A Case study on Delawas Sewage Treatment Plant: Analysis of Performance and Feasibility Treatment Method

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ABSTRACT:

Sewage treatment plant (STP), an important component in the sewage management systems, which requires proper planning and selection of appropriate performing and cost efficient treatment technology for successful implementation. In this connection, urban planners need quick information as ready reckoner on the unit cost of STP for various capacities and technologies including land area requirement. Many technologies for STP have emerged in recent years. However, In India the Sequencing batch reactor (SBR), Waste Stabilization Ponds (WSP), Activated Sludge Process (ASP) and Extended Aeration Activated Sludge Process (EASP) are the widely adopted technologies (WAT's) in India. Performance analysis is necessary for the selection of the appropriate efficient technology from the WATs, which involve the waste parameters removal and the costs in terms of capital, operation & maintenance and land and performance of the plant. Performance analysis is useful tools in predicting the efficiency and working of plant along with the knowledge of any further requirements in plants. The performance of STPs predicted from the methods and procedure involved in the procedural activities.

Performance assessments have not been reported for the widely adopted technologies widely in India. Considering the level of investment required for the construction of STPs and the method adopted for the treatment, there is a need for research for the development of performance assessment and cost models based ready reckoner of STP performance, performance and economic analysis for the benefit of engineers and urban planners, in order to arrive at reasonable estimates and technology of STPs for appropriate technology adoption, formulation of working procedures and future requirements.

INTRODUCTION

India with a population of 1.21 billion as per 2011 census is the second most populated country among the 238 countries on the earth next to China and accounting for about 17.5% of the world population with 3.287 million km^2 land area, which is only 2.5% share of the total land area and only 5 % share of the water resources. The urban population in India was 31.2% in 2011 and it is expected to increase to 38.8 % by 2026. So, there will be sharp rise in forth years in the urban demand facilities of infrastructure. Urban planners will face challenge due to these infrastructural facility demands.

The degradation of quality of water, spread of diseases that are water borne and aesthetic properties of the water are a result of contamination of fecal coliform, suspended solids and BOD in sewage. The appropriate sewage collection and treatment is the good way to keep water resources and land safe from these contaminations. Further, agro industries such as dairies, canneries etc., situated in urban areas, are facing difficulties in treating and disposing their wastes.

The STP technology comprises a sequence of unit processes and operations arranged in numerous alternatives. the standards limit are decided by the BIS are as under-mentioned:

Characteristics	Units	Tolerance limits
pH	none	5.5 – 9.0
SS	mg.L^{-1}	30
BOD	mg.L^{-1}	20
Fecal coliforms	MPN/100 mL	1000

Source: IS 4764: 1973

Standard discharge values of domestic sewage into surface waters (IS:4764-1973)

NEED FOR THE STUDY

The basic intention behind this study is:

- To study important physical, chemical and biological parameters to check the removal efficiency of STP.
- To assess the activity and data for checking any requirement of expansion in units.
- To check the cost efficiency of plant.

METHDOLOGY & PROCESS DETAILING

The chapter includes the elaboration of processes used for sewage treatment and the methodology adopted for the performance analysis of plant under study. The tenure of two months has been adopted for detailed study of the plant and its specification. Collection of sample from the plant and laboratory testing of these samples were done to analyze the various parameters. The data of power consumption and power generation were also analyzed to achieve actual capital of plant.

IMPORTANT PARAMETERS OF SEWAGE QUALITY:

There are several sewage quality parameters that are needed to be checked while dealing with the sewage treatment. These parameters are as follows:

(1) pH:

This is referred to the measurement of the ions of the hydrogen in the sample. The assessment of this acts a vital role on treatment of sewage. This parameter generally depends on the category of the sewage at inlet, it varies for domestic, industry and agricultural processing units. And when it considered in general terms the raw sewage turn to be acidic in nature vary times. The pH found to be changing at slots of times, it varies from inlet to mixing with other sewage, the raw measure has collected at site is found to be acidic.

(2) BOD (Bio-chemical/Biological Oxygen Demand):

It is a dissolved oxygen demand parameter that is consumed by the aerobic microorganism while processing the waste decomposition that are organic in nature in water treatment.

The molecules in sewer receiving which are organic are composed of carbon these substance combines household waste and fecal. Organic molecules are termed in these categories. Decomposition of these in smaller molecules in the sewage are done by the aerobic bacteria and for this process done by such bacteria postulate oxygen. And this required amount of O_2 is BOD. The amount of oxygen needed in 5_day BOD is termed as BOD_5. And BOD_5 is considered to be most relevant used figure for assessment of BOD adopted in Indian standards.

(3) COD:

This is more plausible method of emplacing the organic substances in sample of waste water over the BOD method. This consumes very less time for accomplishment and this specialty makes it more advantageous when compared to BOD. But this shouldn't be served as alternative to BOD and should be performed in individual manner. It can be counted as a parameter of operation adjustment. In the situations when the sample is toxic in great extent, the BOD test can't be performed and in such situation the COD can be implemented. The oxidization of inorganic and predominate organic matters in sample the chemical $K_2Cr_2O_7$ (potassium dichromate) is used with fifty percent H_2SO_4 (sulfuric acid). And this composition of chemical motivates the rich concentration of COD, and it found to be more than that in BOD. The color changing prefabricated vials are used for this testing, as per the amount of oxidation it changes color from green to orange. These vials are prefabricated as per requirement as low and high range that is 3-150 ppm and 20-1500 ppm respectively.

(4) Oil & Grease:

Since these are of unique physical properties, related constituents and high energy concentration, it terms with exclusive concern. Initially the O&G were denotes as fat, oil and grease (FOG), besides both have similar constituents in waste water. The origin of this in waste water is generally sourced from cattle and botanic, along with this the industry waste like lubricants and oils are also included. When it physically seen it is hydro-phobic and due to this property it is non-soluble in water. And this makes it non-biodegradable by microorganisms. The high temperatures makes them to be soluble in water and emulsion is constituted that can be seen apart at lower temperatures in waste water. And this thing causes choking problems in sewer systems. The glass sampling vessels should be used during sampling since it adheres to plastic.

(5) TSS

The particles in waste water, having size more than two micron are considered to be the suspended solids. The substances below this range are considered soluble. Inorganic matters, algae and bacteria are prime contributor to this. Sediments, plankton that floats are counted in this. The decomposition of organic matters like algae, botanical elements also contributes is it, since they defrags in smaller particles after decomposition. The TSS helps in assessing the clearity of water. There are colloidal (non-settleable) and settleable solids, one which floats and other settles down over a period of time. This is greatly depended on the type and quality of sewer received at inlet of plant.

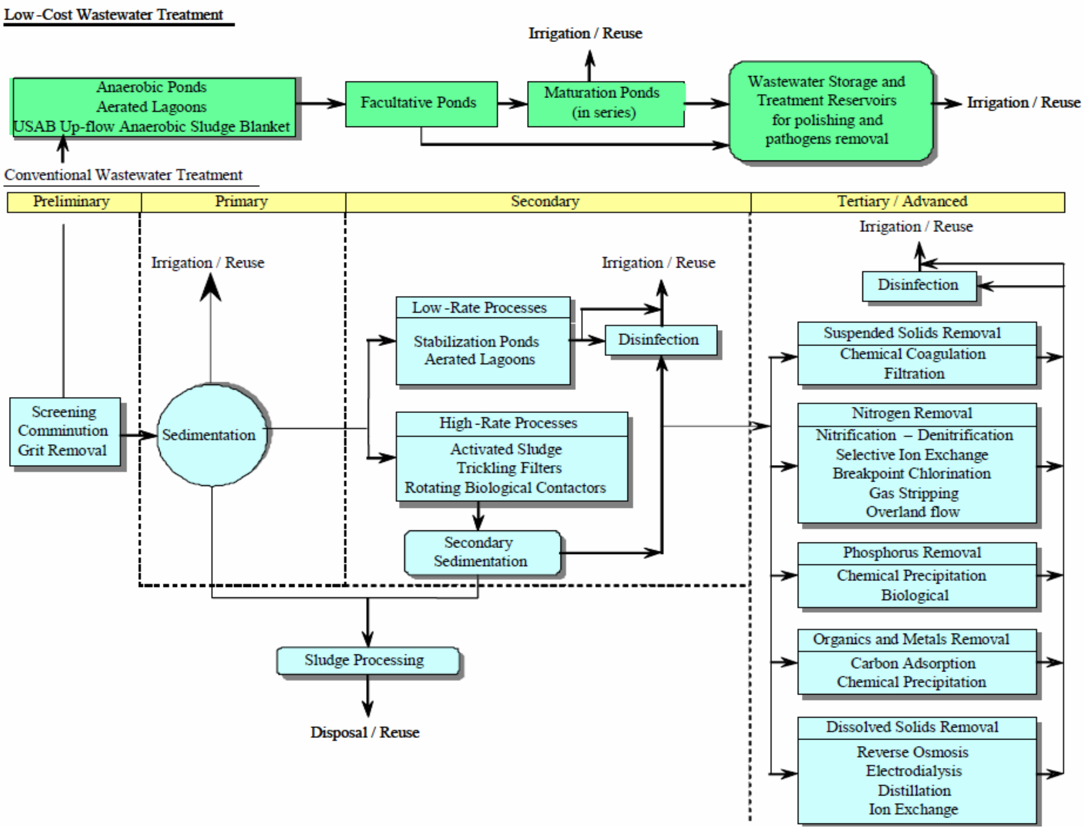
(6) Lead

The industry related to tanneries, metals, power plants and waste from the mining units are the main sources of this heavy metal ion presence in the sewage. It is a soft, malleable and heavy metal. This is a industrial pollutant and it pollutes eco-system in all ways, so it seeks concern due to its higher toxicity. This can cause diseases in humans including damages to brain, throat and kidney. Ion-exchange, precipitation, electro coagulation and cementation are the common method for removal of this pollutant from waste water. The prescribed range in drinking water for this is 0.05 mg/L.

(7) Color & Odor:

Color and odor are imparted in waste water by the industrial waste containment, organic matter, dissolved hydrogen sulphide, dissolved salts and ions. Activated carbon method and aeration are common method for its treatment.

Generalized Treatment flow chart of Plant:



DELAWAS TREATMENT PLANT OVERVIEW

The data collected for the assessment of performance of the Delawasplant is done with the physical visit to plant and by taking help of standard sources.

Following are the general details of Delawas plant:

S.No.	Characteristics	Value
1	Number of unit	2
2	Installed capacity	125
3	Primary settling Tank Volume (cum)	2604
4	Primary sludge rate (cum/day)	1100
5	Aeration tank Voulme (cum)	31320
6	Aeration capacity (cum/hour)	7080
7	Aeration tank retention time (hrs)	6
8	Secondary settling tank volume (cum)	8792
9	SST Retention time (hrs)	2.15
10	Waste Sludge Rate (cum/day)	1300
11	Sludge Digester Volume (cum)	12400
12	Power Requirment (kwh/day)	16000
13	Biogas Production (cum/day)	12000
14	Power Generated (kwh/day)	9600

Source: CPCB 2015

The General specification of the plant is as shown in following table:

General Specifications	
Commisned By	RUDIP
Capacity	62.5+62.5= 125 MLD
Location	Between 26°52' N latitude and 75°47' E longitude
Area	94 Bigah
Locality	Delawas, Pratapnagar, Jaipur
Construction Agency	M/s VatechWabag Pvt. Ltd. Chennai
RUDIP Consultatnt	M/s Shah technical consultancy Services Mumbai
Power Generation	Through Sludge Digestion
I-Unit Funded By	ADB

Disposal standards recommended by the CPCB have been objectively followed by the Delawas plant for the necessary treatment of the sewage such as contamination removal and safe sludge production. The such produced safe sludge and treated effluent can be safely disposed in surrounding. As per the previous practises the farmers were using the direct sewage in agricultural used by Amanishah Nala, since untreated waste was disposed earlier in this. Delawas plant inlets 1800 mm dia sewer line for treatment, before this plant the percolation deteriorated the ground water table. The STP is in operation since beginning on its full design capacity. Only gradient gravity has been utilized in sewerage flow no pumping have adopted, from the distant reach of 25 to proximate point of 1 kilometre. The figure below attached shows the coverage area of sewerage system in city and general layout plan of Delawas plant.

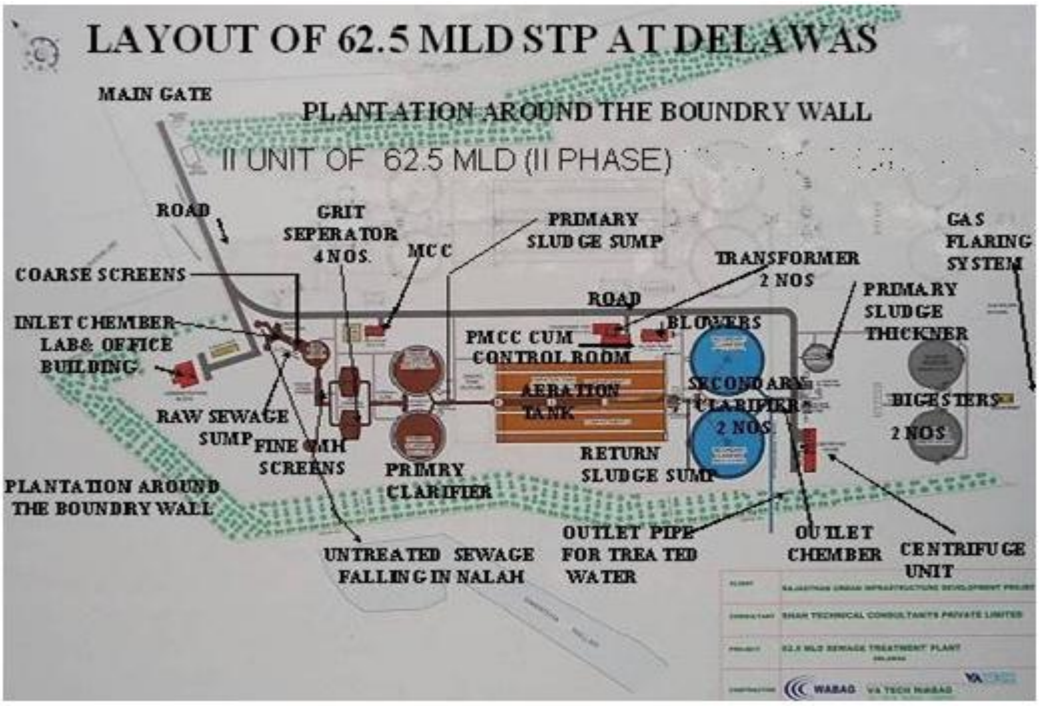


Figure: STP plant General Layout

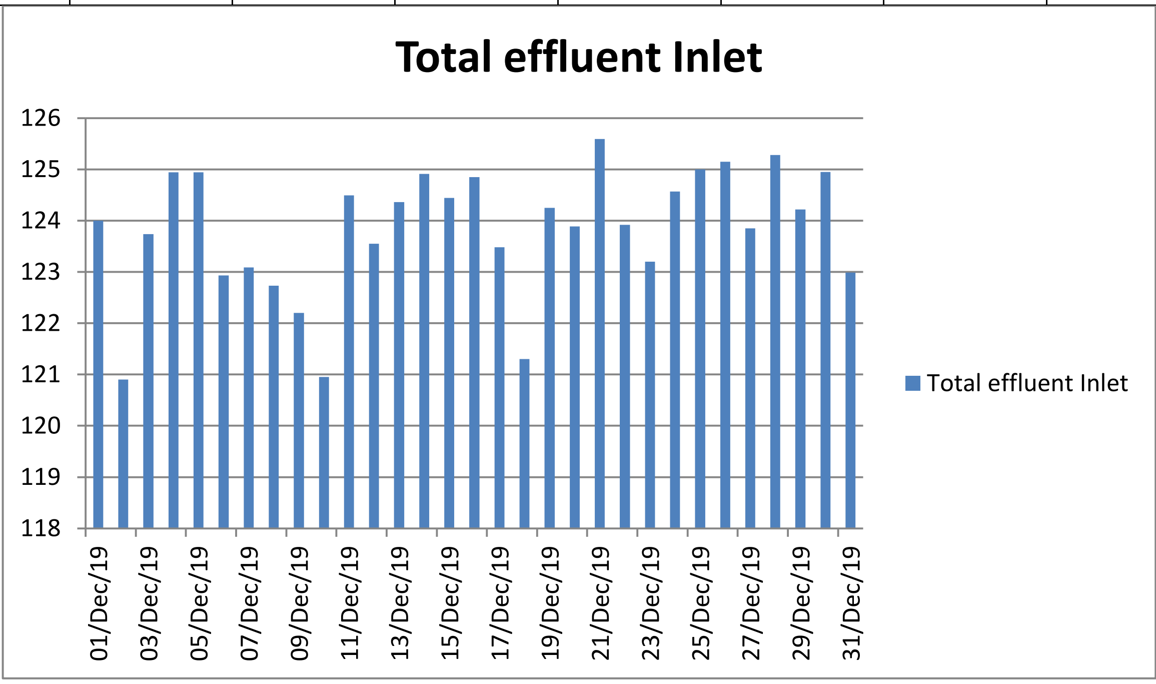
RESULT & DISCUSSION

Followings are the standard values of parameter that has been specified by EPA rule 1986 for the effluents in the sewer:

Sr.No.	Characterstics	Public Sewers (Values in mg/lit unless stated)
1	Colour	All effort needs to be made to remove colour
2	Odour	All effort needs to be made to remove odour
3	pH	Between 5.5 to 9.0
4	Temperature	Should not exceed 5°C above receiving water temperature.
5	Biochemical Oxygen Demand (BOD)	350
6	Chemical Oxygen Demand (COD)	250
7	Total Suspended Solids (TSS)	600
8	Lead	1
9	Oil & Grease	20

(1) Total Effluent Inflow:

Total Effluent Inlet							
Date	1-12-19	2-12-19	3-12-19	4-12-19	5-12-19	6-12-19	7-12-19
Inflow	124	120.9	123.74	124.94	124.94	122.93	123.09
Date	8-12-19	9-12-19	10-12-19	11-12-19	12-12-19	13-12-19	14-12-19
Inflow	122.73	122.2	120.95	124.49	123.55	124.36	124.91
Date	15-12-19	16-12-19	17-12-19	18-12-19	19-12-19	20-12-19	21-12-19
Inflow	124.44	124.85	123.48	121.3	124.25	123.89	125.59
Date	22-12-19	23-12-19	24-12-19	25-12-19	26-12-19	27-12-19	28-12-19
Inflow	123.92	123.2	124.57	125	125.15	123.85	125.28
Date	29-12-19	30-12-19	31-12-19				
Inflow	124.22	124.95	122.99				

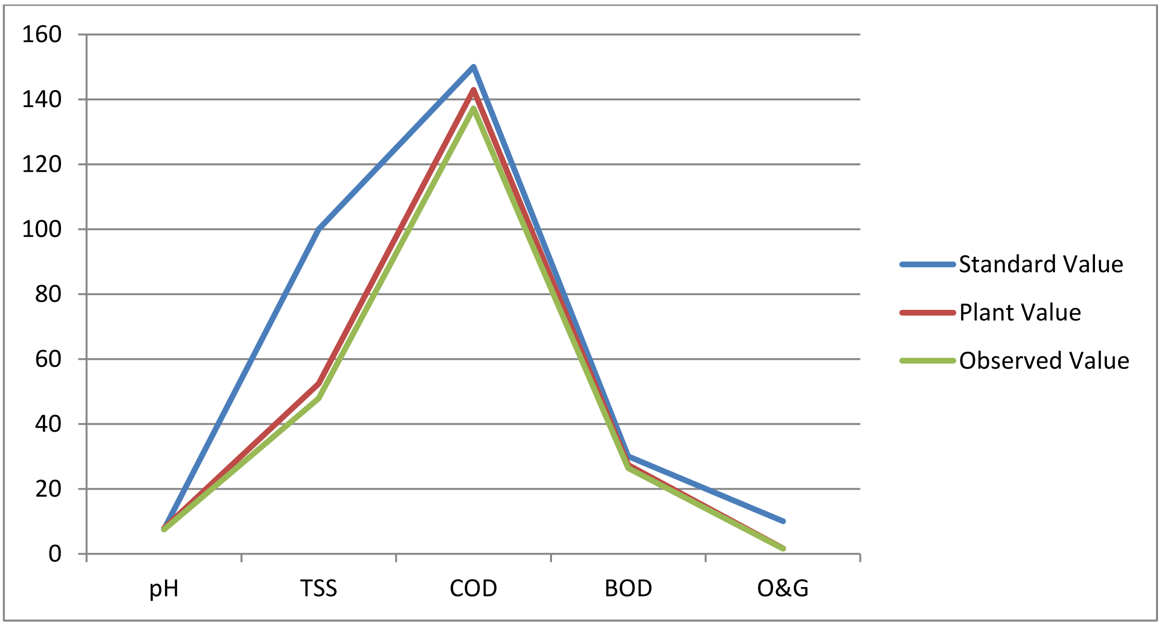


Total effluent Inlet

The efficiency of removal for plant and observed values of effluent quality parameters at treated end is as follows:

PARAMETER	AT	TOTAL VALUE	AVERAGE VALUE	EFFICIENCY OF REMOVAL
pH at Plant	INLET	242.6	8.08	3.09
	OUTLET	234.98	7.83	
pH Observed	INLET	155.42	7.78	4.11
	OUTLET	149.27	7.46	

TSS at Plant	INLET	21350	711.67	92.67
	OUTLET	1567	52.23	
TSS Observed	INLET	12710	635.5	92.48
	OUTLET	956	47.8	
COD at Plant	INLET	31354	1045.14	86.33
	OUTLET	4286	142.87	
COD Observed	INLET	19712	985.6	86.07
	OUTLET	2744	137.2	
BOD at Plant	INLET	9537	317.9	91.34
	OUTLET	820	27.34	
BOD Observed	INLET	6215	310.8	91.51
	OUTLET	528	26.4	
O&G at Plant	INLET	701	23.37	92.85
	OUTLET	49.97	1.67	
O&G Observed	INLET	450	22.5	93.07
	OUTLET	31.2	1.56	



Comparison of observed and plant effluent values with standard values

POWER REQUIRMENTS AND POWER GENERATION:

Delawas plant power needs are being fulfilled by bio gas power plant and JVVNL power grid. The source data state that 8987.14 Kilo watt hour consumption of per day is for first unit of plant, except than this 300 kilo watt hour consumption of power is required for the lighting and other operations. So coming to the average per month consumption it is about 208653 kilo watt hour. Previously the whole power demand is based on the grid supply of JVVNL, but now the bio gas plant installed in the treatment plant efficiently generates power and provides with almost 70 to 75 percent power required by the plant. Remaining 25 to 30 percent power is acquired from JVVNL power grid. This also solves the problem of unexpected power cuts from grid and allows continuous processing in plant.

Sl. No.	DATE	Toatl Engine Running Hours	Gas Consumption	Total Unit generation kWh
1	01-Dec-19	16:14:00	3031	3545
2	02-Dec-19	15:51:00	3313	3448
3	03-Dec-19	16:15:00	3257	3697
4	04-Dec-19	10:45:00	3002	3383
5	05-Dec-19	14:53:00	3080	3402
6	06-Dec-19	13:42:00	2892	3337
7	07-Dec-19	11:11:00	3394	3500
8	08-Dec-19	12:28:00	3063	3545
9	09-Dec-19	12:03:00	3418	3545
10	10-Dec-19	14:04:00	3275	3448
11	11-Dec-19	13:10:00	3352	3697
12	12-Dec-19	13:42:00	2838	3383
13	13-Dec-19	11:11:00	3449	3402
14	14-Dec-19	12:28:00	3166	3337
15	15-Dec-19	12:03:00	3054	3500
16	16-Dec-19	14:04:00	2379	3545
17	17-Dec-19	13:10:00	2297	3399
18	18-Dec-19	11:34:00	2443	3567
19	19-Dec-19	13:15:00	2433	3577
20	20-Dec-19	16:14:00	2452	3507
21	21-Dec-19	15:51:00	2280	3261
22	22-Dec-19	16:15:00	2484	3552
23	23-Dec-19	10:45:00	2432	3623
24	24-Dec-19	14:53:00	2419	3556
25	25-Dec-19	13:42:00	2315	3473
26	26-Dec-19	11:11:00	2357	3371
27	27-Dec-19	12:28:00	2384	3552
28	28-Dec-19	12:03:00	2432	3623

29	29-Dec-19	14:04:00	2540	3556
30	30-Dec-19	13:10:00	2429	3473
31	31-Dec-19	14:12:00	2357	3371
Total		416:51:00	86017	108175

Generation of power at plant

CONCLUSIONS

From the above performance study of Delawas plant following conclusion can be stated:

- The five main parameters analyzed for plant are found to be removed properly in plant processing thus the efficiency of removal of the plant is satisfactory.
- The process water can be reused in industrial uses.
- With further treatment the treated water can be utilized in ground water recharge and agricultural uses.
- Only 25 to 30 percent of power is taken from power grids rest 70 to 75 percent power is generated at plant.
- About 70 to 75 percent power is generated at plant itself, so power requirements can be matched by self sufficiency.
- This will reduce the operation and maintenance cost of plant at great extent.

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