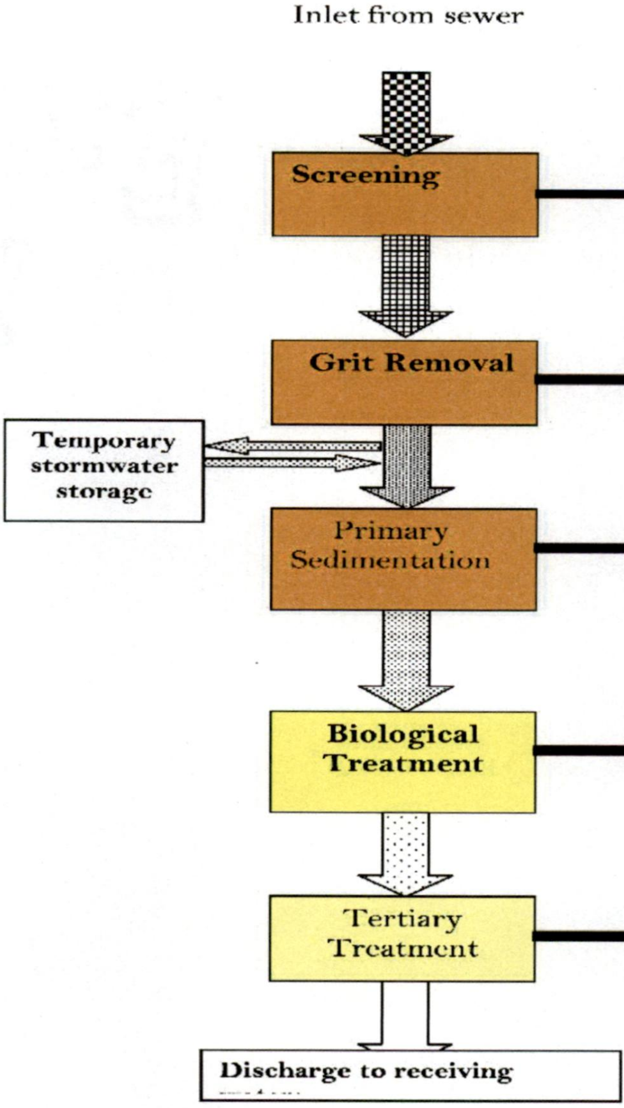


Figure 2.1: This diagram shows a typical sewage treatment process.

2.7.2 PRIMARY WASTEWATER TREATMENT

A portion of the suspended solids and organic matter is removed from the wastewater. This removal is usually accomplished by physical operations such as sedimentation in Settling Basins. The liquid effluent from primary treatment, often contains a large amount of suspended organic materials, and has a high BOD (about 60% of original). Sometimes, the preliminary as well as primary treatments are classified together, under primary treatment. The organic solids, which are separated out in the sedimentation tanks (in primary treatment), are often stabilized by anaerobic decomposition in a digestion tank or are incinerated. The residue is used for landfills or as a soil conditioner. The principal function of primary treatment is to act as a precursor to secondary treatment.

2.7.3 SECONDARY WASTEWATER TREATMENT

It involves further treatment of the effluent, coming from the primary sedimentation tank and is directed principally towards the removal of biodegradable organics and suspended solids through biological decomposition of organic matter, either under aerobic or anaerobic conditions. In these biological units, bacteria will decompose the fine organic matter, to produce a clearer effluent. Since all these aerobic and anaerobic units, generally make use of primary settled sewage; they are easily classified as secondary units.

Secondary treatment systems are classified as attached or suspended growth. Attached growth treatment process includes trickling filters and rotating biological contactors where the biomass grows on media and the sewage passes over its surface. In suspended growth systems—such as activated sludge—the biomass is well mixed with the sewage and can be operated in a smaller space than fixed-film systems that treat the same amount of water. However, fixed-film systems are more able to cope with drastic changes in the amount of biological material and can provide higher removal rates for organic material and suspended solids than suspended growth systems(BOD removal efficiency is 85%). In the typical aerobic process the removal of oxygen-demanding dissolved organics through microorganisms takes place.

$$\text{Organic material} + \text{Bacteria} + \text{Oxygen} \rightarrow \text{More bacteria}$$
$$\text{Organic material} + \text{Bacteria} + \text{Oxygen} \rightarrow CO_2 + H_2O + \text{Stabilized residual}$$

The term secondary treatment is commonly used to describe any of the following biological processes: activated sludge, extended aeration, trickling filters, aerobic and anaerobic lagoons and anaerobic and facultative (mixed) ponds.

2.7.4 TERTIARY/ ADVANCED WASTEWATER TREATMENT

When municipal sewage contains some industrial effluent, the tertiary or advanced waste water treatment system is required. The figure 2.3 shows such processes. It is defined as the level of treatment required beyond conventional secondary treatment to remove constituents of concern including nutrients, toxic compounds, and increased amounts of organic material and suspended solids and particularly to kill the pathogenic bacteria. In addition to the nutrient removal processes, unit operations or processes frequently employed in advanced wastewater treatment are chemical coagulation, flocculation, and sedimentation followed by filtration and chlorination. Less used processes include Ion exchange, Reverse osmosis, Membrane filtration, Air stripping, Carbon adsorption etc.

So we can say that based on this review there are four processes used in sewage treatment plant for treatment of sewage and these are preliminary, primary, secondary and tertiary treatment. After these processes the treated water suitable for reuse and discharge in the water bodies.

CHAPTER-3

SELECTION OF SEWAGE TREATMENT TECHNOLOGIES

3.1 GENERAL

An understanding of the nature of waste-water is fundamental for the design of appropriate wastewater treatment plants and the selection of effective treatment technologies. Waste-water originates predominantly from water usage by residences and commercial and industrial establishments, together with groundwater, surface water and storm water .Consequently, waste-water flow fluctuates with variations in water usage, which is affected by a multitude of factors including climate, community size, living standards, dependability and quality of water supply, water conservation requirements or practices, and the extent of meter services, in addition to the degree of industrialization, cost of water and supply pressure.

3.2 TECHNOLOGICAL OPTIONS FOR SEWAGE TREATMENT

In India, apart from the common unit processes such as pumping, screening, grit removal, plain sedimentation, chemical precipitation, chlorination etc, different biological treatment technologies have been adopted for the treatment of Municipal sewage which are as follows:

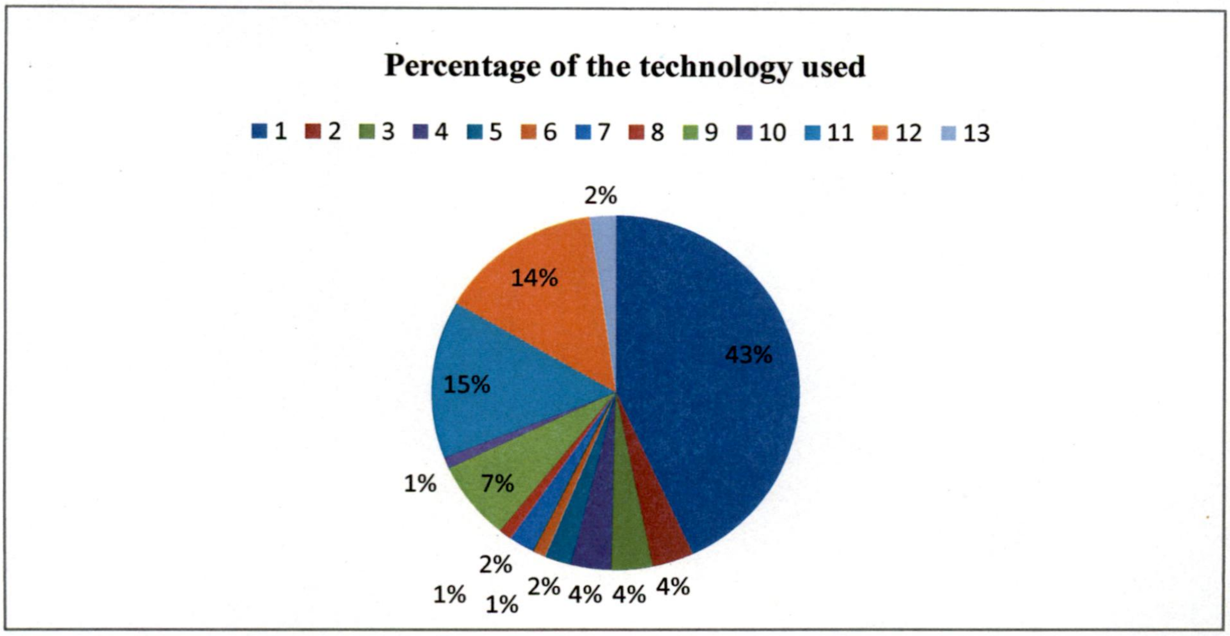
Table 3.1: Technologies used in India for Sewage Treatment.

S.NO	Technology	Number of STP
1.	Activated Sludge Process	36
2	Activated Sludge Process(Extended Aeration)	3
3	Fludized Aerobic Bed (FAB) (Denseg)	3
4	Fludized Aerobic Bed (FAB)	3
5	Trickling Filters	2
6	SAF	1
7	UASB+Aerated Lagoons	2

9	Areated Lagoons	6
10	SBR	1
11	Waste Stabilization Ponds	12
12	UASB+ Polishing Ponds	12
13	Micro Stps	2

(Source-CPCB)

Central Pollution Control Board (CPCB) has carried out a series of studies on performance of Sewage Treatment Plants (STPs) in different parts of the country to evaluate their performance. The findings revealed that a majority of the treatment plants are based on Primary Settling followed by Activated Sludge Process (PS+ASP) technology (with anaerobic digesters for sludge), Oxidation Pond or Waste Stabilization Pond (OP or WSP) technology and UASB followed by Polishing Pond (UASB+PP) technology. We also show that through pie diagram.



As per this pie diagram the majority of STP used in india on ASP, UASB and WSP Technology So for our performance evaluation work we are selected plant which are using ASP, UASB and WSP Technology for sewage treatment.

3.3 DESCRIPTION OF TREATMENT TECHNOLOGIES

3.3.1 ACTIVATED SLUDGE PROCESS (ASP)

In the **Activated Sludge Process**, waste water flows continuously into an aeration tank where air is injected into the waste water to mix the waste water with the activated sludge, and also to provide the oxygen needed for the microorganisms to break down the organic pollutants. The mixture of waste water and activated sludge is called mixed liquor. The mixed liquor flows to *a* secondary clarifier or secondary settling tank (SST) where the activated sludge settles out. A portion of the settled sludge is returned to the aeration tank (and hence is called return sludge*)* to maintain an optimum concentration of acclimated microorganisms in the aeration tank to break down the organics. Since more activated sludge is produced than is needed for return sludge, the excess sludge is discarded or "wasted." The wasted sludge may be further treated in a sludge digester and dewatered on sludge drying beds prior to disposal. The clarified effluent from the SST is discharged on land or into a flowing river.

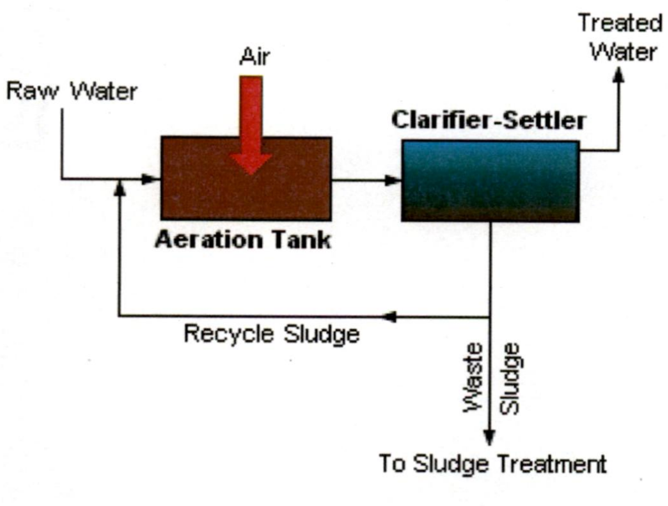


Figure 3.3.1: Typical ASP process flow diagram

Oxidation and Synthesis

$$\underset{\text{(Organic matter)}}{COHNS + O_2 + Nutrients} \xrightarrow{Bacteria} CO_2 + NH_3 + \underset{\text{(New bacterial cells)}}{C_5H_7NO_2} + \text{Other end products}$$

Endogenous Respiration

$$\underset{\text{(Cells)}}{C_5H_7NO_2} + 5O_2 \xrightarrow{Bacteria} 5CO_2 + 2H_2O + NH_3 + \text{Energy}$$

In these equations, COHNS represents the organic matter in wastewater. From equation given above, it can be seen that, if all of the cells can be oxidized completely, the ultimate BOD of the cells is equal to 1.42 times the concentration of cells.

Advantages of ASP are:

- The treated effluent is of very good quality.
- Methane gas can be recovered having energy value, can be utilized as fuel.
- It is very flexible and can be adapted to almost any type of biological waste treatment problem.

Disadvantages of ASP are:

- The major problems encountered in the operation of an ASP are sludge bulking, rising sludge and Nacardia foam.
- The cost for installation is higher than UASB plant.
- For operating ASP large electric power is required.
- It involves a large no of electro-mechanical equipment which needs high technical and skilled personnel.

3.3.2 UP FLOW ANAEROBIC SLUDGE BLANKET (UASB) PROCESS

This process is an anaerobic suspended growth process wherein the organic matter is digested, absorbed and metabolized into bacterial cell mass and bio gas. It is a combination of physical and biological processes. The main feature of physical process is separation of solids and gases from the liquid and that of biological process is degradation of decomposable organic material under anaerobic conditions.

In the UASB treatment concept, the treatment tank consists of an up flow reactor (Fig.-3.3) with feed inter distribution system at the bottom of the reactor with 3 phase's gas, liquid, solid, separator (glss) at the top. The waste water is evenly distributed over the reactor bottom through feed inlet pipes and flows upwards through a bed of anaerobic sludge in the lower part of reactor called the digestion compartment. During passage through the sludge bed particulate matter is entrapped and the degradable matter is completely or partially digested. Dissolved organic matter is removed from the solution by the anaerobic bacteria and converted into bio gas and a small fraction into new bacterial bio mass. The bio gas provides a gentle mixing in the sludge bed. in the upper part of the reactor, 3 phase glss is installed. The bio gas produced is collected in a gas collector (gas holder) from where it is withdrawn. The remaining water sludge mixture enters a settling compartment where the sludge can settle and flow back into the digestion compartment. After settling, the water is collected in the effluent gutters and discharged out of the reactor to the final polishing unit (FPU) to meet discharge standards. The domestic waste water treated in a UASB reactor is suitable for discharge in river water or for irrigation after polishing in a high rate pond. The bio gas generated can be utilized for generating electricity. Sludge cakes after de-watering and drying on sludge dry beds is suitable for use as manure.

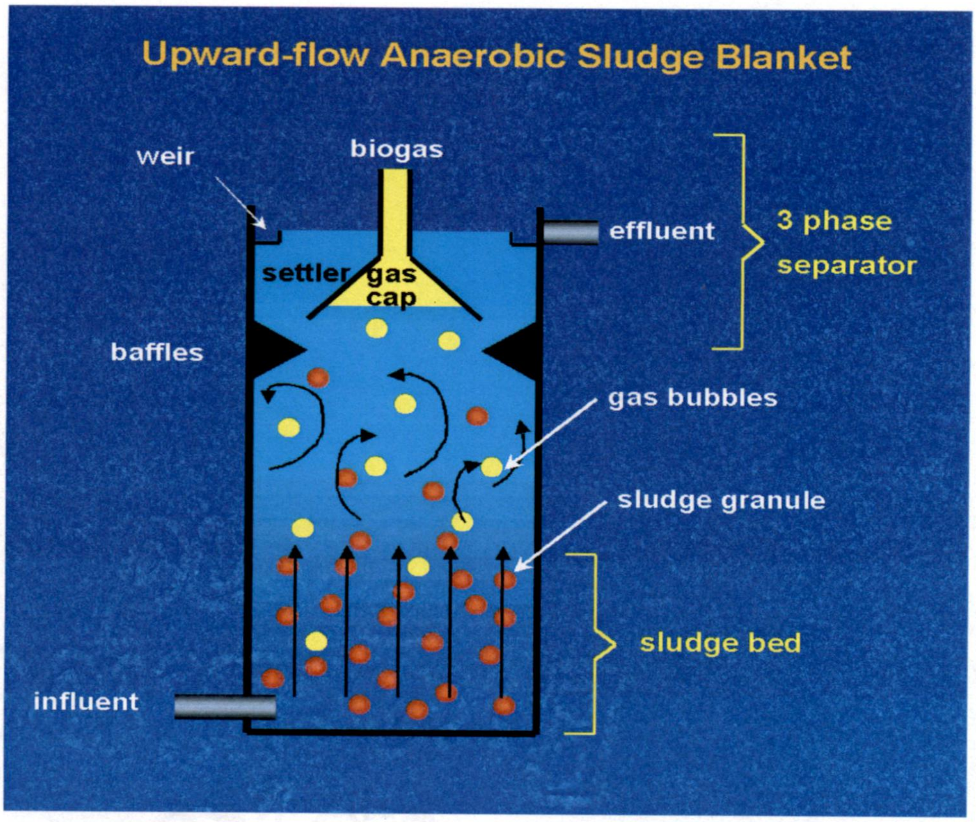


Figure 3.3.2: UASB Reactor.

In recent times the applications for this technology are expanding to include treatment of chemical and petrochemical industry effluents, textile industry wastewater, landfill leachates, as well as applications directed at conversions in the sulfur cycle and removal of metals. Furthermore, in warm climates the UASB concept is also suitable for treatment of domestic wastewater. UASB reactors are typically suited to dilute waste water streams (3% TSS with particle size >0.75mm) where COD removal of up to 80% can be achieved.

Advantages are:

- The cost of UASB plant is significantly lower than that of aerobic plant.
- Low degree of operational and maintenance cost.
- The energy requirement in the UASB reactor is very low.
- ASB system generates energy in the form of bio gas which can be used for the production of electricity and which can make UASB plants self sustaining for power requirement.

- The space requirement is less, which is a big advantage for developing cities.
- The production of excess sludge in a UASB reactor is very low.
- Final polishing pond can be used for fish culture, which can be source of revenue.

Disadvantages are:

- The capital cost of the UASB system will be higher if post-treatment is required for meeting discharge standards.
- The corrosive potential of anaerobic system is a major negative point and makes it important to choose the right construction materials.
- The optimum pH range is from 6.6 to 7.6 the wastewater temperatures should not be less than 5 °C.
- The SS concentration in the feed to the reactor should not exceed 500 mg/l .

3.3.3 WASTE STABILIZATION POND (WSP) SYSTEMS

A waste stabilization pond is a relatively shallow body of wastewater contained in an earthen basin, using a completely mixed biological process without solids return. Mixing may be either natural (wind, heat or fermentation) or induced (mechanical or diffused aeration). Stabilization ponds are usually classified, on the basis of the nature of the biological activity that takes place in them, as aerobic, facultative, maturation and anaerobic.

Aerobic ponds are used primarily for the treatment of waste-water by natural process involving the use of both algae and bacteria. Facultative ponds are those in which stabilization of wastes is brought about by a combination of aerobic, anaerobic and facultative bacteria. Maturation ponds are low-rate stabilization ponds which are designed to provide secondary effluent polishing and seasonal nitrification. Anaerobic ponds, for their part, are particularly effective in bringing about rapid stabilization of strong concentrations of organic wastes.

Stabilization ponds being used to treat wastewater and industrial wastes throughout the nation. These ponds (also referred to as lagoons) can be used alone or in combination with other waste treatment processes (as shown in figure3.6). Stabilization ponds treat a wide variety of pollutants.

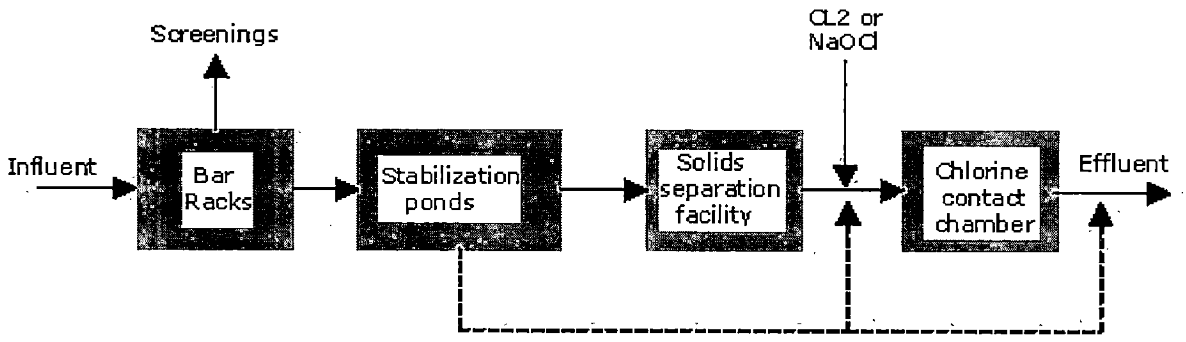


Figure 3.3.3: Typical flow diagram for stabilization ponds

Advantages are:

- Stabilization pond can be cost-effective to design and construct in areas where land is inexpensive.
- They use less energy than most wastewater treatment methods.
- They are simple to operate and maintain and generally require only part-time staff.
- The effluent from lagoon systems can be suitable for irrigation (where appropriate), because of its high-nutrient and low pathogen content.

Disadvantages are:

- They are less efficient in cold climates and may require additional land or longer detention times in these areas.
- Odor can become a nuisance during algae blooms, spring thaw in cold climates, or with anaerobic ponds and ponds that are inadequately maintained.
- Unless they are property maintained, lagoons can provide a breeding area for mosquitoes and other insects. They are not very effective at removing heavy metals from wastewater.
- Effluent from some types of lagoons contains algae and often requires additional treatment or "polishing" to meet local discharge standard.

3.3.4 FLUIDIZED AEROBIC BIOREACTOR (FAB) PROCESS

This technique is based on both suspended and attached growth biological treatment. The characteristic of this system is the bio catalytic use of immobilized enzymes or microbial cells, which are attached to the surface of biologically inert non-porous particles, or entrapped within the matrices of porous particles or gels, or encapsulated within a semi-permeable barrier such as a membrane, or self-aggregated flocks.

Fluidized bed bioreactors, schematized in figure3.4, come in many configurations, including conventional upward fluidization with constant cross-section, inverse, tapered, zigzag , baffled ,with internal circulation (e.g. via draft tube) and with external circulation.

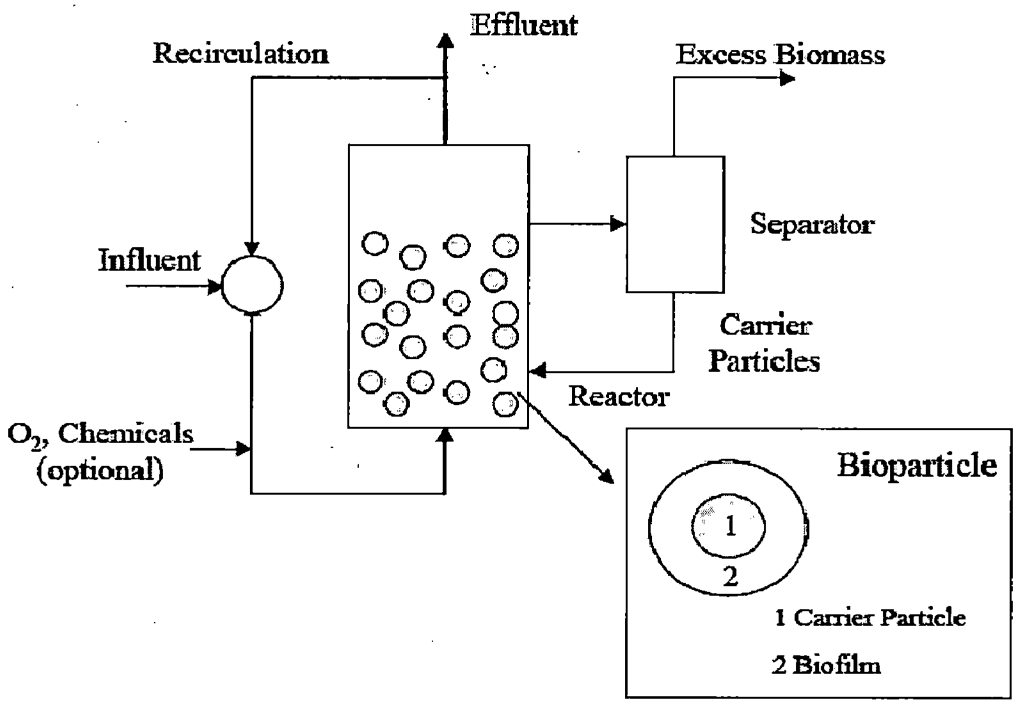


Figure 3.3.4: Schematic diagram of a fluidized bed reactor.

The main component of the FAB system is a fixed film reactor where microbes are immobilized onto individual particles in a hydraulically fluidized bed of media. The media most often used are either granular activated carbon (GAC) or sand. The individual particles of the fluidized media provide a vast amount of surface area for bio-film growth.

Consequently, large inventories of biomass can be maintained, and reactor sizes can be minimized. Use of GAC as the fluidized media enables the integration of the removal mechanisms associated with bio-treatment and physical-chemical adsorption into a single reactor configuration.

The fluidized GAC enhances the ability of the reactor system to treat more recalcitrant organics, and mitigates microbial inhibition due to various toxic inputs.

Advantages are:

- The sewage treatment has following advantages over conventional activated sludge processes.
- Space requirement is less.
- Operating power requirement is less.
- It has low temperature sustaining capability.
- Useful in fluctuating conditions.
- It is capable of removing E-Coli.
- Sludge production is less.

Disadvantages are:

- The power consumption is high due to highly mechanized process.
- It requires highly trained and skilled personnel for operating the plant.

3.3.5 TRICKLING FILTER (TF) PROCESS

The trickling filter is the most commonly encountered aerobic attached-growth biological treatment process used for the removal of organic matter from waste-water. It consists of a bed of highly permeable medium to which organisms are attached, forming a biological slime layer, and through which waste-water is percolated. The filter medium usually consists of rock or plastic packing material. The organic material present in the waste-water is degraded by adsorption on to the biological slime layer. In the outer portion of that layer, it is degraded by aerobic micro-organisms. As the micro-organisms grow, the thickness of the slime layer increases and the oxygen is depleted before it has penetrated the full depth of the slime layer. An anaerobic environment is thus established near the surface of the filter medium. As the slime layer increases in thickness, the organic matter is degraded before it reaches the micro-organisms near the surface of the medium. Deprived of their external organic source of nourishment, these micro-organisms die and are washed off by the flowing liquid. A new slime layer grows in their place. This phenomenon is referred to as 'sloughing'.

After passing through the filter, the treated liquid is collected in an under drain system, together with any biological solids that have become detached from the medium.

The collected liquid then passes to a settling tank where the solids are separated from the treated waste-water. A portion of the liquid collected in the under drain system or the settled effluent is recycled to dilute the strength of the incoming waste-water and to maintain the biological slime layer in moist condition

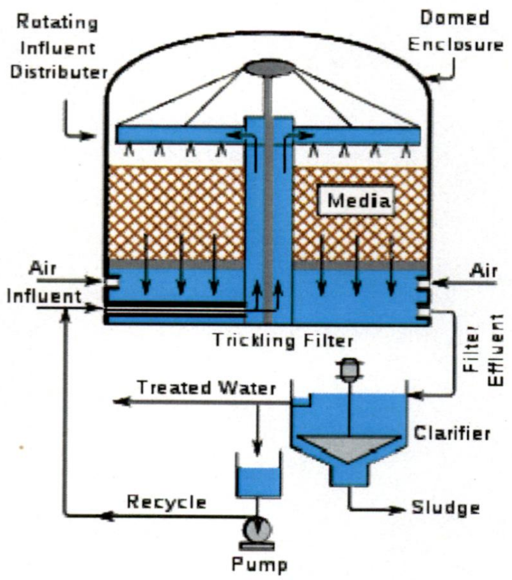


Figure 3.3.5: Flow chart of Trickling Filter

Advantages of TF Systems are:

- Simplicity of operation,
- Resistance to shock loads,
- Low sludge yield
- Low power requirements.

Disadvantages of TF Systems are:

- Relatively low BOD removal (85%),
- High suspended solids in the effluent (20 - 30 mg/L),
- Little operational control,

- Surface layers have changing predominance with season and
- Algae of secondary importance metabolically but luxuriant growth may clog system

3.4 BENEFITS OF THE SEWAGE TREATMENT PLANTS

3.4.1 RECYCLE AND REUSE OF WASTE WATER

The total supply of freshwater on earth far exceeds human demand. Hydrologists estimated that if all the water available on the planet—from oceans, lakes and rivers, the atmosphere, underground aquifers, and in glaciers and snow—could be spread over the surface, the earth would be flooded to an overall depth of some three kilometers. About 97 percent of this water is in the oceans, and out of the remaining three percent, only about one-hundredth is the accessible freshwater that can be used for human demand. If this available water could be evenly distributed, still it is enough to support a population about ten times larger than today. The foremost use of water by humans is for the biological survival. However, water need for the biological survival is not the only issue being discussed in the world today. Because, apart from drinking, water is required also for household needs such as cooking, washing, and is vital for our development needs, such as for agriculture and industry.

Unfortunately, the available freshwater supplies are not evenly distributed in time and space. Historically, water management has focused on building dams, reservoirs, and diversion canals etc., to make available water wherever needed, and in whatever amount desired. Soaring demands due to rapidly expanding population, industrial expansion, and the need to expand irrigated agriculture, were met by ever larger dams and diversion projects. Dams, river diversions, and irrigation schemes affected both water quality and quantity.

Demands on water resources for household, commercial, industrial, and agricultural purposes are increasing greatly. The world population will have grown 1.5 times over the second half of the twenty-first century, but the worldwide water usage has been growing at more than three times the population growth. In most countries human populations are growing while water availability is not. What is available for use, on a per capita basis, therefore, is falling. Out of 100 countries surveyed by the World Resources Institute in 1986, more than half of them were assessed to have low to very low water availability. Given the rapid spread of water pollution and the growing concern about water availability, the links between quantity and quality of water supplies have become more apparent. In many parts of the world, there is already a widespread scarcity, gradual destruction and increased pollution of freshwater resources.

The need for increased water requirement for the growing population in the new century is generally assumed, without considering whether available water resources could meet these needs in a sustainable manner. The question about from where the extra water is to come, has led to a scrutiny of present water use strategies. A second look at strategies has thrown a picture of making rational use of already available water, which if used sensibly, there could be enough water for all. The new look invariably points out at recycle and reuse of wastewater that is being increasingly generated due to rapid growth of population and related developmental activities, including agriculture and industrial productions.

3.4.1.1 HISTORY OF WASTEWATER REUSE

The term "wastewater" properly means any water that is no longer wanted, as no further benefits can be derived out of it. About 99 percent of wastewater *is* water, and only one percent is solid wastes. An understanding of its potential for reuse to overcome shortage of freshwater existed in Minoan civilization in ancient Greece, where indications for utilization of wastewater for agricultural irrigation date back to 5000 years. Sewage farm practices have been recorded in Germany and UK since 16^{th} and 18^{th} centuries, respectively. Irrigation with sewage and other wastewaters has a long history also in China and India. In the more recent history, the introduction of waterborne sewage collection systems during the 19^{th} century, for discharge of wastewater into surface water bodies led to indirect use of sewage and other wastewaters as unintentional potable water supplies. Such unplanned water reuse coupled with inadequate water and wastewater treatment, resulted in catastrophic epidemics of waterborne diseases during 1840s and 50s. However, when the water supply links with these diseases became clear, engineering solutions were implemented that include the development of alternative water sources using reservoirs and aqueduct systems, relocation of water intakes, and water and wastewater treatment systems. Controlled wastewater irrigation has been practiced in sewage farms many countries in Europe, America and Australia since the turn of the current century.

For the last three decades or so, the benefits of promoting wastewater reuse as a means of supplementing water resources and avoidance of environmental degradation have been recognized by national governments. The value of wastewater is becoming increasingly understood in arid and semi-arid countries and many countries are now looking forward to ways of improving and expanding wastewater reuse practices. Research scientists, aware of both benefits and hazards, are evaluating it as one of the options for future water demand.

3.4.1.2 TYPES OF WASTEWATER REUSE

Wastewater can be recycled/reused as a source of water for a multitude of water-demanding activities such as agriculture, aquifer recharge, aquaculture, fire fighting, flushing of toilets, snow melting, industrial cooling, parks and golf course watering, formation of wetlands for wildlife habitats, recreational impoundments, and essentially for several other non-potable requirements. Potential reuse of wastewater depends on the hydraulic and biochemical characteristics of wastewater, which determine the methods and degree of treatment required. While agricultural irrigation reuses, in general, require lower quality levels of treatment, domestic reuse options (direct or indirect potable and non-potable) reuses need the highest treatment level. Level of treatment for other reuse options lie between these two extremes.

3.4.1.2.1 REUSE FOR IRRIGATION

Agricultural irrigation has, by far, been the largest reported reuse of wastewater. About 41 percent of recycled water in Japan, 60% in California, USA, and 15% in Tunisia are used for this purpose. In developing countries, application on land has always been the predominant means of disposing municipal wastewater as well as meeting irrigation needs. In China for example, at least 1.33 million hectares of agricultural land are irrigated with untreated or partially treated wastewaters from cities. In Mexico City, Mexico, more than 70 000 hectares of cropland outside the city are irrigated with reclaimed wastewater. Irrigation has the advantage of "closing-the-loop" combination of waste disposal and water supply. Irrigation reuse is also more advantageous, because of the possibility of decreasing the level of purification, and hence the savings in treatment costs, thanks to the role of soil and crops as biological treatment facilities. As the water supply requirements of large metropolis are growing, the option of reuse of wastewater for domestic purposes is increasingly being considered. Judging from international experience, there is potential for reuse at all system scales, from household level to the large irrigation schemes.

Irrigation reuse of wastewater can be for application on:

- agricultural crops, woodlots and pastures, or

- Landscape and recreational areas.

The choice of type of irrigation application generally depends upon the location and quantity of wastewater available for reuse.

3.4.1.2.2 DOMESTIC AND INDUSTRIAL REUSE

Reuse of wastewater for purposes other than irrigation may be either for:

- Industrial reuse;
- Non-potable purposes;
- Indirect potable purposes; or
- Direct potable purposes.

3.4.1.2.2.1 INDUSTRIAL REUSE

Industrial reuse of reclaimed wastewater represents major reuse next only to irrigation in both developed and developing countries. Reclaimed wastewater is ideal for many industrial purposes, which do not require water of high quality. Often industries are located near populated area where centralized treatment facilities already generate reclaimed water. Depending on the type of industry, reclaimed water can be utilized for cooling water make-up, boiler feed water, process water etc. Cooling water make-up in a majority of industrial operations represent the single largest water usage. Compared to other purposes such as boiler feed and process water, the water quality requirements for industrial cooling is not generally high. Consequently, cooling water make-up presents a single largest opportunity for reuse.

3.4.1.2.2.2 NON-POTABLE DOMESTIC REUSE

Adequately treated wastewater meeting strict quality criteria, can be planned for reuse for many non-potable purposes. Non-potable reuse leads to both a reduction water consumption from other sources, and a reduction in wastewater flow rate. So, non-potable reuse schemes can avoid adverse environmental consequences associated with conventional water sources and wastewater disposal systems. Non-potable domestic reuse can be planned either within single households/building, or on a larger-scale use through a reticulation system meant only for use for non-portable purpose.

3.4.1.2.2.3. INDIRECT POTABLE REUSE

Indirect potable reuse of treated wastewater may occur unintentionally, when wastewater is disposed into a receiving body of water that is used as a source of potable water supply. It can also be through planned schemes, such as that of Cerro del la Estrella sewage treatment plant in Mexico city. Here, treated wastewater which meets the criteria for potable reuse except for total dissolved solids, is diluted by water from other sources to meet these criteria, and used for potable purposes. Another planned indirect potable reuse can be through groundwater recharge of treated wastewater.

Deliberate (artificial) recharge of groundwater aquifers with treated wastewater can be carried out to achieve one or more of the following objectives:

- as storage during periods of low water demand;
- as an additional treatment method;
- as a measure to improve the depleting groundwater potential; and
- as a measure to improve the overall quality of groundwater by injecting reclaimed water of specific qualities.

Use of treated wastewater for artificial groundwater recharge is increasing as a way to treat and store effluent underground for subsequent recovery and unrestricted reuse. A recent report by the National Academy of Sciences, USA, has given a cautious green signal for potable use of water from aquifers recharged with wastewater. The report suggests that with surface infiltration systems for artificial recharge, considerable quality improvements can be obtained as the water flows through the unsaturated zone to the aquifer, and this soil-aquifer treatment (SAT) reduces pretreatment requirement. However, it cautions that impaired quality waters used to recharge groundwater aquifers must receive a sufficiently high degree of pretreatment (prior to recharge) to minimize the extent of any degradation of groundwater quality, as well as to minimize the need for any extensive post-treatment at the point of recovery.

3.4.1.2.2.4. DIRECT POTABLE REUSE

Direct potable reuse means adding treated wastewater directly into the normal drinking water distribution system. Though the idea of such a wastewater reuse may be repugnant to many, technologically, direct potable reuse of treated wastewater has been feasible for many years. A classic example of wastewater reuse for direct potable purposes in an emergency happened in 1950s in the town of Chanute, Kansas, USA. The Nesho river in eastern Kansas served as the sole water source of Chanute. Due to continuous drought for five years, surface flow of the river ceased in 1956. After considering all other alternatives, the river was dammed just below the towns sewage outfall, and the treated wastewater was used to fill the potable water intake pool. For five months, the city reused its sewage, circulating it some eight to fifteen times.

3.4.2 BENEFITS OF SEWAGE SLUDGE

As the amount of sewage sludge and manure increases, governments, corporations and the general public are developing methods through which to process and reuse this excess waste.

3.4.2.1 SLUDGE TREATMENT

The use and disposal of biosolids is always preceded with treatments designed to ensure regulatory requirements are met, public health and the environment are being protected, to facilitate handling and to reduce costs. The treatment processes prepare biosolids specifically for intended methods of use or disposal.

Stabilization and dewatering are the two common methods of treatment. In the dewatering process, excess water is removed from biosolids so they can be composted, used in landfills, dried or incinerated. Methods include: air drying, vacuum filters, plate and frame filters and centrifuges belt filter process.

In the stabilization treatment, the processes are designed to reduce pathogen levels, odour and volatile solids content. Table provides a list of the different stabilization treatment processes, a brief description of the treatment and the associated end disposal method.

3.4.2.2 SEWAGE SLUDGE USE AND DISPOSAL

There are three common practices for the disposal of sewage sludge:

- Land Application
- Sludge Incineration
- Surface Disposal

3.4.2.2.1 LAND APPLICATION

Land application is defined as the spreading, spraying, injection, or incorporation of sewage sludge, including a material derived from sewage sludge (e.g., compost and pelletized sewage sludge), onto or below the surface of the land to take advantage of the soil enhancing qualities of the sewage sludge.

Land application is considered to be the most common method for using biosolids. Some land application practices include crops, revitalization of mines, forests and fertilizer for parks and landscaping.

Advantages

- Ideally, the use of sewage sludge for land applications turns a waste into a resource.
- Biosolids condition the soil and plants while reducing the impacts of high levels of excess nutrients entering the environment.
- Improves conditions of several types of land and has the potential to improve others with future research and testing

Disadvantages

There are several disadvantages to using sewage sludge for land application. Most deal with the environmental and health problems that could occur:

- The general public may negatively view the use of sewage on or near their food source or living spaces - no matter how government tries to convince them otherwise.
- Proper treatment and testing of the sludge must be performed regularly and regulatory standards must be updated. Failure to do so may cause health and environmental problems especially if pathogens are not found or identified.
- The odour associated with the application of sludge is often disliked by many people residing in the area where land application occurred.
- Animals and people who wander into recently treated areas could be harmed
- Food companies may not buy food which is grown from sludge

3.4.2.2.2 SLUDGE INCINERATION

Incineration is a sludge disposal process that involves the firing of sewage sludge (biosolids) at high temperatures in an enclosed area. The incineration process permanently destroys toxic organic materials by breaking their chemical bonds and reverting them to their constituent elements, therefore reducing or removing their toxicity. This combustion process reduces the volume of hazardous waste to be disposed on land by converting solids and liquids to ash. The collection of ash is less than 20% of its original volume. Many urban sewage treatment facilities produce large volumes of sludge and have limited available space for sludge management. Hence, they are likely to see incineration as their most feasible option.

Types of Incineration Systems

Incineration systems generally consist of a furnace and one or more air pollution control devices. The two most commonly used incineration systems are multiple hearth furnaces and fluidized-bed reactors.

Advantages and Disadvantages

In addition to the problems associated with detrimental emissions in air, soil and water, there are economical disadvantages to incineration.

Cost and Technical Feasibility

Cost is a major consideration with incineration technology. Incinerators are very mechanized and capital-intensive investment that must be managed with a high level of expertise and attention to maintenance. The incineration option is a long-term commitment that is most cost-effective for large volume biosolid treatment systems. To evaluate this option, communities must consider factors like ash disposal, economies of scale, and air pollution. Generally, most incinerators should handle a sludge input rate between 0.25 and 3 dry tons per hour. Anything less than 0.25 dry tons would most likely be too expensive for this technology. In contrast, over 3 dry tons per hour may exceed the limit of the technology and may require multiple incinerators.

Beneficial Use/Production of Energy

Energy recovered from the incineration of sludge may be used to support some of the energy needs of the Wastewater Treatment Plant. Heat from the incinerator may be used to pre-dry the sludge. Incinerators may also be utilized to assist in odour control at a facility. Ash by-products may be used as a substitute raw matter in the manufacturing of cement and brick and as a landfill cover.

3.4.2.2.3 SURFACE DISPOSAL

Surface disposals (biosolids) are placed on an area of land for final disposal. If biosolids remain on land for longer than two years, this land is considered an active biosolids unit. A surface disposal site is an area of land that contains one ore more active sludge units. Some surface disposal sites may be used for beneficial purposes as well as for final disposal. Surface disposal site include:

- Monofills
- Surface impoundments
- Lagoons
- Waste piles
- Dedicated disposal sites
- Dedicated beneficial use sites.

Advantages

- Surface disposal methods are the cost-effective and generally safe process to recycle, fertilize and condition agricultural, forest and reclamation soils.

Disadvantages

- Generation of emissions into the air, mainly greenhouse gases like methane and carbon dioxide.
- Generation of emissions into the soil and water at dumpsites, including various compounds such as ions, heavy metals, organic compounds and micro organisms in leachate
- Noise and dust from the delivery vehicles
- Odours
- Disturbance of vegetation and the landscape.

3.4.3 BENEFITS OF BIOGAS

Biogas is a valuable fuel which is in many countries produced in purpose built digesters filled with the feedstock like dung or sewage. Digesters range in size from one cubic metre for a small 'household' unit to more than thousand cubic meters used in large commercial installation or farm plants. The input may be continuous or in batches, and digestion is allowed to continue for a period of from ten days to a few weeks. The bacterial action itself generates heat, but in cold climates additional heat is normally required to maintain the ideal process temperature of at least 35 degrees Celsius, and this must be provided from the biogas. In extreme cases all the gas may be used for this purpose, but although the net energy output is then zero, the plant may still pay for itself through the saving in fossil fuel which would have been needed to process the wastes. A well-run digester will produce 200-400 m3 of biogas with a methane content of 55% to 75% for each dry tonne of input.

3.4.3.1 COMPOSITION OF BIOGAS

Biogas is a colorless, odorless, inflammable gas, produced by organic waste and biomass decomposition (fermentation). Biogas can be produced from animal, human and plant (crop) wastes, weeds, grasses, vines, leaves, aquatic plants and crop residues etc. The composition of different gases in biogas is as below: [3]

- Methane (CH_4): 55-75%
- Carbon Dioxide (CO_2): 25-45%
- Hydrogen Sulphide (H_2S): 0.1-0.5%
- Nitrogen (N_2): 1-5%
- Hydrogen (H_2): 0-3%
- Carbon Mono Oxide (CO): 0-0.3%
- Oxygen (O_2): Traces

3.4.3.2 BIOGAS AND ENERGY

When biogas is captured, it can be used to generate heat, hot water, or electricity-significantly reducing the cost of electricity and other farm fuels such as natural gas, propane, and fuel oil. Biogas can also be flared to control odor if energy recovery is not feasible. Both the flaring and use of biogas reduce greenhouse gas emissions. Biogas is a renewable source of energy with much lower environmental impacts than conventional fossil fuel. The methane generated from anaerobic digestion provides rural electric cooperatives and utilities with a source of "green power" to sell to customers who wish to purchase power from renewable sources. Biogas recovery also provides rural energy benefits such as distributed generation and voltage support.

CHAPTER 4

PERFORMANCE EVALUATION OF SELECTED STPs

4.1 INTRODUCTION

Performance evaluation of sewage treatment plants of different technology depends upon wastewater characteristics and on the treatment objectives as translated into desired effluent quality. Effluent quality control is typically aimed at public health protection, preservation of the oxygen content in the water, prevention of eutrophication, prevention of sedimentation, preventing toxic compounds from entering the water and food chains and promotion of water reuse. The selected technologies should be environmentally sustainable, appropriate to the local conditions, acceptable to the user, and affordable to those who have to pay for them. Simple solution that are easily replicable, that allow further upgrading with subsequent development, and that can be operated and maintained by the local community.

In this regard existing STPs of various technology were visited and based on the observations on the status of O&M of individual STPs on the basis of physical inspection, and information given at site by operating staff/officers, evaluation have been prepared. As treatment methods range from the physico-chemical to the biological, from the aerobic to anaerobic and accordingly the following treatment plants based on different technologies were studied, as shown in Table4.1.

Table 4.1.1: Various treatment plants selected for performance study

Sl. No.	Sewage Treatment Technologies	Capacity MLD	Location of Site	Operating Status
1.	Activated Sludge Process (ASP)	18	Haridwar (Uttarakhand)	In operation
2.	Upflow Anaerobic Sludge Bed with Final Polishing Pond (UASB)	73	Ghaziabad, (Uttar Pradesh).	In operation
3.	Upflow Anaerobic Sludge Bed with Final Polishing Pond (UASB)	56	Ghaziabad, (Uttar Pradesh).	In operation
4.	Waste Stabilization Pond (WSP)	6	Rishikesh (Uttarakhand)	In operation

4.2 SELECTION OF PERFORMANCE EVALUATION PARAMETERS FOR STP

As part of evaluation methodology for various technological options for sewage treatment, a number of parameters are selected. These include performance, stability, resource requirement and associated costs, impact of effluent discharge on environment and possibility of resource recovery.

4.2.1 PERFORMANCE IN TERMS OF QUALITY OF TREATED SEWAGE

Conventionally, the major concern in terms of discharge of treated or untreated wastewaters in water bodies has been the presence of organic matter and pathogens.

4.2.2 PERFORMANCE STABILITY

Potential for performance stability is generally 'very high' for processes producing recyclable quality effluent

4.2.3 RESOURCE REQUIREMENTS AND ASSOCIATED COSTS

All treatment technologies were judged against the following parameters,

1) Potential for low capital cost,
2) Potential for low energy requirements,
3) Potential for low level of operator skills.
4) Potential for low land requirements.

4.2.4 IMPACT OF EFFLUENT DISCHARGE

All treatment technologies were judged against the following parameters,

1) Potential for no adverse impact on land
2) Potential for no adverse impact on surface water,
3) Potential for no adverse impact on groundwater.

4.2.5 POTENTIAL OF RESOURCE GENERATION

Typically three types of end products, which can be treated as resources, are produced from sewage treatment – treated effluent, excess biomass or sludge, which can be used as manure or soil conditioner; biogas, which can be used as a fuel for power generation or other uses.

4.2.6 IMPACT OF STP ON SURROUNDING

Different technology have varying degree of local impacts because of foul odours, release of corrosive and harmful gases such as H2S, ammonia, methane and flies nuisance, etc. Parameters used for judging these impacts were,

1) Potential for no adverse impacts on the health of STP staff/locals, and
2) Potential for no adverse impact on surrounding buildings/properties.

4.3 SEWAGE TREATMENT PLANT ASP TECHNOLOGY, HARIDWAR (UTTARAKHAND)

4.3.1 DETAILS OF ASP

The plant is using Activated Sludge process (ASP) and was commissioned in the year 1993 with a capacity of 18 MLD spread over an area of 2.9 hectare, and of initial project cost of Rs.15.00 crores. The current sewage generation is approximately 25-30 MLD but during festive season it goes even higher upto 45MLD (Peak designed capacity) and beyond 18MLD sewage is being bypassed and is mixed with treated effluent, used for irrigation purpose. Lay out plan is shown in Figure 4.1.

Design parameter	Influent	Effluent
BOD_5 (in mg/l)	250-300	< 30
TSS (in mg/l)	450-600	< 50
MPN No. / 100ml	10^6 - 10^9	< 10^3

Salient Feature :

1. Collection Chamber

Size	: 2.8m×1.1m×1.8 m
Flow	: 18 MLD
Free Board	: 600 mm
TWL	: 281.11 m
MPS	: 75HPx3 & 25HPx2

2. Screen Chamber (3Nos.Mechanical Screen+1No.Mannual screen) size 25mm

	Flow	: 625 m^3/hr.
	Total Head Loss	: 0.15 m

3. Grit Chamber

	Detention Time	: 1 min.
	Settling Velocity	: 41 m/hr

4. Flow Measuring Devices

	Throat Width	: 0.915 m.

5. Primary Sedimentation Tank

	Diameter	: 15 m
	Dia. of Feedwell	: 2.25 m
Surface Loading Rate		
	Peak	: 84.925 $m^3/m^2/d$
	Average	: 50 $m^3/m^2/d$
	Detention Time	: 2.09 hrs.
	Weir Loading	: 133 $m^3/m/d$
	S.W.D	: 3.0 m
Percentage Removal		
	(i) BOD	: 40
	(ii) SS	: 60

6. Aeration Tank

	F.S.L	: 278.81 m
	Free Board	: 500 mm
	F/M Ratio	: 0.4
	H.R.T	: 3.6 hrs.
	M.L.S.S	: 3000 mg/l
	Volume loading Rate	: 1.0 Kg/BOD/m^3
	DO level	: 1 ppm

O_2 transfer Capacity	: 1.8 Kg/SHP/ Hr at 20^0 C

7. Secondary Sedimentation Tank

Diameter	: 18.6 m
Dia. of Feed well	: 2.79 m.
Surface Loading Rate	
Peak	: 55 $m^3/m^2/d$
Average	: 22 $m^3/m^2/d$
Detention Time	: 2.63 hrs.
Wear Loading	: 106.38 m^2 /m/D
SWD	: 3.5 m
Percentage Removal	
(i) BOD	: 53.3 %
(ii) SS	: 35 %

8. Return Sludge Recirculation Pump House

No. of Pumps	: 4 Nos.
Discharge/Head	: 190 m^3/H.

9. Sludge Thicker-2 Nos.

Solid Loading Rate	: 40 $Kg/m^2/d$
Hydraulic Loading Rate	: 49,200 l /m^2/d
Expected Consistency	: 6 %
SWD	: 3.0 m
Free Board	: 600 mm

10. Digester

Detention Time for sludge Digestion	: 25 Days
Capacity for digested Sludge	: 15 Days
Diameter	: 18 m

LWD : 7.3 m

Free Board : 600 mm

Solids in digested Sludge : 8%

11. Gas Holder

Capacity : 460 m^3

Diameter : 9.5 m

Effective Depth of Holder for movement of Dome : 7.23 M

Free Board : 500 mm

12. Duel Fuel Gas Engine, 365KVA, uses 40% Diesel and 60% gas

13. Sludge Drying Beds

Number : 12

Size : 34.8×24 m

Depth of Application : 25 cm

No of Cycles : 10 per year

14. Cost Recovery :

From treated water irrigation : Rs.90 per bigha

Bio-solids : Rs.106/m^3

15. Operating & maintenance cost : 9-10 lacs /month

Fig 4.3.1 to Fig 4.3.10 showing the sewage treatment processes of the sewage treatment plant Hariduar.

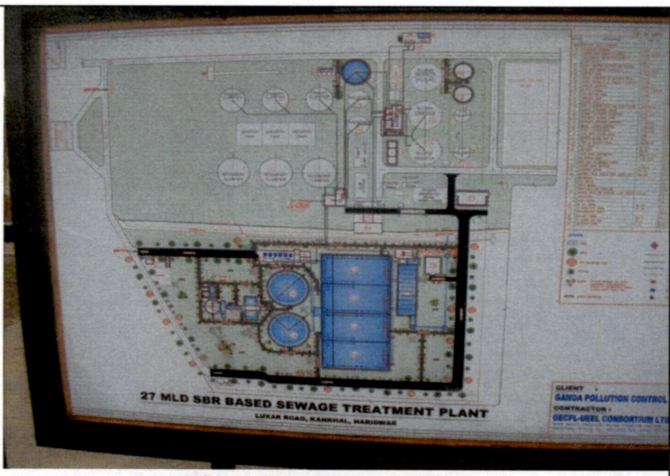


Fig 4.3.1:Layout Plan

Fig 4.3.2:Mechanical Grit Chamber

Fig 4.3.3 Primary Settling Tank

Fig 4.3.4:Aeration Tank

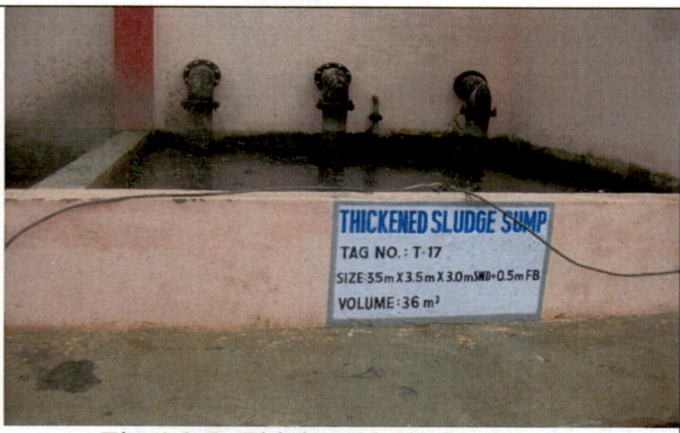


Fig 4.3.5: Thickened Sludge Sump

Fig 4.3.6: Bio Gas Tanks

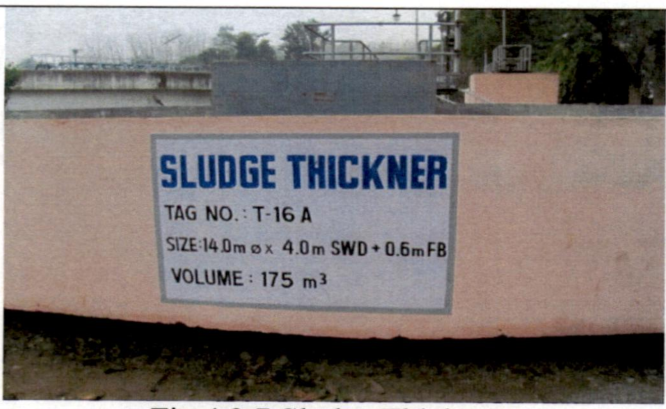


Fig 4.3.7:Sludge Thickener

Fig 4.3.8:Effluent

Fig 4.3.9: Sludge Drying Bed

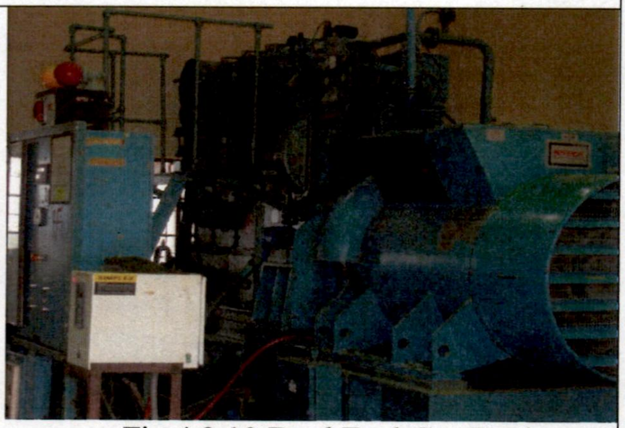


Fig 4.3.10:Dual Fuel Gas Engine

4.3.2 SAMPLE COLLECTION AND ANALYSIS

For evaluating the performance of the STP in term of treated effluent quality we are collecting 10 sample of the water and measuring in lab by experiment their pH, TSS, BOD and COD values. In the Table 4.3.1 all samples TSS, pH, BOD and COD values are given. We have also collected the TSS, BOD data of last four years from MOEF for our work. In the Table 4.3.2 that data are shown.

Table 4.3.1: Analysis of 18 MLD capacity sewage treatment plant, ASP, Hariduar

S. No	Month & Year	pH Influent	pH Effluent	TSS (mg/l) Influent	TSS (mg/l) Effluent	BOD (mg/l) Influent	BOD (mg/l) Effluent	COD (mg/l) Influent	COD (mg/l) Effluet
1	January 2012	7.10	7.51	280	20	145	15	301	3

2	January 2012	7.08	7.57	290	22	146	17	300	3
3	January 2012	7.14	7.58	288	27	148	14	340	3
4	January 2012	7.18	7.52	300	29	155	13	321	4
5	January 2012	7.15	7.59	314	23	159	11	350	3
6	February 2012	7.16	7.56	312	25	144	16	344	3
7	February 2012	7.13	7.60	298	27	160	15	306	3
8	February 2012	7.25	7.56	277	24	156	18	330	3
9	February 2012	7.13	7.57	285	28	143	20	345	3
10	February 2012	7.12	7.59	301	25	141	18.5	305	3
Average		7.14	7.56	295	25	150	14.5	324	3

In the Table 4.3.1 the analysis result of pH, BOD, COD & TSS of the water samples of Hariduar STP of Month January and February are shown. with the help of this we have also calculated the removal efficiency of BOD , COD & TSS of the STP.

Table 4.3.2: Analysis data of four years 18 MLD STP, ASP, Hariduar

S.No	Month and Year	TSS (mg/l) Influent	TSS (mg/l) Effluent	TSS Removal Efficiency	BOD (mg/l) Influent	BOD (mg/l) Effluent	BOD Removal Efficiency
1.	January 2009	178	13	92.7	165	14	91.5
2.	February 2009	168	11	93.5	156	11	92.9

3.	March 2009	262	12	95.4	190	9	95.3
4.	April 2009	198	15	92.4	158	11	93.0
5.	May 2009	180	13	92.7	222	11	95.0
6.	June 2009	212	14	93.4	168	12	92.8
7.	July 2009	235	11	95.3	156	11	92.9
8.	August 2009	210	18	91.4	145	08	94.5
9.	September 2009	268	16	94.0	168	12	92.8
10.	October 2009	222	14	93.7	144	10	93.0
11.	November 2009	192	12	93.7	132	08	93.9
12.	December 2009	175	10	94.2	145	10	93.1
13.	**Average Efficiency of 2009**			**93.5**			**93.3**
14.	January 2010	166	12	92.7	155	12	92.2
15.	February 2010	155	10	93.5	145	10	93.1
16.	March 2010	242	14	94.2	165	12	92.7
17.	April 2010	255	18	92.9	172	15	91.2
18.	May 2010	232	16	93.1	185	17	90.8
19.	June 2010	246	14	94.3	165	12	92.7

20.	July 2010	222	11	95.0	152	09	94.0
21.	August 2010	235	13	94.5	165	13	92.1
22.	September 2010	265	11	95.8	158	11	93.0
23.	October 2010	252	13	94.8	145	09	93.8
24.	November 2010	222	26	88.3	165	14	91.5
25.	December 2010	195	13	93.3	165	13	92.1
26.	**Average Efficiency of 2010**			**93.5**			**92.4**
27.	January 2011	190	20	89.4	155	13	91.6
28.	February 2011	210	22	89.5	160	16	90.0
29.	March 2011	180	11	93.8	155	11	92.9
30.	April 2011	166	12	92.7	165	13	92.1
31.	May 2011	158	10	93.6	155	11	92.9
32.	June 2011	165	12	92.7	166	13	92.1
33.	July 2011	155	10	93.5	158	11	93.0
34.	August 2011	165	12	92.7	165	13	92.1
35.	September 2011	155	11	92.9	155	11	92.9

36.	October 2011	144	10	93.0	150	10	93.3
37.	November 2011	155	12	92.2	155	11	92.9
38.	December 2011	166	14	91.5	160	13	91.8
39.	**Average Efficiency of 2011**			**92.2**			**92.3**
40.	January 2012	158	13	91.7	165	14	91.5
41.	February 2012	165	15	90.9	155	12	92.2
42.	March 2012	158	12	92.4	148	15	89.8
43.	**Average Efficiency of 2012**			**91.6**			**91.1**

In The Table 4.3.2 the testing results of BOD & TSS of the last four years and removal efficiency of the plant are shown. From this result we observed that the BOD & TSS removal efficiency of the plant are more than 90% throughout the four year.

4.3.3 RESOURCE RECOVERY

Resource recovery from the sewage treatment plant is given below.

1. The treated effluent is being sold at the rate of Rs 90 /bigha giving revenue of Rs 1.50 lakh/year.
2. About 2500 cum. of nutrient rich digested sludge cakes, which is an excellent bio-fertilizer and soil conditioner, are sold to the farmers at the rate of Rs 106/cum to yield a revenue of Rs 2 lakh per year.
3. Sales to safety-match box factories, mature poplar trees will fetch Rs 40 lakhs in the year 2003.

TABLE 4.3.3: **Resource Recovery at Hariduar**

Sl.No	Resource Recovery	Rs in lakh /year
1	Treated effluent at the rate of Rs 90 /bigha	1.50
2	Digested sludge cakes, of Rs 106/cum	2.00
	Total	**3.50**

4.3.4 PROJECTED GAS PRODUCTION AT HARIDUAR

The gas produced per million litre of sewage = 111 m3 (Appendix 1). The projected Biogas production is 1998 m3. The Actual Biogas production is 435 m3. C.V.of Biogas is 21.24 MJ/kg (Appendix 1)

TABLE 4.3.4: Energy Production from Biogas

Sl. No	Location of STPs	Biogas production in m3/day	C.V.of Biogas MJ/m3	Energy production for 1 m3 biogas@21.24 MJ/m3	Energy production/day	
					kWh/day	MWh/day
1	Kankha	435	21.24	2.04 kWh	887.4	0.89
Total Energy production per day						0.88
Cost of E.B. Power savings = 0.89 MWh/day X365 days X 4.00 X1000 =Rs.12.99 lakhs/year.						
Cost of E.B. Power savings per 1MLD = Rs.1299000 / 18 MLD = Rs. 0.72 lakhs/year.						

4.3.5 PROJECTED SLUDGE PRODUCTION IN HARIDWAR

Mass of sludge in ASP based STP = 221.88 kg/MLD

Sludge concentration =65 to 75 kg/ m^3 (say) 70 kg/m3

Volume of sludge = 221.88 /70 kg/ m^3 = 3.17 m3/MLD

Sludge production per day = 18 MLD X 3.17m3/MLD =57.06 m^3

Quantity of dry sludge=15% of wet sludge =57.06 X 0.15 = 8.56 m^3

Sludge production per year = 8.56 m^3 X 365 days = 3124 m^3

Cost of sludge @ Rs. 106.00 per m^3 = Rs. 3.31 lakhs.

4.3.6 POWER GENERATION THRO' GAS ENGINE

At present, the gas is being utilized for running of DFG during power breakdown only and the rest is being flared.

4.3.7 OBSERVATIONS

1. Gas generated in aerobic sludge reactor is not being utilized fully.
2. Plant is able to comply with the discharge standards.
3. No facility is provided to measure the quantity of bio-gas being produced daily.
4. Lot of greenery/plants have been grown inside the STP campus.
5. Treated effluent is meeting the design standards for BOD & TSS.

4.4.56 MLD SEWAGE TREATMENT PLANT UASB TECHNOLOGY, GHAZIABAD (U.P)

UASB process with polishing ponds (2 nos.) has been provided to treat 56 mld wastewater at Indirapuram under YAP-I in 2001. Plant has been handed over by UPJN to Ghaziabad Municipal Corporation for its O&M in Sept., 06. Plant generally receives an average of 65 mld of wastewater and is thus overloaded. In view of rapid development of Indirapuram and adjoining areas, expansion of the STP may be required very soon. Operation of the plant is being done through contract and repair/maintenance departmentally. Mechanical screens (2 nos.) installed at the inlet of STP are getting rusted. Manual screens of 10 mm size have been provided through which lot of floating matter; solids, plastics etc. are passing into the reactors. Smaller size of screens i.e. 6 mm can also be provided. M.S. railing, platform etc. are getting rusted. Proportionate weir/V-notch plates at the end of the grit channels are getting damaged and need to be recalibrated. A floating layer of scum/algae is found on the surface of reactors and the weir/V-notches provided in the effluent FRP gutter are also blocked by floating matter/sludge at some places.

Large pieces of sludge were floating on the surface of the reactor at some places, as if, sludge blanket is getting disturbed. As preventive maintenance, UASB reactors should be put out of operation, emptied, cleaned and repaired every five years which is already due. Some of the FRP baffle plates are found to be twisted/bent. Reactors have not been cleaned so far since commissioning. No O&M manual is available at site. DFGs (63 KVA, 2Nos) are mostly used during power cut only. Bio-gas produced is just sufficient to run the DFGs during power cut. Gas meter has been installed to measure the quantity of gas being produced but no record of the same is available. Sampling/testing of the effluent is being done in IIT Roorkee. Treated effluent is meeting the discharge standards for BOD & SS Treated effluent is being discharged into river Hindon. Sludge from sludge drying beds is being sold for use as manure. It was informed that due to funds constrain it is not possible to improve O&M of the STP. No regular training has been provided to operators/supervisory staff. Moreover, availability of competent/qualified personal in the Corporation for O&M of the STP is doubtful.

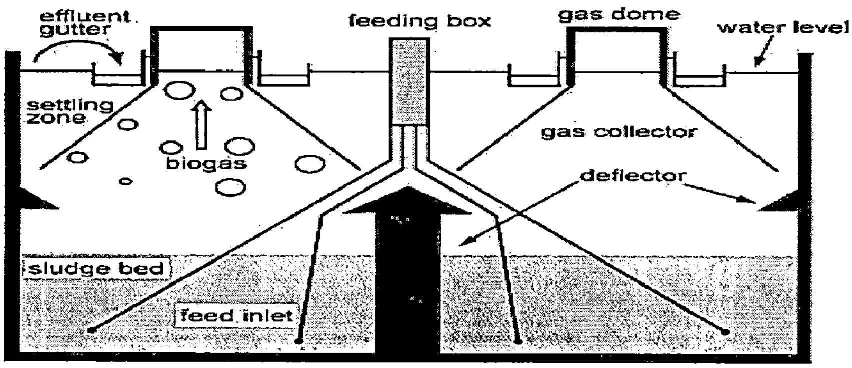


Figure No.4.4.1: SECTION OF UASB REACTOR

Table 4.4.1: Technical Details at Ghaziabad 56 MLD

S.No.	UNIT	SIZE (Mtr)	QTY.(Nos.)
1.	**Inlet chamber**	20 x 6.2 x 3.75	1
2.	**Screen chamber mechanical**	5.0 x 1.5 x 1.6	2
3.	**Screen chamber manually**	5.0 x 1.5 x 1.3	2
4.	**Grit chamber**	2.0 x 2.0 x 1.5	4
5.	**Collection tank**	2.5 x 8.45 x 10.0	1
6.	**Division Box**	7.0 dia x 1.5	1
7.	**Distribution Box (circular)**	3.0 x 2.5 x 0.45	8
8.	**U.A.S.B Reactor**	32 x 32 x 6.1	4
9.	**Sludge Pump (Circular)**	4.5 dia x 7.5	1
10.	**Sludge Pump**	20 HP	2
11.	**Sludge drying Bed**	30 x 15	24
12.	**Final Polishing Pond**	180 x 120	2
13.	**Filtrate sump (Circular)**	4.0 dia x 6.25	1
14.	**Filtrate Pump**	10 HP	2
15.	**Flow meter**	Digital	2
16.	**Gas holder (circular)**	10. dia x 5.0	1
17.	**Gas Burner**	flare	1
18.	**MEP Room**	80 m2	1
19.	**Generator Room**	70 m^2	1

Fig 4.4.1 to Fig 4.4.8 showing the sewage treatment processes of the sewage treatment plant Ghaziabad.

Fig 4.4.1:Influent coming for treatment

Fig4.4. 2:Distribution Box

Fig 4.4.3:UASB Reactor

Fig 4.4.4:Effluent going to Final polishing pond

Fig 4.4.5: Final polishing ponds

Fig 4.4.6: Sludge drying bed

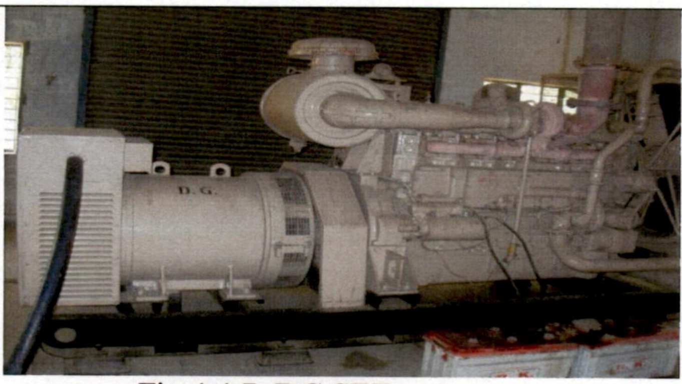


Fig 4.4.7: DG SET

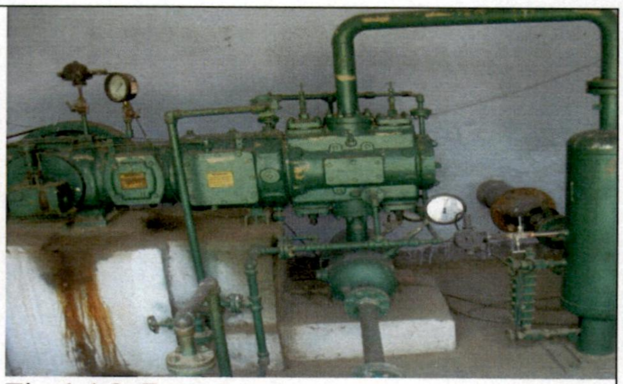


Fig 4.4.8: Pump

4.4 2. SAMPLE COLLECTION AND ANALYSIS

For evaluating the performance of the STP in term of treated effluent quality we are Collecting 10 sample of the water and measuring in lab by experiment their pH,TSS, BOD and COD value. In the Table 5.2 all samples TSS, pH, BOD and COD values are given. We have also collected the TSS, BOD data of last four years from MOEF for our work. In the Table 4.4.3 that Data are shown.

Table 4.4.2: Analysis of 56 MLD capacity sewage treatment plant, UASB , Ghaziabad

S. No	Month & Year	pH Influent	pH Effluent	TSS (mg/l) Influent	TSS (mg/l) Effluent	BOD (mg/l) Influent	BOD (mg/l) Effluent	COD (mg/l) Influent	COD (mg/l) Effluent
1	January 2012	7.18	7.61	298	80	256	35	332	6
2	January 2012	7.20	7.67	295	82	255	33	334	6
3	January 2012	7.19	7.68	299	65	265	28	344	7
4	January 2012	7.14	7.72	304	67	261	27	338	7
5	January 2012	7.19	7.79	311	63	259	29	351	7

6	February 2012	7.20	7.86	300	65	261	29	346	7
7	February 2012	7.18	7.77	297	62	259	34	342	76
8	February 2012	7.16	7.86	288	69	258	29	339	7
9	February 2012	7.14	7.87	298	68	263	28	340	7
10	February 2012	7.15	7.67	300	69	265	26	338	6
Average		7.17	7.75	299	69	260	30	340	7

In the Table 4.4.2 the analysis result of pH, BOD, COD & TSS of the water samples of Ghaziabad STP of Month January and February are shown. with the help of this we have also calculated the removal efficiency of BOD , COD & TSS of the STP.

Table 4.4.3: Analysis data of four years of 56 MLD capacity STP, UASB , Ghaziabad

S.No	Month and Year	TSS (mg/l) Influent	TSS (mg/l) Effluent	TSS Removal Efficiency	BOD (mg/l) Influent	BOD (mg/l) Effluent	BOD Removal Efficiency
1.	January 2009	294	143	51.3	175	38	78.2
2.	February 2009	327	183	44.0	151	25	83.4
3.	March 2009	354	140	60.4	178	28	84.2
4.	April 2009	270	138	48.8	201	20	90.0
5.	May 2009	298	128	57.0	171	26	84.8
6.	June 2009	266	130	51.1	180	22	87.7
7.	July 2009	240	90	62.5	131	25	80.9

8.	November 2009	147	98	33.3	166	25	84.9
9.	December 2009	222	114	48.6	280	43	84.6
10.	**Average Efficiency of 2009**			**50.7**			**84.3**
11.	January 2010	303	118	61.0	296	44	85.1
12.	February 2010	207	108	47.8	218	30	86.2
13.	March 2010	153	84	45.0	220	30	86.4
14.	April 2010	195	114	41.5	251	27	89.2
15.	May 2010	231	105	54.5	191	25	86.9
16.	June 2010	183	87	52.5	146	25	82.8
17.	July 2010	186	86	53.7	137	22	83.9
18.	August 2010	128	72	43.7	65	19	70.7
19.	September 2010	131	62	52.6	98	22	77.5
20.	October 2010	156	79	49.3	117	26	77.7
21.	November 2010	160	68	57.5	251	28	88.8
22.	December 2010	232	139	40.0	204	40	80.3
23.	**Average Efficiency of 2010**			**49.9**			**82.9**
24.	January 2011	143	76	46.8	251	28	88.8

25.	February 2011	224	133	40.6	271	33	87.8
26.	March 2011	176	81	53.9	213	30	85.9
27.	April 2011	144	70	51.4	217	27	87.6
28.	May 2011	173	92	46.8	270	27	90.0
29.	June 2011	190	88	53.6	131	25	80.9
30.	July 2011	199	97	51.2	125	25	80.0
31.	August 2011	193	107	44.5	132	22	83.3
32.	September 2011	183	93	49.1	123	25	79.6
33.	October 2011	194	79	59.3	140	21	85.0
34.	November 2011	216	98	54.6	146	26	82.1
35.	December 2011	159	64	59.7	183	22	87.9
36.	**Average Efficiency of 2011**			**50.9**			**84.9**
37.	January 2012	253	138	46.7	223	28	87.4
38.	February 2012	282	147	47.8	202	25	87.6
39.	March 2012	188	99	47.3	194	35	81.4
40.	**Average Efficiency of 2012**			**47.2**			**85.4**

In The Table 4.4.3 the testing results of BOD & TSS of the last four years and removal efficiency of the plant are shown. From this result we observed that the average BOD removal efficiency of the plant are more than 80%.

4.4.3 Resource Recovery

About 7000 cum. of nutrient rich digested sludge cakes, which is an excellent bio-fertilizer and soil conditioner, are sold to the farmers at the rate of Rs 110/cum to yield a revenue of Rs 5 lakh per year.

4.4.4 PROJECTED GAS PRODUCTION

The gas produced per million litre of sewage = 97 m3 (Appendix 1). The projected Biogas production is 5432 m3. C.V.of Biogas is 21.24 MJ/kg (Appendix 1)

TABLE 4.4.4: Energy Production from Biogas at Ghaziabad 56 MLD

Sl. No	Location of STPs	Biogas production in m3/day	C.V.of Biogas MJ/m3	Energy production for 1 m3 biogas@21.24 MJ/m3	Energy production/day	
					kWh/day	MWh/day
1	Indrapuram	5432	21.24	2.04 kWh	11080	11.08
Total Energy production per day						11.08
Cost of E.B. Power savings = 11.08 MWh/day X365 days X 4.00 X1000 =Rs.161.76 lakhs/year.						
Cost of E.B. Power savings per 1MLD = Rs.16176000 / 18 MLD = Rs. 2.88 lakhs/year.						

4.4.5 PROJECTED SLUDGE PRODUCTION IN GHAZIABAD 56 MLD

Mass of sludge in UASB based STP	= 197.5 kg/MLD
Sludge concentration	=65 to 75 kg/ m^3 (say) 70 kg/ m^3
Volume of sludge	= 197.5 /70 kg/ m^3= 2.82 m3/MLD
Sludge production per day	= 56 MLD X 2.82 m^3/MLD =157.92 m^3
Quantity of dry sludge	=15% of wet sludge=157.92X0.15=23.7m3
Sludge production per year	= 23.7 m^3 X 365 days = 8650 m^3
Cost of sludge @ Rs. 106.00 per m^3	= Rs. 9.16 lakhs

4.4.6. OBSERVATIONS:-

1) The effluent BOD_5 after treatment comes to 30mg/l, within permissible limit of NRCD norms to further discharged into river.
2) They are not generating biogas from the sludge.
3) Treated Effluent from the plant is entered in the Hindon River.
4) Sludge cake formed is being sold to farmer.

4.5 SEWAGE TREATMENT PLANT UASB TECHNOGY, GHAZIABAD (U.P)

4.5.1 DETAILS OF COMPONENTS

S. No.	Particular	Value
1	**Flow**	
a	Average Design Flow	73 MLD
b	Design Peak flow	140 MLD
2.	**Raw Sewage Characteristics**	
a.	PH	7 – 8
b.	BOD_5 at 20^0 C	200 mg / l
c .	COD	450 mg / l
d.	TSS	350 mg / l
3.	**Required Treated Waste Water Quality**	
a.	BOD_5 at 20^0 C	= 30 mg / l
b.	TSS	= 50 mg / l
4.	**Screen**	
a.	Mechanical Screen	2 Nos.
b.	Manual Screen	2 Nos.

5.	**UASB REACTOR**	
a.	UASB Reactor	73 MLD
b.	Angle of Deflector Beam	45 deg
c.	Angle of Gas Collector	50 deg
d.	Effluent HRT	10 hrs
6.	**Final Polishing Pond**	3 Nos.
a.	Min Detention Time at Average Flow	1 Day
b.	Number of Compartment in each Pond	3 Nos.
c.	Liquid Depth Provided	1.50 m
7.	**Gas Holder**	1 Nos.
a.	Storage capacity	6 hrs.
8.	**Sludge Drying Beds**	
a.	Thickness of Sludge layer	0.20 m
b.	Minimum Cycle for Sludge Drying & Removal	10 Days
c.	Number of Cycle in a Year	30 Nos.

4.5.2 SAMPLE COLLECTION AND ANALYSIS

For evaluating the performance of the STP in term of treated effluent quality we are collecting 10 samples of the water and measuring in lab by experiment their pH, TSS, BOD and COD value. in the Table 5.2.1 all samples TSS ,pH,BOD and COD values are given. We have also collected the TSS,BOD data of last four years from MOEF for our work. In the Table 4.5.2 that data are shown.

Table 4.5.1 Analysis of 73 MLD capacity sewage treatment plant, UASB , Ghaziabad

S. No	Month & Year	pH Influent	pH Effluent	TSS (mg/l) Influent	TSS (mg/l) Effluent	BOD (mg/l) Influent	BOD (mg/l) Effluent	COD (mg/l) Influent	COD (mg/l) Effluent
1	January 2012	7.09	7.51	300	79	254	30	331	68
2	January 2012	7.06	7.67	298	83	259	28	332	64
3	January 2012	7.05	7.88	310	85	267	25	340	75
4	January 2012	7.13	7.82	311	87	278	36	334	71
5	January 2012	7.14	7.69	299	79	244	29	350	74
6	February 2012	7.19	7.76	301	87	289	28	344	73
7	February 2012	7.10	7.79	295	83	235	30	341	69
8	February 2012	7.22	7.76	297	76	256	28	338	68
9	February 2012	7.18	7.87	295	91	243	31	345	79
10	February 2012	7.14	7.67	306	79	241	25	335	67
Average		7.13	7.74	301	70	257	29	339	71

In the Table 4.5.1 the analysis result of pH, BOD, COD & TSS of the water samples of Ghaziabad STP of Month January and February are shown. with the help of this we have also calculated the removal efficiency of BOD , COD & TSS of the STP.

Table 4.5.2 Analysis data of four years of 73 MLD capacity STP, UASB , Ghaziabad

S.No	Month and Year	TSS (mg/l) Influent	TSS (mg/l) Effluent	TSS Removal Efficiency	BOD (mg/l) Influent	BOD (mg/l) Effluent	BOD Removal Efficiency
1.	January 2009	364	161	55.7	160	36	77.5
2.	February 2009	327	183	44.0	105	25	76.1
3.	March 2009	364	191	47.5	200	38	81.0
4.	April 2009	235	119	49.36	201	30	85.0
5.	May 2009	328	170	48.1	182	24	86.8
6.	June 2009	267	135	49.4	67	22	67.1
7.	July 2009	240	90	62.5	66	25	62.1
8.	November 2009	271	152	43.9	174	31	82.1
9.	December 2009	260	127	51.1	193	40	79.2
10.	**Average Efficiency of 2009**			**50.1**			**77.4**
11.	January 2010	303	118	61.0	296	56	81.0
12.	February 2010	207	108	47.8	240	29	87.9
13.	March 2010	262	132	49.6	225	27	88.0
14.	April 2010	195	114	41.5	251	27	89.2
15.	May 2010	243	143	41.1	166	26	84.3
16.	June 2010	233	115	50.6	97	29	70.1

17.	July 2010	186	86	53.7	137	22	83.9
18.	August 2010	170	105	38.0	99	19	80.8
19.	September 2010	182	112	38.4	89	19	78.6
20.	October 2010	160	90	43.7	163	30	81.6
21.	November 2010	146	48	67.1	136	24	82.3
22.	December 2010	232	139	40.0	204	57	72.0
23.	**Average Efficiency of 2010**			**47.7**			**81.6**
24.	January 2011	233	120	48.4	225	39	82.6
25.	February 2011	245	130	46.9	255	32	87.4
26.	March 2011	212	90	57.5	265	29	89.0
27.	April 2011	212	95	55.1	217	27	87.5
28.	May 2011	193	107	44.5	236	26	88.9
29.	June 2011	190	83	56.3	120	29	75.8
30.	July 2011	141	92	34.7	136	24	82.3
31.	August 2011	228	125	45.1	133	22	83.4
32.	September 2011	205	112	45.3	106	24	77.3

33.	October 2011	247	88	64.3	196	21	89.2
34.	November 2011	193	100	48.1	236	26	88.9
35.	December 2011	178	117	34.2	224	24	89.2
36.	**Average Efficiency of 2011**			**48.3**			**85.1**
37.	January 2012	287	152	47.0	254	29	88.5
38.	February 2012	-	-		209	52	75.1
39.	March 2012	204	104	49.0	205	33	83.9
40.	**Average Efficiency of 2012**			**48.0**			**82.5**

In The Table 4.5.2 the testing results of BOD & TSS of the last four years and removal efficiency of the plant are shown. From this result we observed that the average BOD removal efficiency of the plant are more than 80% exempt the year 2009.

4.5.3 RESOURCE RECOVERY

About 8000 cum. of nutrient rich digested sludge cakes, which is an excellent bio-fertilizer and soil conditioner, are sold to the farmers at the rate of Rs 110/cum to yield a revenue of Rs 5.5 lakh per year.

4.5.4 PROJECTED GAS PRODUCTION

The gas produced per million litre of sewage = 97 m3 (Appendix 2). The projected Biogas production is 7081 m3. C.V.of Biogas is 21.24 MJ/kg (Appendix 2)

TABLE 4.5.3: Energy Production from Biogas at Ghaziabad 73 MLD

Sl. No	Location of STPs	Biogas production in m3/day	C.V.of Biogas MJ/m3	Energy production for 1 m3 biogas@21.24 MJ/m3	Energy production/day	
					kWh/day	MWh/day
1	Indrapuram Ghaziabad	7081	21.24	2.04 kWh	14442	14.44
Total Energy production per day						14.44
Cost of E.B. Power savings = 11.08 MWh/day X365 days X 4.00 X1000 =Rs.210.82 lakhs/year.						
Cost of E.B. Power savings per 1MLD = Rs.16176000 / 18 MLD = Rs. 2.89 lakhs/year.						

4.5.5 PROJECTED SLUDGE PRODUCTION IN GHAZIABAD 73 MLD

Mass of sludge in UASB based STP	= 197.5 kg/MLD
Sludge concentration	=65 to 75 kg/ m^3 (say) 70 kg/ m^3
Volume of sludge	= 197.5 /70 kg/ m^3= 2.82 m3/MLD
Sludge production per day	= 73 MLD X 2.82m3/MLD =205.86 m^3
Quantity of dry sludge	=15% of wet sludge=205.86X0.15= 30.9 m3
Sludge production per year	= 30.9 m^3X 365 days = 11278 m^3
Cost of sludge @ Rs. 106.00 per m^3	= Rs. 11.95 lakhs.

4.6 SEWAGE TREATMENT PLANT WSP TECHNOLOGY, RISHIKESH

Rishikesh, surrounded by virgin forests at the toe of the Himalayas, is the first town on river Ganga taken up under the Ganga Action Plan Phase-I for pollution abatement of the river. Hundreds of ashrams, temples, residences, hotels and other commercial establishments dot the banks. This immense human activity, in a narrow band along the length of the town on both the banks, generates nearly 6 million litres of sewage per day into the pristine Ganga before it emerges into the plains.

TABLE 4.6.1: Salient Features of STP

Location:	Lakhat Ghat – 6.5 km from Rishikesh
No. of ponds:	5 ponds same retention period

Capacity of pond:	6MLD -Size=167m x 84m x 1.5m
Retention period:	15 days
Flow of sewage:	Zigzag for no short circuiting
Effluent discharge:	Effluent is discharged into Nallah to Saung River near Raiwalla- 15 Km from Rishikesh-by gravity
Effluent quality:	BOD=25 to 30 Mg/l
Silt removal:	After 2 years interval

4.6.1 GANGA ACTION PLAN PHASE-I

The Ganga Action Plan works in Rishikesh comprise, inter alia, sewerage works to tap the sewage outfalls and through appropriate pumping station, diversion of the sewage to a pond type STP at Lakkarghat between Haridwar and Rishikesh. Under the GAP, existing ponds were renovated and expanded by additional pondage to treat a flow of 6 MLD sewage per day from the town of Rishikesh.

Figure 4.6.1: Inlet Water

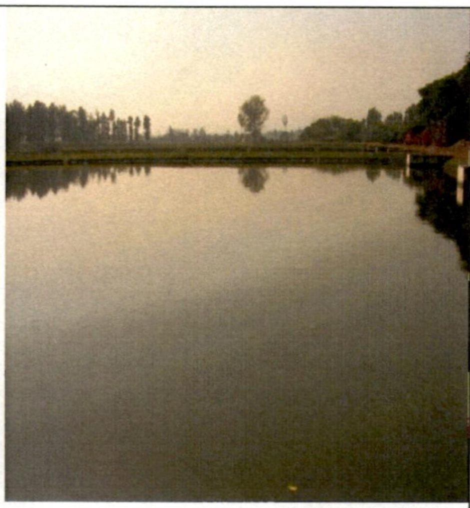


Figure 4.6.2: Pond View

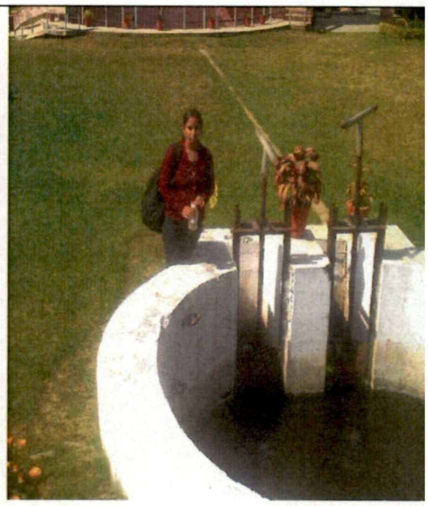


Figure 4.6.3: Outlet Chamber

4.6.2 SAMPLE COLLECTION AND ANALYSIS

For evaluating the performance of the STP in term of treated effluent quality we are Collecting 10 sample of the water and measuring in lab by experiment their pH, TSS, BOD and COD value. in the Table 4.6.2 all samples TSS ,pH,BOD and COD values are given. We have also collected the TSS, BOD data of last four years from MOEF for our work. In the Table 4.6.3 that data are shown.

Table 4.6.2 Analysis of 8 MLD capacity sewage treatment plant, WSP, Rishikesh

S.No	Month & Year	pH Influent	pH Effluent	TSS (mg/l) Influent	TSS (mg/l) Effluent	BOD (mg/l) Influent	BOD (mg/l) Effluent	COD (mg/l) Influent	COD (mg/l) Effluer
1	January 2012	7.20	7.50	277	60	155	31	351	8
2	January 2012	7.18	7.57	289	61	176	34	340	8
3	January 2012	7.26	7.60	280	63	168	30	347	9
4	January 2012	7.28	7.54	303	66	178	33	361	9
5	January 2012	7.25	7.57	324	58	169	31	350	9
6	February 2012	7.19	7.56	315	62	174	30	354	8
7	February 2012	7.23	7.68	294	60	155	27	346	8
8	February 2012	7.23	7.66	287	61	159	34	360	9
9	February 2012	7.19	7.57	284	63	163	30	358	8
10	February 2012	7.18	7.67	298	61	171	32	365	9
Average		7.21	7.59	295	61	167	31	353	9

In the Table 4.6.2 the analysis result of pH, BOD, COD & TSS of the water samples of Rishikesh STP of Month January and February are shown. With the help of this we have also calculated the removal efficiency of BOD, COD & TSS of the STP.

Table 4.6.3: Analysis data of four years of 73 MLD capacity STP, UASB , Ghaziabad

S.No	Month and Year	TSS (mg/l) Influent	TSS (mg/l) Effluent	TSS Removal Efficiency	BOD (mg/l) Influent	BOD (mg/l) Effluent	BOD Removal Efficiency
1.	January 2009	235	54	77.0	166	34	79.5
2.	February 2009	244	50	79.5	158	30	81.0
3.	March 2009	210	48	77.1	150	35	76.6
4.	April 2009	255	52	79.6	166	38	77.1
5.	May 2009	228	46	79.8	188	35	81.3
6.	June 2009	218	52	76.1	174	36	79.3
7.	July 2009	236	48	79.6	160	30	81.2
8.	August 2009	210	40	80.9	150	26	82.6
9.	September 2009	196	36	81.6	155	25	83.8
10.	October 2009	176	30	82.9	135	22	83.7
11.	November 2009	168	46	72.6	154	28	81.8
12.	December 2009	155	41	73.5	145	26	82.0
13.	**Average Efficiency of 2009**			**78.3**		-	**80.8**
14.	January 2010	198	46	76.7	155	28	81.9
15.	February 2010	210	42	80.0	148	25	83.1

16.	March 2010	266	46	82.7	165	29	82.4
17.	April 2010	285	48	83.1	178	30	83.1
18.	May 2010	301	50	83.3	168	29	82.7
19.	June 2010	286	42	85.3	155	26	83.2
20.	July 2010	267	39	85.4	145	24	83.4
21.	August 2010	258	43	83.3	155	28	81.9
22.	September 2010	278	50	82.0	165	30	81.8
23.	October 2010	225	42	81.3	155	28	81.9
24.	November 2010	212	38	82.0	148	26	82.4
25.	December 2010	205	42	79.5	165	28	83.0
26.	**Average Efficiency of 2010**			**82.0**			**82.5**
27.	January 2011	220	48	78.1	165	26	84.2
28.	February 2011	250	50	80.0	175	28	84.0
29.	March 2011	160	45	71.6	160	26	83.7
30.	April 2011	171	48	71.9	168	28	83.3
31.	May 2011	165	42	74.5	160	26	83.7
32.	June 2011	172	43	75.0	165	28	83.0

33.	July 2011	181	40	77.9	160	26	83.7
34.	August 2011	192	44	77.0	165	28	83.0
35.	September 2011	210	40	80.9	155	26	83.2
36.	October 2011	230	43	81.3	162	28	82.7
37.	November 2011	213	40	81.2	155	27	82.5
38.	December 2011	238	45	81.0	148	26	82.4
39.	**Average Efficiency of 2011**			**77.5**			**83.2**
40.	January 2012	250	48	80.8	155	28	81.9
41.	February 2012	263	50	80.9	165	29	82.4
42.	March 2012	275	48	82.5	175	30	82.8
43.	**Average Efficiency of 2012**			**81.4**			**82.3**

In The Table 4.6.3 the testing results of BOD & TSS of the last four years and removal efficiency of the plant are shown. From this result we observed that the average BOD removal efficiency of the plant are more than 80% and TSS removal efficiency of the Plant are more than 78%.

4.7 COMPARING REMOVAL EFFICIENCY OF SELECTED TREATMENT PLANTS

In the Table 4.7.1 measured treated water quality parameter like TSS & BOD removal efficiency of selected treatment plant are compared with the literature and Expected efficiency of TSS & BOD By CPHEEO. The comparison shows that the measured TSS & BOD removal efficiency of all plants is within range of Expected efficiency by CPHEEO and literature.

Table 4.7.1 Comparison of Typical & Expected Removal Efficiency with Measured Efficiency of Selected Plants

		TSS Removal Efficiency			BOD Removal Efficiency		
S.No		**ASP**	**UASB**	**WSP**	**ASP**	**UASB**	**WSP**
1	**Literature [7]**	87 to 93	65 to 80	70 to 80	85 to 97	60 to 75	75 to 85
2	**Expected Efficiency By CPHEEO [29]**	85 to 90	70 to 90	80 to 90	85 to 95	75 to 85	80 to 90
3	**2009**	93.5	50.7	78.3	93.3	84.3	80.8
4	**2010**	93.5	49.9	82	92.4	82.9	82.5
5	**2011**	92.2	50.9	77.5	92.3	84.9	83.2
6	**2012**	91.6	47.2	81.4	91.1	85.4	82.3
7	**Measured**	91.5	76.5	79.3	90.3	88.3	81.1

Through this comparison we conclude that the TSS & BOD removal efficiency of the ASP plant are better than the UASB and WSP. In Figure 4.7.1 to Figure 4.7.3 we have compared the measured effluent quality parameter like COD, BOD and TSS treated by Different Technologies based sewage treatment plant. From the figures we conclude that the BOD, COD and TSS removal efficiency of ASP is Highest.

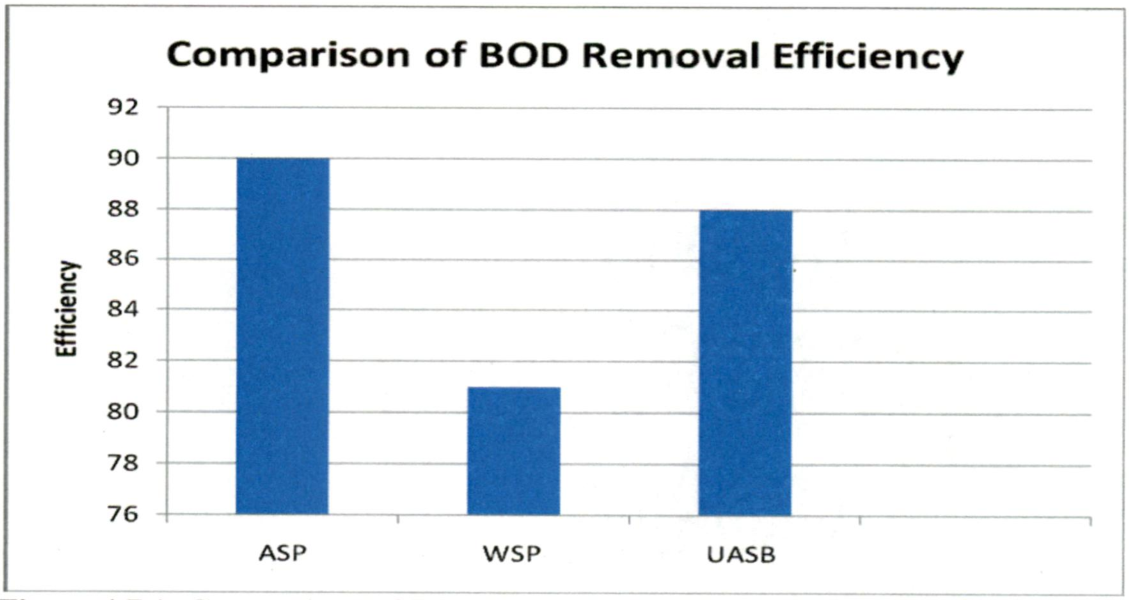


Figure 4.7.1: Comparison of BOD Removal efficiency of different Sewage Treatment Technologies

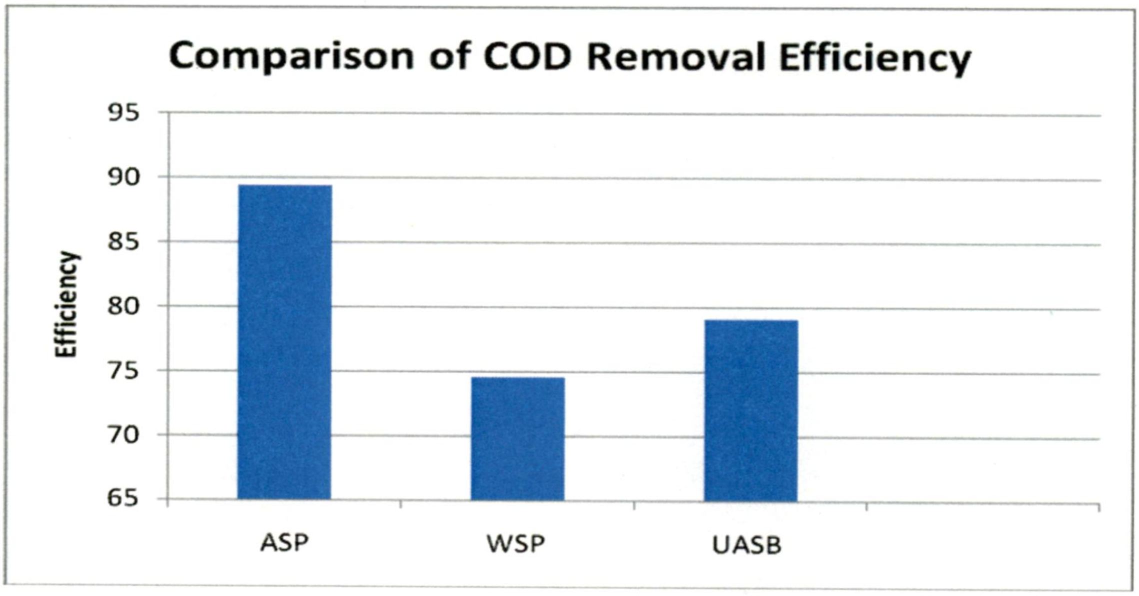


Figure 4.7.2: Comparison of COD Removal efficiency of different Sewage Treatment Technologies

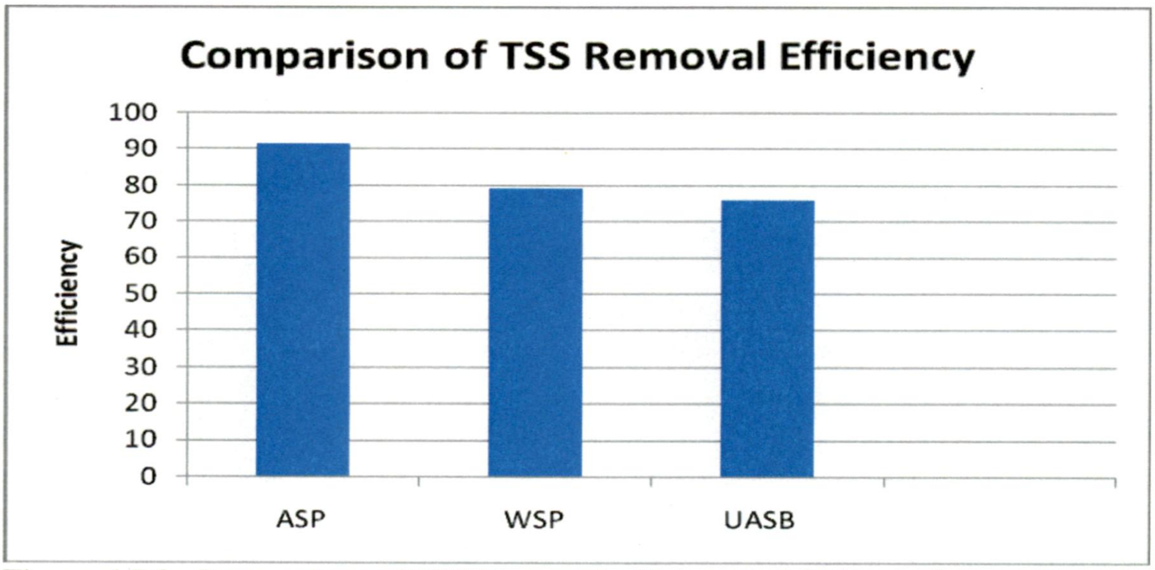


Figure 4.7.3: Comparison of TSS Removal efficiency of different Sewage Treatment Technologies

4.8 COST COMPARISON OF TECHNOLOGIES

Haridwar have ASP technology STPs. Ghaziabad have UASB technology STPs and Rishikesh have WSP technology STPs. For measuring economical feasibility, we have to compare the cost of the STPs of the selected the technology. Table 4.8.1 shows the Unit area of STP required, the unit cost of construction of STP and the unit cost of annual O&M of STP for 1 MLD capacity. With the help of figure 4.8.1 to figure 4.8.4 the cost comparison and area requirement, power requirement and operation and maintenance cost are shown.

TABLE 4.8.1: Cost, area and O & P Maintenance Cost requirement comparison

S.No	Assessment Parameter/Technology	ASP	UASB	WSP
1	**Capital Cost Lacs/MLD**	108.00	108.00	63.00
2	**Area Requirements , m2 per MLD**	1000.00	1100.00	6100.00
3	**Operation & Maintenance Costs**			
3.1	**Energy Costs (Per MLD)**			
3.1.1	**Total Daily Power Requirement (avg.), kWh/d /MLD**	185.70	125.70	5.70
3.1.2	**Daily Power Cost (@` 6.0 per KWh), /MLD/h** (Including Standby power cost)	46.43	31.43	1.43
3.1.3	**Yearly Power Cost**, lacs pa/MLD	**4.07**	**2.75**	**0.49**
3.2	**Annual Repairs Costs,** Lacs pa/MLD	**2.38**	**2.48**	**1.76**
3.3	**Total Chemical Cost,** Lacs pa/MLD	**5.30**	**6.30**	**7.20**

3.4	**Manpower Cost (Assuming 50 MLD Plant)**			
3.4.1	**Manager**, Lacs pa (1 No.)	3.60	3.60	3.60
3.4.2	**Chemist/Engineer**, Lacs pa (1 No.)	3.60	3.60	3.60
3.4.3	**Operators**, Lacs Pa ((@ 12000 pm)	8.64	8.64	4.32
3.4.4	**Skilled technicians**, Lacs pa (@ 10000 pm)	7.20	7.20	1.20
3.4.5	**Unskilled personnel**, pa (@ 7000 pm)	5.04	5.04	8.64
3.4.6	**Total Salary Costs**, Lacs pa	28.08	28.08	21.36
3.4.7	**Benefits** **(50% of total salary)**, Lacs pa	14.04	14.04	10.68
3.4.8	**Total (Salary + Benefits)**, Lacs pa	**42.12**	**42.12**	**32.04**
3.5	**Total O & M costs lacs pa/MLD**	**53.87**	**53.65**	**41**

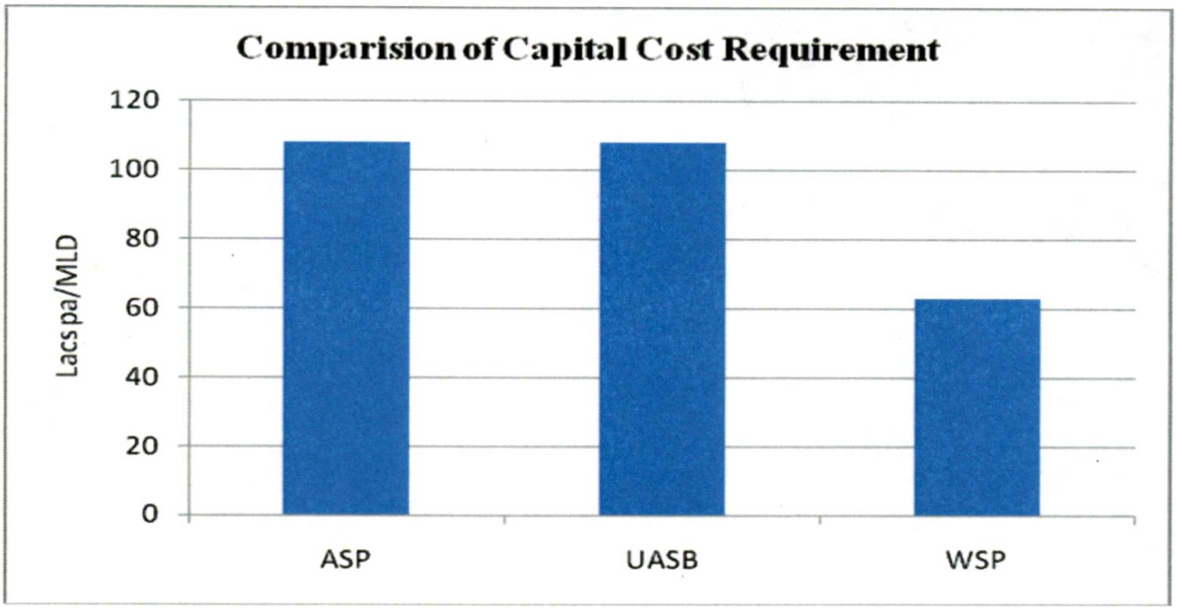


Figure 4.8.1: Comparison of Capital Cost Requirement of Sewage Treatment Different Technologies

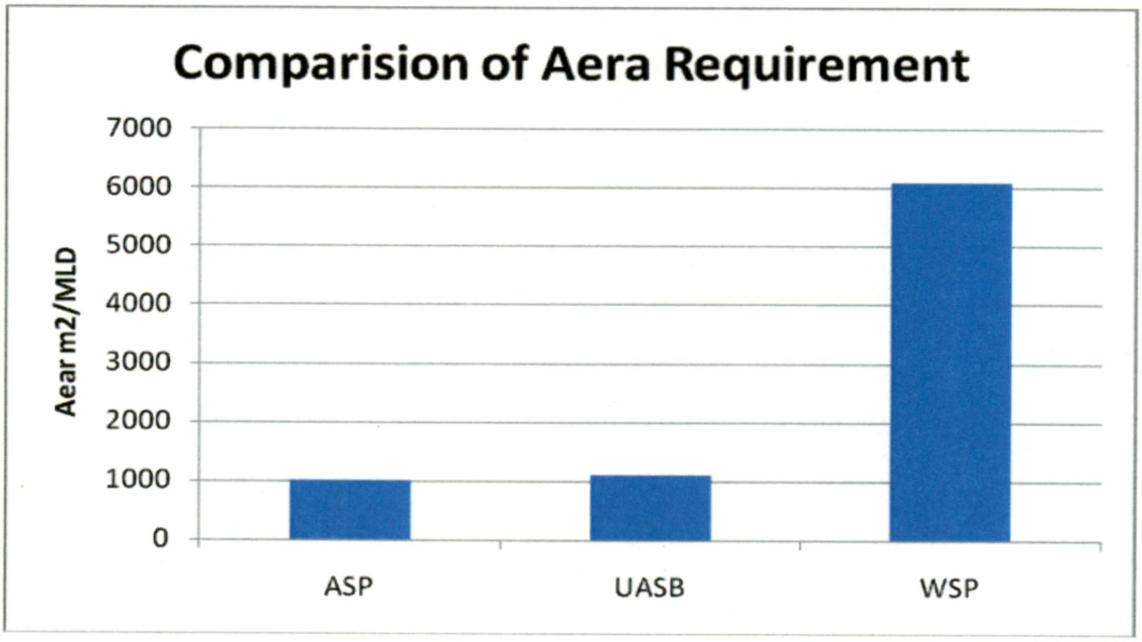


Figure 4.8.2: Comparison of Area Requirement of Sewage Treatment Different Technologies

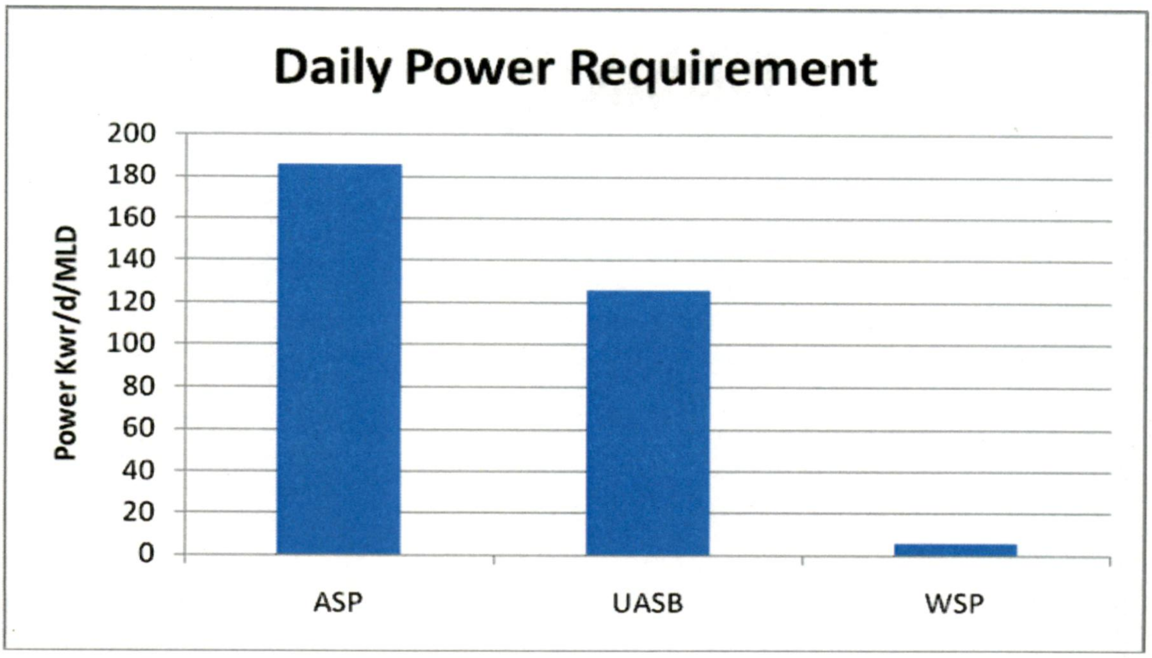


Figure 4.8.3: Comparison of Power Requirement of Sewage Treatment Different Technologies

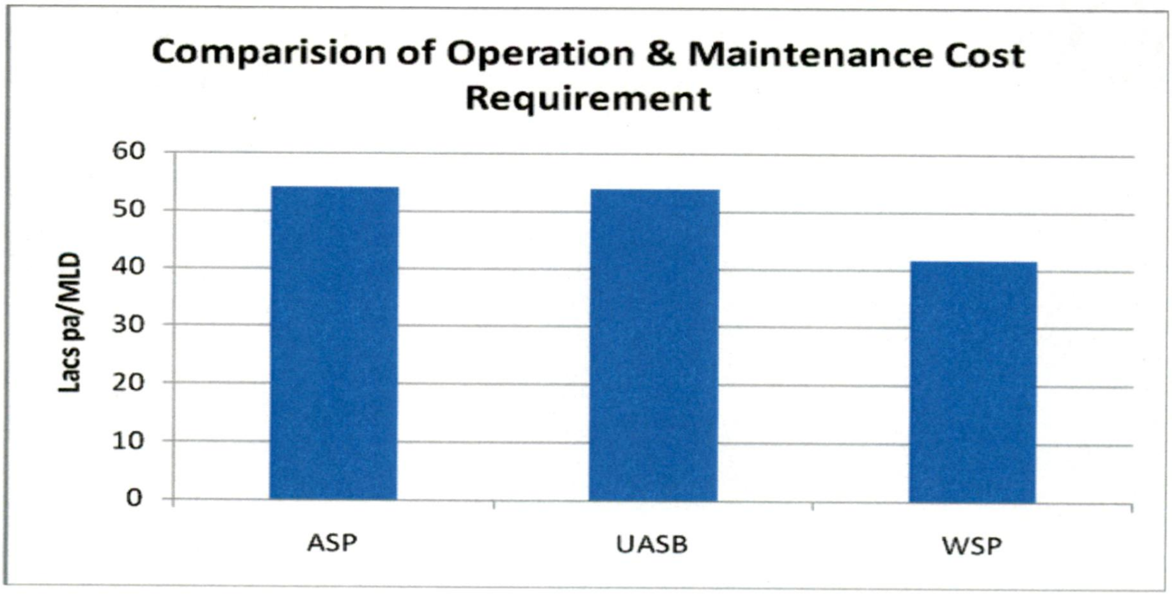


Figure 4.8.4: Comparison of Operation and Maintenance Requirement of Sewage Treatment Different Technologies

4.9 RESOURCE RECOVERY FOR ALL STPS

The actual resource recoveries from each STP like sale of treated effluent, sale of digested sludge cake, revenue from growing vegetables, gross and trees, revenue from fish culture etc. are furnished in Table 4.9.1.The expenditure and resource recovery for 1 MLD plants are also tabulated

TABLE 4.9.1: Comparison of Resource Recovery for All STPs (Values: Rs. In lacs)

Sl.No	Parameters	Haridwar	Ghaziabad	Ghaziabad	Rishikesh
1	R.R. from treated effluent	1.50	nil	nil	nil
2	R.R. from digested sludge cakes	2.00	5.0	5.5	nil
3	R.R. from growing vegetables, gross and trees	nil	nil	nil	nil
4	Aquaculture	nil	nil	nil	nil
6	Total of 2,3,4,5 and 6	03.50	nil	nil	nil
7	Total per 1 MLD	0.90	nil	nil	nil

8	Savings in expenditure due to power generation from methane	nil	nil	nil	nil
9	Savings in expenditure due to power generation from methane per 1 MLD	nil	nil	nil	nil
10	Total Resource Recovery per 1 MLD	0.21	0.09	0.08	nil

4.10 PROJECTED SLUDGE PRODUCTION FOR ALL STPS

The quantity of sludge produced as per theoretical is calculated in Appendix 1.The values are tabulated below in Table 4.10.1.

TABLE 4.10.1: Projected Sludge Production (Rs. in lacs)

Sl.No	Name of the town	Capacity of STP in MLD	Sludge production/ year in m3	Cost of sludge	Cost of sludge/ 1 MLD
1	Haridwar	18	3124	3.31	0.18
2	Ghaziabad	56	8650	9.16	0.16
3	Ghaziabad	73	11278	11.95	0.16
4	Rishikesh	6	900	0.95	0.15

4.11 FULL UTILISATION OF RESOURCE RECOVERY

The Resources are not fully utilised in all the STPs. Most of the biogas is flared-up instead of utilising it for power production. The quantity of power production is reduced due to the existence of higher volume percentage of carbon-di-oxide in the biogas. The quantity of biogas will always be reduced due to short loading of the STP. The bio manure sale is also not satisfactory in many cases due to unawareness of the farmers. To find out the best technological option, it is necessary to calculate the resource recovery from the treatment plants on full utilisation of all resources. If all the resources are fully utilized, the remuneration from resource recovery for all the eight STPs will be vary with actual. The values thus calculated are tabulated in Table: 4.11.1.

Table:4.11.1: Comparison of All STPs of Full Utilisation of Resource recovery (values in Lacs)

Sl.No	Parameters	Haridwar 18 MLD	Ghaziabad 56 MLD	Ghaziabad 73 MLD	Rishikesh 6 MLD
1	R.R. from treated effluent	1.50	nil	nil	nil
2	R.R. from digested sludge cakes	3.31	9.16	11.95	0.95
3	R.R. from growing vegetables, gross and trees	14.00	nil	nil	10.00
4	Aquaculture	nil	nil	nil	0.85
5	Total of 1,2,3 and 4	18.81	9.16	11.95	11.8
6	Total per 1 MLD	1.05	0.16	0.16	1.96
7	Savings in expenditure due to power generation from methane	12.99	161.76	210.82	nil
8	Savings in expenditure due to power generation from methane per 1 MLD	0.72	2.88	2.89	nil
9	Total Resource Recovery per 1 MLD	1.77	3.04	3.05	1.96

4.12 LIFE CYCLE COST ANALYSIS

Life Cycle Cost Analysis is an essential design process for controlling the initial and the future cost of building ownership. LCCA can be implemented at any level of the design process and can also be an effective tool for evaluation of existing building systems. LCCA can be used to evaluate the cost of a full range of projects, from an entire site complex to a specific building system component. Life Cycle Cost (LCC) is defined as "the total discounted cost of owning, operating, maintaining, and disposing of a building or a building system" over a period of time. Life Cycle Cost Analysis (LCCA) is an economic evaluation technique that determines the total cost of owning and operating a facility over period of time.

The sum of initial and future costs associated with the construction and operation of a building over a period of time is called the life cycle cost of a facility, taking into consideration the future maintenance and replacement costs in their selections. In this method, the present worth of a technology assuming an infinite life is computed, i.e., the capitalized cost is the initial cost plus the present value of an infinitely lived technology. The technology with the lowest capitalized cost is the best technology from an economic standpoint.

Life cycle cost for 20 years = Capital Cost including land cost + Present Worth of AM cost for 20 years.(assuming interest rate of 10%)

Present worth of AM cost for 20 years = AM cost*[{1-1/(1+i)^n}/i]

Where, i = interest rate (10% assumed) &

n = Total life or period (20 years assumed).

Life cycle cost has been done based on data arrived from:-

1) Land requirement per MLD of STP has shown in Table 4.8.1
2) Unit cost of annual O&M per MLD of STP has been referred from Table 4.8.1
3) Cost of land is considered as Rs. 1.00 lacs per hectare.
4) Unit cost of construction of STP per MLD has been shown in Table 4.12.1.

The life cycle cost for each technology for various capacities of STP with land cost as Rs.1.00 lacs per ha has been prepared in Table 4.12.2 and plotted in graph (Figure 4.12.2) and the life cycle cost for each technology has been presented in Table 4.12.1 and plotted in graph. The graph showing the LCC for each technology is furnished in Figure 4.13.1.

Table 4.12.1: LCC analysis of Selected technologies plants

Sl.No.	Description	Unit	WSP	UASB	ASP
1	Design Flow	MLD	1.00	1.00	1.00
2	Unit area of STP required	ha	0.61	0.11	0.10
3	Area required for design flow	ha	0.61	0.11	0.10
4	Rate of land	Rs. in Lacs / ha	1.00	1.00	1.00
5	Unit cost of construction of STP	Rs. in Lacs / MLD	63	108	108
7	Cost of land	Rs. in Lacs	0.61	0.11	0.10
8	Cost of construction of STP including land cost	Rs. in Lacs	63.61	108.11	108.10
9	Total cost of annual O&M of STP	Rs. in Lacs	41.49	53.67	53.87

10	Capitalised cost of O&M for 20 years @ 10% int.	Rs. in Lacs	352.66	456.19	457.89
11	**Life cycle cost of STP for 20 years**	**Rs. in Lacs**	**416.27**	**564.3**	**565.99**

Table 4.12.2: Life cycle cost analysis of varying capacity for land cost

CAPACITY in MLD	**WSP**	**UASB+FPP**	**ASP**
	Rs. In crores		
1	4.16	5.64	5.65
10	41.16	56.43	56.59
20	83.24	112.86	113.18
30	123.48	169.29	169.77
40	164.64	225.72	226.36
50	205.8	282.15	282.95
60	246.96	338.58	339.54
70	288.12	395.01	396.13
80	329.28	451.44	452.72
90	370.44	507.87	509.31
100	411.6	564.30	565.90

Table 4.12.3: Life Cycle Cost analysis for Selected Sewage Treatment Technologies

Land cost Rs in Lacs	**WSP**	**UASB**	**ASP**
	Rs. In crores		
0	4.16	5.64	5.65
50	4.46	5.69	5.70
100	4.76	5.75	5.75
150	5.07	5.80	5.80
200	5.37	5.86	5.85

4.13 RESULT & DISCUSSION

From LCC analysis, an attempt has been made to correlate the life cycle cost with capacity and land cost for all STPs, shown in Figure 4.13.1. To Figure 4.13.6 for WSP, UASB , and ASP respectively. Herein it has been observed that LCC cost of WSP has wide range of variation Life cycle cost of any capacity with land cost can be derived from graph of respective STP (see Annexure -II).

Performance evaluation based on formulated work, the final results are presented in Table 4.13 which grades the various STP technologies selected for the object.

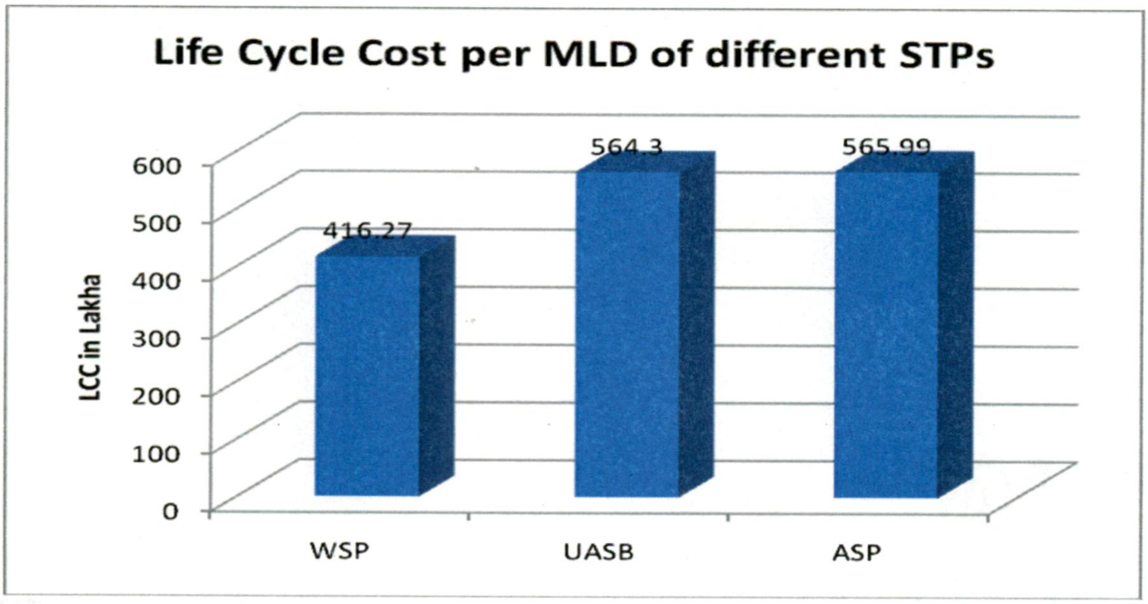


Figure 4.13.1: Life cycle cost per MLD of different STPs

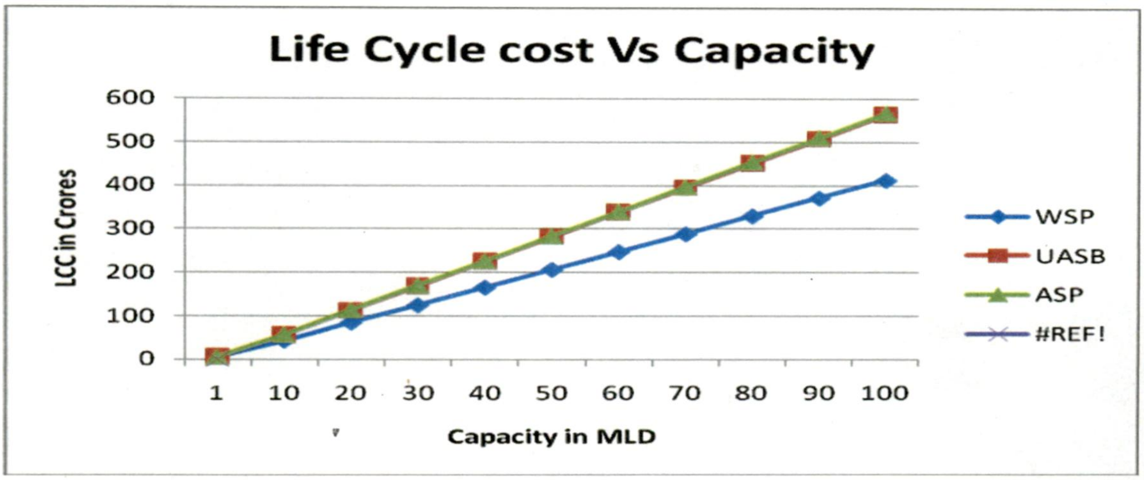


Figure 4.13.2: Life cycle cost Vs capacity, considering land cost Rs.1.00lacs/ha

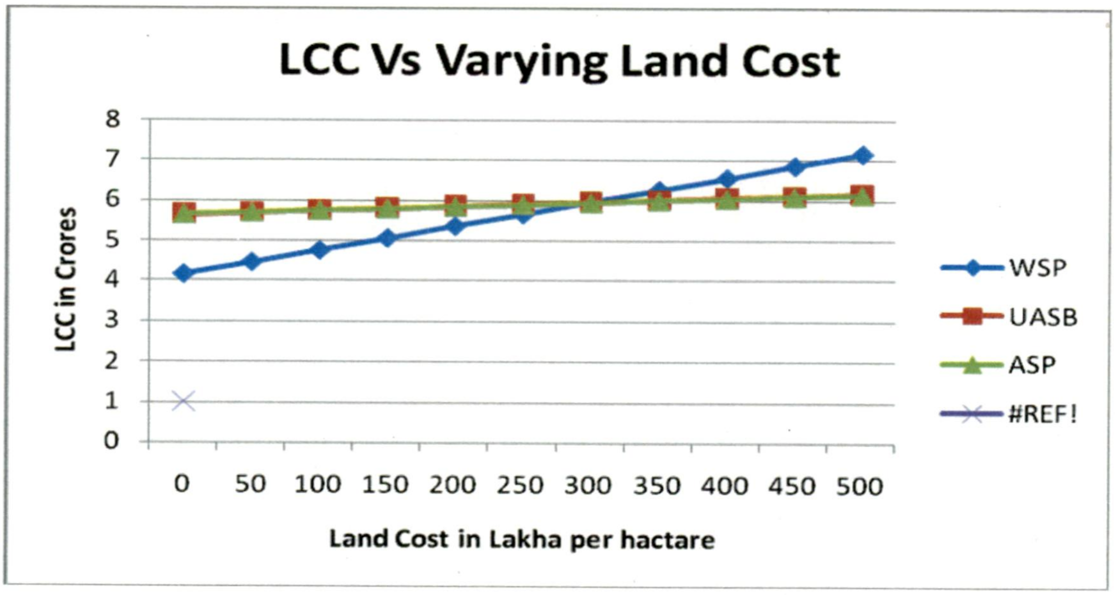


Figure 4.13.3: Life cycle cost Vs land cost for 1.00 MLD plant

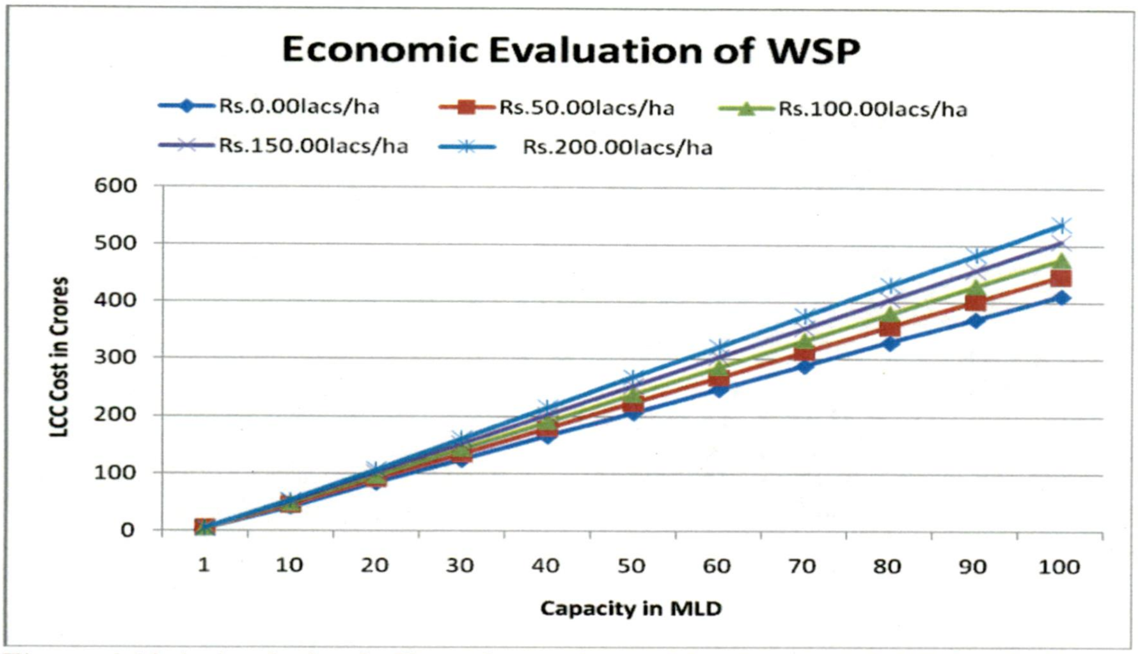


Figure 4.13.4: Analysis of effect of capacity and land cost on LCC for WSP

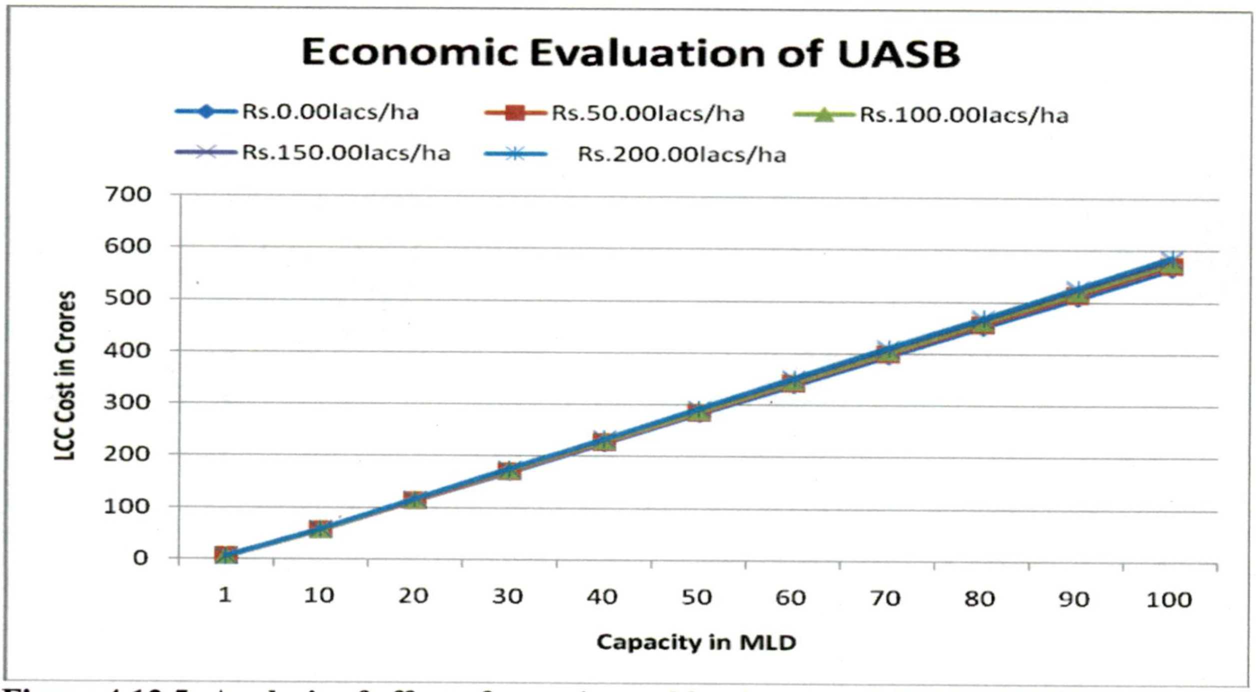


Figure 4.13.5: Analysis of effect of capacity and land cost on LCC for UASB

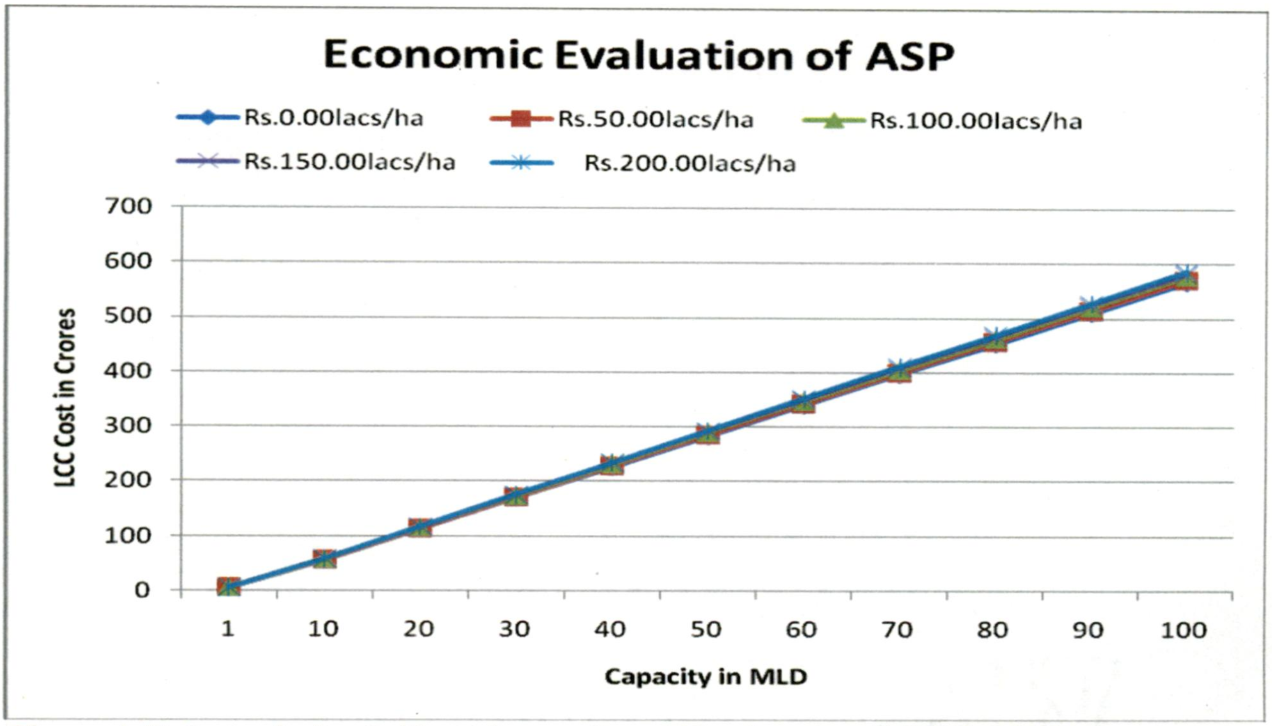


Figure 4.13.6: Analysis of effect of capacity and land cost on LCC for ASP

Table 4.13: Evaluation of Wastewater Treatment Technology

Sl. No.	Evaluation Parameter	WSP	UASB	ASP
		Rank (1 = Best)		
1.	Potential of Meeting the TSS,BOD, and COD Discharge Standards	Low	Medium	High
2	**Impact of Effluent Discharge**			
2.1	Potential of No Adverse Impact on Land	High	Medium	Low
2.2	Potential for No adverse impact on surface water	Low	Medium	High
2.3	Potential for No adverse impact on Ground water	Low	Medium	High
3	Capital cost of Construction	High	Medium	Low
4	Revenue generation potential	Low	High	Medium
5.	Land area requirement	Low	Medium	High
6.	Operation & Maintenance cost	High	Medium	Low
7.	Power use	High	Medium	Low
8.	Life Cycle Cost Analysis (for fixed land cost)	High	Medium	Low
9	**Impact Of STP**			
9.1	Potential for no adverse impacts on the health of STP staff/locals	Medium	Low	High
9.2	Potential for no adverse impact on surrounding buildings/properties.	Medium	Low	High

Low	**MEDIUM**	**HIGH**

In this chapter the details of selected sewage treatment plant for study is explained and the parameter which was selected for performance evalution are also presented, after that the analysis results of water sample of selected sewage treatment plants are presented and the collected data of last four year of sewage treatment plants is also present with the help of this data the we have compared the selected STP in term of Treated water quality parameter. After this the comparison of STPs in term of cost, energy requirement and O & M cost has explained. In this chapter the selected STPs are also compared with help of LCC. based on these on all analysis the final conclusion are drawn.

CHAPTER 5

CONCLUSIONS

From the Performance evaluation of selected sewage treatment plant in term of different parameter following conclusions are drawn.

- From life cycle cost analysis it is conclude that WSP is the most economical and cost effective technology if cost of land is low i.e. approx. in the range upto Rs. 200 Lacs per ha. Power requirement is also low in WSP. WSP is the simple method for waste water treatment it does not required operating skills. But the treated effluent quality is not good in comparison to UASB and ASP because its BOD & COD removal efficiency is lower than ASP & UASB.
- In ASP treated effluent quality is best among UASB & WSP. The average BOD & TSS removal efficiency of ASP are more than 90% which is very high in comparison to UASB & WSP. Where land cost is high, land scarcity areas where huge area is not available, ASP are found to be economical in order, a suitable option in Mega & Metropolitan areas. In ASP through biogas we can generate power which reduce energy requirement of the plant. Revenue generation from dry sludge as manure and treated effluent which is used by former is also available which make plant self sustainable.
- The revenue generation potential from UASB with FPU is the highest among ASP & WSP, its projected energy production capacity of 56 MLD STP is 11.08 MWh/day which very high in comparison to ASP & WSP, the cost of electricity saving per MLD ASP STP is 072 laks/year and the UASB STP is 2.88 lakhs/year which very high in comparison to ASP, in WSP energy generation through biogas is not available. In case of UASB the treated effluent preserving N, K, & P, is suitable for irrigation, use of dry sludge as manure, utilization of bio-gas generated for power saving and encouraging aquaculture in FPU. In UASB daily power requirement is low in comparison to ASP.

From the environmental point of view the best technology for sewage treatment is ASP because the treated effluent by ASP is good in comparison to UASB and WSP.

FURTHER SCOPE OF WORK

Performance evaluation of the sewage treatment plant is very important for calculating there efficiency of sewage treatment and for calculating the potential of revenue generation so that performance evaluation is requiring for all the plants in the India, but we are evaluating the performance of the selected sewage treatment plants only. If all the plants performance evaluation will be done like SBR, MBBR, FAB and MBR then the best method for sewage treatment will be find out.

APPENDIX 1

A.1 GAS PRODUCTION IN HARIDWAR

A.1.1 GAS PRODUCTION

Total suspended solids in the influent =295 mg/l.

Total suspended solids in the effluent = 25 mg/l.

Total suspended solids removed =270 mg/l.

Assuming volatile solids to be equal to 70 % of suspended solids, we have

Volatile solids removed = 70 % X 270 mg/l. = 189 mg/l.

Now assuming that the volatile solids (matter) are reduced by 65% in the sludge by digestion, we have Volatile solids reduced = 65% X 189 = 122.85 mg/l.

Volatile matter reduced per million litre of sewage = 122.85 $X10^6/10^6$ = 122.85 kg

Now assuming that 0.9 m3 of gas is produced per kg of volatile matter reduced, we have, the gas produced per million litre of sewage = 0.9X122.85=110.56 m^3(Say)=111 m^3

For Haridwar STP (18 MLD) = 18 X 111 = 1998 m^3

Actual Biogas production = 430 m^3

A.1.2 CALORIFIC VALUE OF BIOGAS

CH_4=65vol%; CO_2=32vol%

Calorific value of pure CH_4 =50,000kJ/kg

Calorific value of biogas(0.65 X16 X 50,000)/(0.65 X 16 +0.32X44)

=21241.8kJ/kg = 21.24 MJ/kg

Avg. mole wt. = 0.65 X 16 + 0.35 X 44 = 25.8 kg/k.mole

Volume per unit weight = 22.414/mol wt. (m3/kg) = 22.414/ 25.8

= 0.8688 m3/kg

C.V. of biogas = 21241.8 kJ/kg

= 21241.8/0.8688 [(kJ/kg)/ (m3/kg)]

= 24450 kJ/ m^3

Projected Electricity = 24450/3600 [1J=1watt sec]

= 6.792 kWh/ m^3

Efficiency of Gas engine, η = 30%,

Actual Electricity = 6.792 X 0.30 = 2.04 kWh/ m^3

A.1.3 PROJECTED ENERGY PRODUCTION FROM BIOGAS

Biogas production from STP = 435 m^3

Energy production per day =435 X2.04 = 887.4 kWh/day

=0.89 MWh/day

Cost of Electricity r savings (0.89 MWh/day X365 days X 4.00 X1000)

= Rs.12.99 lakhs/year

Cost of Electricity savings per 1MLD = Rs. 12.99 lakhs / 18 MLD

= 0.72 lakhs/year

A.2 GAS PRODUCTION IN 56 MLD GHAZIABAD

A.2.1 GAS PRODUCTION

Total suspended solids in the influent =299 mg/l.

Total suspended solids in the effluent = 61 mg/l.

Total suspended solids removed =238 mg/l.

Assuming volatile solids to be equal to 70 % of suspended solids, we have

Volatile solids removed = 70 % X 238 mg/l. = 166.6 mg/l.

Now assuming that the volatile solids (matter) are reduced by 65% in the sludge by digestion, we have Volatile solids reduced = 65% X 166.6 = 108.29 mg/l.

Volatile matter reduced per million litre of sewage = 108.29 X10^6/10^6 = 108.29 kg

Now assuming that 0.9 m3 of gas is produced per kg of volatile matter reduced, we have, the gas produced per million litre of sewage = 0.9X108.29=97.4 m^3(Say)=97 m^3

For Ghaziabad STP (56 MLD) = 56 X 97 = 5432 m^3

A.2.2 CALORIFIC VALUE OF BIOGAS

CH4=65vol%; CO2=32vol%

Calorific value of pure CH4 =50,000kJ/kg

Calorific value of biogas(0.65 X16 X 50,000)/(0.65 X 16 +0.32X44)

=21241.8kJ/kg = 21.24 MJ/kg

Avg. mole wt. = 0.65 X 16 + 0.35 X 44 = 25.8 kg/k.mole

Volume per unit weight = 22.414/mol wt. (m3/kg) = 22.414/ 25.8

= 0.8688 m3/kg

C.V. of biogas = 21241.8 kJ/kg

= 21241.8/0.8688 [(kJ/kg)/ (m3/kg)]

= 24450 kJ/ m^3

Projected Electricity = 24450/3600 [1J=1watt sec]

= 6.792 kWh/ m^3

Efficiency of Gas engine, η = 30%,

Actual Electricity = 6.792 X 0.30 = 2.04 kWh/ m^3

A.2.3 PROJECTED ENERGY PRODUCTION FROM BIOGAS

Biogas production from STP = 5432 m^3

Energy production per day =5432 X2.04 = 11.08 MWh/day

Cost of Electricity r savings (11.08 MWh/day X365 days X 4.00 X1000)

= Rs.161.76 lakhs/year

Cost of Electricity savings per 1MLD = Rs. 161.76 lakhs / 56 MLD

= 2.88 lakhs/year

A.3 GAS PRODUCTION IN 73 MLD GHAZIABAD

A.3.1 GAS PRODUCTION

Total suspended solids in the influent =301 mg/l.

Total suspended solids in the effluent = 63 mg/l.

Total suspended solids removed =238 mg/l.

Assuming volatile solids to be equal to 70 % of suspended solids, we have

Volatile solids removed = 70 % X 238 mg/l. = 166.6 mg/l.

Now assuming that the volatile solids (matter) are reduced by 65% in the sludge by digestion, we have Volatile solids reduced = 65% X 166.6 = 108.29 mg/l.

Volatile matter reduced per million litre of sewage = 108.29 $X10^6/10^6$ = 108.29 kg

Now assuming that 0.9 m3 of gas is produced per kg of volatile matter reduced, we have, the gas produced per million litre of sewage = 0.9X108.29=97.4 m^3(Say)=97 m^3

For Ghaziabad STP (73 MLD) = 73 X 97 = 7081 m^3

A.3.2 CALORIFIC VALUE OF BIOGAS

CH_4=65vol%; CO_2=32vol%

Calorific value of pure CH_4 =50,000kJ/kg

Calorific value of biogas(0.65 X16 X 50,000)/(0.65 X 16 +0.32X44)

=21241.8kJ/kg = 21.24 MJ/kg

Avg. mole wt. = 0.65 X 16 + 0.35 X 44 = 25.8 kg/k.mole

Volume per unit weight = 22.414/mol wt. (m3/kg) = 22.414/ 25.8

= 0.8688 m3/kg

C.V. of biogas = 21241.8 kJ/kg

= 21241.8/0.8688 [(kJ/kg)/ (m3/kg)]

= 24450 kJ/ m^3

Projected Electricity = 24450/3600 [1J=1watt sec]

= 6.792 kWh/ m^3

Efficiency of Gas engine, η = 30%,

Actual Electricity = 6.792 X 0.30 = 2.04 kWh/ m^3

A.3.3 PROJECTED ENERGY PRODUCTION FROM BIOGAS

Biogas production from STP = 7081 m^3

Energy production per day =7081 X2.04 = 14.44 MWh/day

Cost of Electricity r savings (14.44 MWh/day X365 days X 4.00 X1000)

= Rs.210.82 lakhs/year

Cost of Electricity savings per 1MLD = Rs. 210.82 lakhs / 73 MLD

= 2.89 lakhs/year

A.6 SLUDGE PRODUCTION

A.6.2 HARIDWAR

Mass of sludge in ASP based STP = 221.88 kg/MLD

Sludge concentration	=65 to 75 kg/ m^3 (say) 70 kg/m3
Volume of sludge	= 221.88 /70 kg/ m^3 = 3.17 m3/MLD
Sludge production per day	= 18 MLD X 3.17m3/MLD =57.06 m^3
Quantity of dry sludge=15% of wet sludge	=57.06 X 0.15 = 8.56 m^3
Sludge production per year	= 8.56 m^3 X 365 days = 3124 m^3
Cost of sludge @ Rs. 106.00 per m^3	= Rs. 3.31 lakhs.

A.6.5 GHAZIABAD 56 MLD

Mass of sludge in UASB based STP	= 197.5 kg/MLD
Sludge concentration	=65 to 75 kg/ m^3 (say) 70 kg/ m^3
Volume of sludge	= 197.5 /70 kg/ m^3= 2.82 m3/MLD
Sludge production per day	= 56 MLD X 2.82 m^3/MLD =157.92 m^3
Quantity of dry sludge	=15% of wet sludge=157.92X0.15=23.7m3
Sludge production per year	= 23.7 m^3 X 365 days = 8650 m^3
Cost of sludge @ Rs. 106.00 per m^3	= Rs. 9.16 lakhs.

A.6.6 GHAZIABAD 73 MLD

Mass of sludge in UASB based STP	= 197.5 kg/MLD
Sludge concentration	=65 to 75 kg/ m^3 (say) 70 kg/ m^3
Volume of sludge	= 197.5 /70 kg/ m^3= 2.82 m3/MLD
Sludge production per day	= 73 MLD X 2.82m3/MLD =205.86 m^3
Quantity of dry sludge	=15% of wet sludge=205.86X0.15= 30.9 m3
Sludge production per year	= 30.9 m^3X 365 days = 11278 m^3
Cost of sludge @ Rs. 106.00 per m^3	= Rs. 11.95 lakhs.

A.6.7 RISHIKESH

Sludge production per day = 0.08 m^3/person/year (Population of the town = 75000)

Wet sludge production per year	= 0.08X 75000 = 6000 m^3
Quantity of dry sludge=15% of wet sludge	=6000 X 0.15 = 900 m3
Cost of sludge @ Rs. 106.00 per m^3	= Rs. 0.95 lakhs.

APPENDIX 2

A.2: LIFE CYCLE COST OF VARIOUS STPs WITH VARIABLE LAND COST AND CAPACITY

A.2.1: LCC of WSP (Land Cost in lacs. Per ha)

Capacity in MLD	Rs.0.00	Rs.50.00	Rs.100.00	Rs.150.00	Rs.200.00
1.00	4.16	4.46	4.76	5.07	5.37
10.00	41.16	44.61	47.66	50.71	53.76
20.00	83.24	89.22	95.32	101.42	107.52
30.00	123.48	133.83	142.98	152.13	161.28
40.00	164.64	178.44	190.64	202.84	215.04
50.00	205.8	223.05	238.30	253.55	268.80
60.00	246.96	267.66	285.96	304.26	322.56
70.00	288.12	312.27	333.62	354.97	376.32
80.00	329.28	356.88	381.28	405.68	430.08
90.00	370.44	401.49	428.94	456.39	483.84
100.00	411.6	446.1	476.60	507.10	537.60

A.2.2: LCC of UASB with FPP, (Land Cost in lacs. per ha)

Capacity in MLD	Rs.0.00	Rs.50.00	Rs.100.00	Rs.150.00	Rs.200.00
1.00	5.64	5.69	5.75	5.80	5.86
10.00	56.43	56.96	57.51	58.06	58.61
20.00	112.86	113.92	115.02	116.12	117.22
30.00	169.29	170.88	172.53	174.18	175.83
40.00	225.72	227.84	230.04	232.24	234.44
50.00	282.15	284.80	287.55	290.30	293.05
60.00	338.58	341.76	345.06	348.36	351.66
70.00	395.01	398.72	402.57	406.42	410.27

80.00	451.44	455.68	460.08	464.48	468.88
90.00	507.87	512.64	517.59	522.54	527.49
100.00	564.30	569.60	575.10	580.60	586.10

A.7.3: LCC of ASP, (Land Cost in lacs. per ha)

Capacity in MLD	Rs.0.00	Rs.50.00	Rs.100.00	Rs.150.00	Rs.200.00
1.00	5.65	5.70	5.75	5.80	5.85
10.00	56.59	57.08	57.58	58.08	58.58
20.00	113.18	114.16	115.16	116.16	117.16
30.00	169.77	171.24	172.74	174.24	175.74
40.00	226.36	228.32	230.32	232.32	234.32
50.00	282.95	285.40	287.90	290.40	292.90
60.00	339.54	342.48	345.48	348.48	351.48
70.00	396.13	399.56	403.06	406.56	410.06
80.00	452.72	456.64	460.64	464.64	468.64
90.00	509.31	513.72	518.22	522.72	527.22
100.00	565.90	570.80	575.80	580.80	585.80

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