PERFORMANCE EVALUATION OF COMMON EFFLUENT TREATMENT

PLANTS AT MANGOLPURI INDUSTRIAL AREA

A Thesis Submitted in Partial Fulfillment for the Award of Degree of

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Submitted By

Saket Bihari

University roll no. 12395

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Department of Civil & Environmental Engineering
Delhi College of Engineering, Delhi-110042

CERTIFICATE

This is to certify that the project entitled ***"Performance evaluation of Common Effluent Treatment Plants at Mangolpuri Industrial Area, Delhi"***, which is being submitted by Saket Bihari, under the guidance and supervision of Dr. Anubha Mandal and Sh. T. Vijaya Kumar in partial fulfillment of requirement for the award of the Degree **of Master of Engineering in Civil (Environmental Engineering), Delhi College of Engineering, University of Delhi, Delhi.**

Dr. Anubha Mandal

Scientist, B
(Civil & Environmental Engg. Department,
Delhi College of Engineering**)**

Sh. T. Vijaya Kumar

Lecturer
(Civil & Environmental Engg. Department,
Delhi College of Engineering**)**

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Saket Bihari

University Roll No. 12395

DECLARATION

I here by declare, that the thesis report entitled, ***"Performance evaluation of Common Effluent Treatment Plants at Mangolpuri Industrial Area,Delhi"***, submitted by me to **Delhi College of Engineering, University of Delhi, Delhi.** in partial fulfillment of the requirements for the degree of **Master of Engineering in Civil (Environmental Engineering)**. This is my original work & conclusions drawn are based on material collected by me.

I further declare that this work has not been submitted to any other university for the award of any other degree any where.

Saket Bihari

University Roll No. 12395

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ABSTRACT

In order to mitigate the environmental hazards due to discharge of untreated effluents, the Delhi Government entrusted the work to Delhi Pollution Control Committee (DPCC) who contracted with National Environmental Engineering Research Institute (NEERI) in 1996 for the design of common effluent treatment plants (CETPs) for the industrial estates. Mangolpuri, CETP is one of the ten common effluent treatment plants at present operational in Delhi. It is serving the Mangolpuri Industrial Area, Phase I & II. An attempt has been made to evaluate performance efficiency of the treatment plant. Water samples were collected at different stages of treatment units and analysed for the major water quality parameters, such as pH, biological oxygen demand (BOD), chemical oxygen demand (COD), and total dissolved solids (TDS). The performance efficiency of each unit (particularly secondary treatment unit) in treating the pollutants was calculated. The result of experimental work has showed that the performance of common effluent treatment plant was by and large satisfactory and complying with the discharge standard limits.

CHAPTER 1: INTRODUCTION

INTRODUCTION

No life can exist without water. Further, it is necessary that the water required for their needs must be good, and it should not contain unwanted impurities. Population growth coupled with industrialization and urbanization has lead to the industrial effluent and sewage, resulting in water pollution which leads to water crisis in India and all over the world. The effluent stream coming out the industries comprised of organic and inorganic impurities mixed with hazardous and toxic chemicals. The effluent, before being disposed either in river stream or on land, has generally to be treated, so as to make it safe. The method of treatment required, however, depends upon characteristics of effluent.

Mangolpuri, common effluent treatment plant (CETP) is one of the plant meant to treat the effluent coming out from Mangolpuri industrial area. The physico- chemical characteristic of wastewater sample from various drains at Mangolpuri industrial area by National Environmental Engineering Research Institute (NEERI) before its construction suggests the absence of toxic and hazardous substance beyond the permissible limit.[5] Therefore biological treatment having extended aeration process is used for the treatment method in Mangolpuri, CETP. For the evaluation of performance of the Mangolpuri, CETP, samples at the four different locations of the CETP is taken and then tests are carried out on each samples for pH, BOD, COD, TDS, DO. In addition to that MLSS of the sample in the aeration tank, effluent from secondary clarifier, and activated sludge is carried out. The results obtained from performance evaluation studies were compared with the effluent standards prescribed in order to assess compliance with the latter.

1.1 Aim and Objectives

Objectives of the present study can be explicitly stated as the following:

1. To review the performance of the different units of the CETP particularly secondary treatment unit
2. To assess the overall performance of the CETP
3. To make recommendations to increase its performance on the basis of the survey and monitoring performed.

4. To review the functioning of all the constituent facilities of CETP
5. To review the existing operational practices

However, financial arrangements, organizational setup, and resources for the operation and maintenance of the CETP have not been included in the study. Sufficient background information about the contributing industries and their effluents has not been carried out.

CHAPTER 2: OVERVIEW OF CETP

OVERVIEW OF CETP

In last 30 years the industrial sector in India quadrupled in size. The MoEF (ministry of environment and forest) estimates that industries contribute to more than one third of the total pollution in rivers and other water bodies. The significant amount of industrial pollution in India is caused by the small scale industrial (SSIs) sector. A small scale unit is defined as any industry whose plant and machinery are valued at less than 1 crore (Government is planning to increase this to 5 crores) [1]**.** Though the quantity of industrial waste generated by individual SMIs may not be large, it aggregates becomes large. SMIs account for over 40percent of the total industrial output in the country and generate over 44percent of hazardous wastes alone as compared to 13percent generated by the large scale industry**.**[2]

Common facilities and common effluent treatment plant (CETP) is widely believed as solution to the effluents problem for clusters of SSIs. World Bank under its "Pollution Prevention Programme" is promoting CETPs as a viable solution to control industrial pollution[3]. Accordingly the Ministry of Environment and Forests instructed various State Pollution Control Boards, to examine the possibilities of establishing CETPs in various industrial estates in the respective states. Many CETPs have been installed and operated all over the country for tackling the water pollution problems arising from the clusters of SSIs. All is not well even with the CETPs. There are very few CETPs, which have been successful in tackling the water pollution problems from SSIs. Heterogeneous nature of the effluent generated by different units of the cluster is seen as one of the major causes for the failure.

2.1 Concept of CETP

It is generally observed that, either due to their economies of scale coupled with their unplanned growth, most of the small-scale industrial units cannot individually afford to set-up their own full fledged effluent treatment plants to meet the prescribed pollution control norms. Hence the desirable option is shared and combined treatment, wherein, managerial, cost and operational aspect are collectively addressed.[6] This has been responsible for the origination of the concept of CETP. According this, a cluster of small-scale industrial units through their collective effort installs and operates a CETP for the treatment of the effluents they generate. This concept is similar to the concept of Municipal Sewage treatment plant for the treatment of sewage from all the individual houses of a municipality. Main objective of a CETP is to reduce the treatment cost to individual units.[7]

2.2 Status of CETP'S in India

The first CETP in India was constructed in 1985 in Jeedimelta near Hyderabad, Andhra Pradesh, to treat waste waters from pharmaceuticals and chemicals industries – long before the World Bank became active in this sector. This CETP was followed by others in Andhra Pradesh, Gujarat, Madhya Pradesh, Maharashtra, and Tamil Nadu. As of June 1994, in the State of Gujarat, one CETP – which had been constructed by the Gujarat Industrial Development Corporation (GIDC) in Nandesari – could not be commissioned for several years because the member industries had failed to provide the necessary primary treatment. At that time, construction work at the CETPs in Ankleshwar, Sachin, Sarigam, Panoli, and Vapi (the subject of Greenpeace's protest) had not even been initiated.

Extensive public interest litigation and numerous verdicts by the Indian courts provided a major impetus to construct CETPs at an accelerated pace, and the World Bank was asked to provide assistance toward this process in the early 1990s, at a time when this appeared to be a viable solution to the problem. Most of the court verdicts were given in the State of Tamil Nadu, followed by New Delhi, and the State of Gujarat. As on 2000 there were 88 CETPs in India.[7] Statewise break up of these is given in **Table:1**. Location, capacity utilisation and flow sheet of CETPs in Delhi is given in **Table:2** and **Table:3.**

Table 1: Status of CETPs(India)

Sl. No.	Name of the State/UT	No. of CETPs
1	Andhra Pradesh	3
2	Delhi	15
3	Gujarat	7
4	Himachal Pradesh	4
5	Haryana	1
6	Karnataka	3
7	Madhya Pradesh	3
8	Maharastra	8
9	Punjab	4
10	Rajasthan	2
11	Tamil Nadu	36
12	Uttar Pradesh	2
Total		**88**

Source: Ministry of Environment and Forests

Table 2: Location and capacity of CETPs in Delhi

No	Name of CETP	Industrial estates served	Date of complet ion	Design capacity, MLD	Flow sheet
1	Wazirpur	Wazirpur Industrial Area	23.01.03	24	A
2	Mangolpuri	Mangolpuri Industrial Area, phase I & II	28.11.01	2.4	B
3	Mayapuri	Mayapuri Industrial Area, phase I & II	03.03.03	12	A
4	Lawrence Road	Lawrence road Industrial Area	30.09.04	12	A
5	Jhilmil	Jhilmil & Friends colony Industrial Area	22.08.04	16.8	A
6	Badli	Badli Industrial Area	31.03.03	12	A
7	Okhla	Okhla Industrial Area	30.04.03	24	A
8	GTK Road	GTK Road Industrial Area	01.12.02	6	A
9	SMA	Rajasthan Udyognagar, SMA & SSI Industrial Areas	30.05.03	12	A
10	Nangloi	DSIDC, Nangloi & Udyognagar Industrial areas	30.05.03	12	A

Source: CPCB, Highlights 2005

A - screen, grit chamber, equalisation tank, flash mixer, tube settler, sand filter, activated carbon column, sludge thickener and rotary vacuum filter.
B - same as A but primary sedimentation, extended aeration tank and secondary sedimentation in place of flash mixer and tube settler.

Table 3: Status of CETPs in Delhi

S.No.	Name of CETP	Design Capacity in million litres per day (mld)	Status of handing over of O&M to CETP Society as of Jan 2008	Capacity utilisation reported in Jan 2007	Utilisation in Jan 2008	% Capacity utilisation in Jan 2008
1	GT Karnal Road Industrial Area	6	Handed over	2.5-3.0	2.3	38
2.	Mangolpuri Industrial Area	2.4	Handed over	1-1.5	1.5-2.0	62.5 to 83
3	Mayapuri Industrial Area	12	Handed over	5.3	4.0-4.5	30 to 37.5
4.	Nangloi & DSIDC Industrial area	12	Handed over	2-2.5	3.0	25
5	Wazirpur Industrial Area	24	Handed over	4.0	2.0	8.3
6	Jhilmil & Friends Colony Industrial Area	16.8	Handed over	2.5-3.0	3.5-4.0	15-18
7	Badli Industrial Area	12	Handed over	5.0	2.5	20.8
8	Okhla Industrial Area	24	Handed over	0	4.0-5.0	17-20
9	Lawrence Road Industrial Area	12	Not handed over	3.0	3.0	25
10	SMA Industrial Area	12	Handed over	2.0	2.0	16.7
Total		**133**	**9 out of 10 CETPs handed over**	**27-29.3**	**27.8 to 30.3**	**20.9 to 22.8**

Note: mld-million litres per day; Source: Delhi Pollution Control Committee, March 2008

2.3 Feasibility assessment of Common effluent treatment plants [17]

2.3.1 Identifying Environmental and Infrastructural Issue

The initial stage of a feasibility assessment involves gathering information on existing and proposed institutional, environmental and infrastructural issues in the particular geographic area. The study also aims at identifying and establishing various parameters that ultimately influence the design of the plant.

While determining whether a CETP is feasible for a group of firms, it is important to recognize that certain characteristics of industries, certain regional and regulatory considerations favour the establishment of CETPs. Preliminary investigation of the following factors is essential during the feasibility assessment

1. **Number of firms**- This is a very important factor as this decides the unit cost of treatment. The more the firms participate, the lower would be the unit cost of treatment for each firm.
2. **Location of firms**- This factor has a major impact on the transportation costs which strongly influences the feasibility and cost-effectiveness of a CETP.
3. **Presence of sewer system** - This also has a positive effect on the feasibility of CETP. Proper laid out sewer lines aid in conveyance of effluents from the individual factories to the centralized facility. If no sewer line is present then good roads are essential for truck access.
4. **Volume and strength of waste**- Firms that produce waste of small volume of concentrated waste are more likely to benefit from CETP while firms that produce large quantities of waste are more likely to find that installing their own waste treatment system is more economical. In some cases a firm can reduce it's waste flow using recovery, recycling and waste reduction practices and then join a CETP.
5. **Firm size**- It is also an important factor that affects the applicability of CETP. Small firms often lack the ability to raise the capital needed to install pollution control equipment. Using CETP, small firms need to implement less costly waste reduction techniques and install small storage facility.

6. **Existence and enforcement of waste water regulations-** Existence and enforcement of regulations is the key, otherwise if such regulations are absent, firms will not take initiatives for installing onsite pollution control equipment or utilizing a CETP.[18]

2.3.2 Conducting a waste inventory

The second stage of feasibility assessment involves conducting a waste inventory of the specific industries for which the CETP is being proposed. It involves the following steps-

1. **Identifying industries in the geographic area-** Identification of the industries that are the potential users of the CETP, which includes determining the number and type of industries, sources such as industrial associations, trade organisations and local governmental organisations can be consulted.
2. **Identifying types and volumes of wastes generated** - Collecting data on the types and volumes of wastes is a complex and difficult one. Data to be collected on this aspect should reveal enough information that can distinguish among types of wastes such as organic and inorganic and should reveal the volume of diluted and concentrated wastes and the amount of total waste to be received at the CETP. Depending on the waste stream to be treated, it is determined whether a centralized facility to treat hazardous and/or non-hazardous waste is needed and will affect how a CETP is designed and managed.
3. **Estimating future waste loads-** Collecting data about future waste generation from the concerned industries is as important as collecting data about the present load. This may be a difficult task as most of the industries do not plan for more than 2 to 3 years but estimating future loads correctly could be very useful in designing the plant capacity. And to have a provision for new industries coming in that area so as to include them also in the CETP future waste load.
4. **Identifying treatment options-** Once the types and volumes of wastes generated by the industries are identified, the next step is to examine their compatibility and to identify potential treatment options.

5. **Evaluating cleaner technologies-** This is the last but the most important step in the feasibility assessment and the possibility of recommending changes in the raw material, manufacturing processes or finished products to reduce waste generation. For some industries adoption of cleaner technologies should be considered along with or in lieu of development of the CETP itself.

2.4 Design criteria

The impact of the plausible pollution prevention measures including waste segregation measures have to be assessed based on which characteristics of the combined waste water will have to be evaluated. Site characteristics and wastewater characteristics form an integral part of design basis. Pre-treatment standards for waters entering the collection system serving the CETP and treatment standards for effluents discharged from CETP also are significant design considerations.[19]

1 **Site characteristics-** Characteristics such as topography, soils, geology, hydrology, climate and land use are to be considered while designing a sewer network and a CETP. Topography and depth to bedrock effect the cost of sewer installation, for example elevation distributions that allow gravity flow and adequate depth for burial of pipe are most desirable. Soil thickness and soil characteristics like clay content, sand content, permeability etc. play a major role while deciding on certain treatment options such as land and lagoon treatment or granular media filtration etc. Climatic factors such as precipitation are important when inflow is a problem with sewers and evaporation is important when treatment processes being considered rely on evaporation of treated waste water.

2 **Wastewater characteristics-** Key characteristics that must be considered in designing CETP are flow and physical and chemical characteristics of the wastewater.

3 **Flow (m^3/day or MLD)-** It is important in determining the size of CETP. Minimum and maximum flows should be computed as they decide the hydraulic computations

and the size of distribution pipes. Anticipated future increase should also be incorporated. Temporal flow variations require use of equalisation ponds to allow a constant flow rate through downstream processes. Mixing of waste water with lower concentration such as addition of sewage helps in reducing toxic shock on treatment processes.

Physical characteristics- Significant physical characteristics include-

1. **Solids-** Solids in the form of floating debris, grease and oil slicks indicate a highly polluted stream and suspended solids contribute to turbidity and silt load and require sedimentation or filtration for removal.

2. **Temperature-** It is an important criterion as it affects chemical and biological reactions and solubility of gases such as oxygen. For example high temperatures increase reaction rates and solubility to a certain extent.

3. **Colour and odour-** These serve as indicators of the degree of pollution of a waste stream and there presence in waste water indicate inadequate pre-treatment prior to discharge.

Chemical characteristics- Significant chemical characteristics include organics, inorganics in solution and gases. These are indicated by

1. **BOD (mg/l)-** Biological oxygen demand provides an indicator of the amount of organic substances of biological origin such as proteins, carbohydrates, fats and oils and biodegradable synthetic organic chemicals in water.
2. **COD (mg/l)-** Chemical oxygen demand measures non-biodegradable as well as biodegradable organics. The ratio between BOD and COD provides an indicator of the ease of biological treatment.

Pre-treatment standards

Wastewater from industrial processes requires some form of pre-treatment prior to discharge to CETP (given in **Table 4**). This is mainly required (1) when waste water is carried through sewer lines to minimise corrosion and clogging of sewer lines and (2) to prevent reductions in biological treatment process efficiency by toxic effects

Table 4: Inlet effluent quality standard for CETP

Parameter	Into Inland surface water
1. PH	5.5 – 9.0
2. Oil & Grease	20
3. Temperature°C	45°C*
4. Suspended solids	250
5. Ammonia (as N)	50
6. Arsenic (As)	0.2
7. Mercury (Hg)	0.01
8. Lead (Pb)	1.0
9. Cadmium (Cd)	1.0
10. Chromium (Cr)	2.0
11. Copper (Cu)	3.0
12. Zinc (Zn)	15.0
13. Selenium (Se)	0.05
14. Nickel (Ni)	3.0
15. Boron (B)	2.0
16. Cyanide (CN)	2.0
17. Fluoride (F)	15.0
18. Phenolic compound	5.0

Concentration in mg/l except pH and temperature

1.These standards apply to small-scale industries i.e. total discharge upto 25 KL/day

2. For each CETP and it's constituent units, the State board will prescribe standards as per the local needs and conditions; these can be more stringent than those prescribed above. However, in case of the cluster of units, the State board with the concurrence of CPCB in writing may prescribe suitable limits.

Source: Environment protection rule,1986 from toxic concentration of organic and inorganic substances. Pre treatment standards for sulphides, sulphates and pH are concerned with preventing corrosion of concrete parts in sewers and limits to discharge of oil, grease, grit and heavy sediments prevent clogging of sewers. Limits to heavy metals and toxic organics ensure proper performance of biological treatment and minimise accumulation of contaminants in residual sludge.

Conveyance System- Industrial effluents may be transported to CETP by tankers, piping system or a combination of these two.

Tankers- If the industrial estate is in early stage of development and has mostly small-scale industries then tankers are the best alternative and at some places topography of the region may allow only use of tankers. Advantage of using tankers is that money in construction of pipelines is not blocked in the early stages of development. Tanker works well when the small-scale industries are well spread and multiple liquid waste streams are to be handled. Specific design elements of this system include

1. selection of container material that will suit the types of wastes to be transported
2. choosing types and sizes of vehicles that are suitable for the transport routes
3. choosing the number of vehicles and
4. developing safe operating procedures for handling hazardous materials.[20]

Piping system- Piping wastes is practical when participating firms are located close to CETP or we can say piping wastes are limited to an industrial estate. Design of piping system for CETP's require more attention to corrosion prevention and control which is mainly done by preventing sulphide content to enter the pipes. Pipe thickness can be increased to allow for some corrosion.

Treated effluents discharge standards

Waste water treatment processes differ in reducing the concentration of parameters of concern such as BOD or Suspended solids etc. and the standards of discharge determine whether a given combination of treatment processes provide an acceptable level of treatment. Thus before designing a CETP effluent discharge standards should be identified. Standards may vary depending on the point of discharge of treated wastewater. For example sewer standards, irrigation standards, drinking water standards are different[21] (shown in **Table 5**).

Treated water distribution system

Depending on the use of treated water proper facilities should be provided. If the water is meant for recycling or reuse then proper holding capacity must be provided. Treated water depending on the quality can be either used for irrigation or disposed off in municipal sewers or in inland water- courses

2.5 Wastewater treatment Technologies [4][17]

2.5.1 Primary treatment

It involves the removal of suspended solids, oils and coarse fractions, which could damage and interfere with downstream equipment. It alters characteristics of the wastewater through chemical addition to meet the needs of the ensuing treatment processes.

Preliminary treatment- It involves a number of unit processes to eliminate undesirable characteristics of wastewater. Processes include use of screen sand grates for removal of large particles, communitors for grinding of coarse solids, pre-aeration for odour control and some removal of grease.

These are mainly physical processes. This includes-

1. **Grit chambers** use gravity to remove grit and dirt which mainly consists of mineral particles and coarse screens strain out large solids and when organic material enters as large particles comminutors can be used to reduce particle size to enhance treatment in later stages.
2. **Equalisation-** Equalisation is a process to equalise wastes by holding waste streams in a tank for a certain period of time prior to treatment in order to obtain a stable waste stream that is easier to treat. Equalisation helps in mixing smaller volumes of concentrated wastes with larger volumes at lower concentrations. It also controls the pH to prevent fluctuations that could upset the efficiency of treatment system, by mixing acid and alkaline wastes. Equalisation tanks are equipped with agitators that

Table 5: Treated effluent quality standard for CETP

Parameter	Into Inland surface water	On land for irrigation	Into marine coastal area
1. PH	5.5 – 9.0	5.5 - 9.0	5.5- 9.0
2. BOD 20°C	30	100	100
3. Oil & Grease	10	10	20
4. Temperature°C	40°C*	—	45°C at the point of discharge 100-Process water 10 percent above total suspended matter of influent - cooling water
5. Suspended solids	100	200	
6. Dissolved solids (inorganic)	2100	2100	
Total residual Cl	1.0		1.0
Ammonia (as N)	50		50
Kjeldahl (as N)	100		100
COD	250		250

Table 5: (contd...)

12. Mercury (Hg)	0.01		0.01
13. Lead (Pb)	0.1		1.0
14. Cadmium (Cd)	1.0		2.0
15. Chromium (Cr)	2.0		2.0
16. Copper (Cu)	3.0		3.0
17. Zinc (Zn)	5.0		15.0
18. Selenium (Se)	0.05		0.05
19. Nickel (Ni)	3.0		5.0
20. Boron (B)	2.0	2.0	
21. percent Sodium		60.0	
22. Cyanide (CN)	0.2	0.2	0.2
23. Chloride (Cl)	1000	600	
24. Fluoride (F)	2.0		15
25. Sulphate (SO4)	1000	1000	
26. Sulphide (S)	2.8		5.0
27. Pesticides	absent	absent	absent
28. Phenolic compound	1.0		5.0

Concentration in mg/l except pH and temperature
* Temperature shall not exceed 40°C in any section of the stream with in 15m down stream from the effluent outlet.
Note: All efforts should be made to remove colour and unpleasant odour as far as possible
Source: Source: Environment protection rule,1986

helps not only in proper mixing of waste water but also prevents suspended solids from settling to the bottom of the unit.

3. **Pre-aeration or pre-chlorination-** This process helps in controlling odours if wastewater becomes oxygen deficient while travelling through the sewer collection system. It also helps in grease removal during primary clarification.

Primary treatment- These are also mainly physical processes. These include-

1. **Sedimentation**- Removal of readily settleable inert and organic solids is accomplished in sedimentation. Fine screens may also be used in the treatment process. Sedimentation chambers may also include baffles and oil skimmers to remove grease and floatable solids and may include mechanical scrapers for removal of sludge at the bottom of the chamber.
2. **Dissolved air floatation-** It is the process of using fine bubbles to induce suspended particles to rise to the surface tank where they can be collected and removed. Gas bubbles are introduced into the wastewater and attach themselves to the particles, thus reducing their specific gravity and causing them to float. Bubbles may be generated by (1) dispersing air mechanically (2) by drawing them from water using vacuum or (3) by forcing air into solution under elevated pressure followed by pressure release. This is called dissolved air floatation. It is used to remove suspended solids and dispersed oil and grease from oily wastewater. It reduces the sedimentation times of suspended solids that have a specific gravity slightly greater than 1.0. Wastewater is pressurised and contacted with air in a retention tank. The pressurised water that is nearly saturated with air is passed through a pressure- reducing valve and introduced into at the bottom of floatation tank. As soon as pressure is released the supersaturated air begins to come out of solution in the form of fine bubbles. The bubbles get attached to suspended particles and become enmeshed in sludge flocs, floating them to surface. Float is continuously swept from the surface and sludge may be collected from the bottom. Addition of certain coagulants increases the oil removal efficiency of DAF units.

3. **Flocculation-**It is physical- chemical process that encourages the aggregation of coagulated colloidal and finely divided suspended matter by physical mixing or chemical coagulant aids. Flocculation process consists of a rapid mix tank and a flocculation tank. The waste stream is initially mixed with a coagulant in the rapid mix tank and after mixing the coagulated waste water flows to the flocculation basin where slow mixing of waste occurs which allows the particles to agglomerate into heavier more settleable solids. Either mechanical paddles or diffused air provide mixing. Three different types of chemicals used in coagulation are inorganic electrolytes, natural organic polymers and synthetic poly electrolytes. The selection of a specific chemical depends on the characteristics and chemical properties of the contaminants.
4. **Emulsion breaking-** It involves addition of chemicals and/or heat to cause dispersed oil droplets to coalesce and separate from the wastewater. This process mainly used for pre-treatment of oily wastewater. Commonly used method is acid cracking where sulphuric or hydrochloric acid is added to the oil water mixture until pH reaches 1 or 2. Another alternative to this is where emulsion breaking chemicals such as surfactants and coagulants are added to the mixture and the contents are mixed. After the emulsion bond is broken, oil residue is allowed to float to the top of the tank. Heat may be applied to speed the separation process. The oil is then skimmed by mechanical means or the water is decanted from the bottom of the tank.
5. **Clarification-** Clarification system utilise gravity to provide continuous, low cost separation and removal of particulate, flocculated impurities and precipitates from water and generally follow the processes which generate suspended solids such as biological treatment. In a clarifier wastewater is allowed to flow slowly and uniformly, permitting the solids more dense than water to settle down. The clarified water flows from the top of the clarifier over the weir. Solids get collected at the bottom and sludge must be periodically removed, dewatered and disposed.

6. **Granular media filtration-** Many processes fall under this category and the common element being the use of mineral particles as the filtration medium. It removes suspended solids by physical filtration, physical chemical sorption and biological decomposition.

   Sand filters are the most common type which consists of either a fixed or moving bed of media that traps and removes suspended solids from water passing through media.

   Dual or multimedia filtration consists of two or more media and it operates with the finer, denser media at the top and coarser, less dense media at the top. Common arrangement being garnet at the bottom, sand in the middle and anthracite coal at the top. Flow pattern of multimedia filters is usually from top to bottom with gravity flow. These filters require periodic back washing to maintain their efficiency.

Granular media filters can separate particle size (generally less than 2 mm) smaller than biological filters which increase their efficiency over other treatment process. These processes are most commonly used for tertiary treatment in municipal wastewater treatment plants and for supplemental removal of residual suspended solids from the effluents of chemical treatment processes.

Land treatment

Major types of land waste water treatment system include

1. Slow rate where waste water is applied using pipes or sprinklers to a vegetated land surface at such a rate so as to avoid runoff. Wastewater is treated by the plant soil matrix and the rest enters the ground water system.
2. Rapid infiltration where wastewater is applied to unvegetated flooding basins on soils with high percolation rates.
3. Sub surface infiltration where wastewater is subsurface soil absorption drain fields.
4. Overland flow where waste water is applied to the upper reaches of grass covered slopes and is allowed to flow over the vegetated surface to runoff collection ditches. Land treatment is suitable for waste waters coming from food processing industries, provided suitable land is available nearby while

waste water from the manufacturing industries are unsuitable for land treatment.

Chemical treatment Processes

Chemical treatment may be used at any stage in the treatment process as and when required. Mainly used methods are-

1. **Neutralization**- This process is used to adjust pH of the waste water to optimise treatment efficiency. Untreated wastewater has a wide range of pH values and may require neutralization to eliminate either high or low values prior to certain treatment. Acids such as sulphuric or hydrochloric may be added to reduce pH or alkalis such as sodium hydroxide may be added to raise pH values. Neutralization may take place in a holding, rapid mix or an equalisation tank. It can be carried out mainly at the end of the treatment system to control the pH of discharge in order to meet the standards.
2. **Precipitation**- It is carried to remove metal compounds from waste water. It is a two step process. In the first step precipitants are mixed with wastewater allowing the formation of insoluble metal precipitants. Detention time depends on the wastewater being treated, chemical used and the desired effluent quality. In the second step precipitated metals are removed from wastewater through filtration or clarification and the resulting sludge must be properly treated, recycled or disposed. Various chemicals used are lime, sodium hydroxide, soda ash, sodium sulphide and ferrous sulphate. Normally hydroxide precipitation which is effective in removing metals like antimony, arsenic, chromium, copper, lead, mercury, nickel and zinc and sulphide precipitation which is used in removing lead, copper, silver, cadmium etc. may be used.

Other than the chemical other important thing in chemical precipitation is pH. Metal hydroxides are amphoteric in nature and can react chemically as acids or bases and their solubility increases towards higher or lower pH. Thus, there is an optimum pH for hydroxide precipitation for each metal. Wastewater generally contains more than one metal selecting the optimum treatment chemical and pH becomes more difficult and involves a trade off between optimum removal of two or more metals. Other chemical treatment methods used include oxidation This is mainly done to control disinfection and odour. The methods used are chlorination, ozonation and ultraviolet radiation.

2.5.2 SECONDARY TREATMENT

Biological treatment processes are used primarily for secondary treatment and use microbial action to decompose suspended and dissolved organic wastewater. Microbes use the organic compounds as both a source of carbon and as a source of energy. Success of biological treatment depends on many factors such as the pH, temperature, nature of pollutants, nutrient requirement of microbes, presence of inhibiting pollutants and the variations in the feed stream loading.

Biological treatment can be either aerobic where microbes require oxygen to grow or anaerobic where microbes will grow only in absence of oxygen or facultative where microbes can grow with or without oxygen. Micro-organisms may be either attached to surface as in trickling filter or be unattached in a liquid suspension in activated sludge process. Biological treatment methods either requires large area such as land treatment and stabilisation ponds/lagoons or small area requirement using engineered methods such as activated sludge process, biological filters and anaerobic treatment systems.

1. **Stabilisation ponds/lagoons-** Also called oxidation ponds, treats waste water by the interaction of sunlight, wind and algae with or without assistance of mechanical aeration equipment. Lagoons are smaller than ponds and have a second pond to remove suspended solids. Lagoons are simple in design and require low operation and maintenance costs and the control of discharge may eliminate the need for additional treatment. Disadvantages include large area requirements and bad odours.[22]
2. **Activated sludge process-** It is continuous flow, aerobic biological treatment process that employs suspended growth aerobic micro organisms to biodegrade organic contaminants. In this process a suspension of aerobic microbes is maintained by mechanical mixing or turbulence induced by diffused aerators. Influent is introduced in the aeration basin and is allowed to mix with the contents. A series of biochemical reactions is performed in the basin degrading

organics and generating new bio mass. Micro organisms oxidize the matter into carbon dioxide and water using the available supplied oxygen. These organisms agglomerate colloidal and particulate solids. After a specific period the mixture is passed to a settling tank or a clarifier where micro organisms are separated from the treated water. Major portion of the settled solids are recycled back to the aeration tank to maintain a desired concentration of micro organisms in the reactor and the remainder of the settled solids are sent to sludge handling facilities.

To ensure biological stabilization of organic compounds adequate nutrient levels of nitrogen and phosphorous must be available to the bio mass. The key variables to the effectiveness of the system include -

1. organic loading which is described as food to micro organism ratio (F/M) ratio or Kg of BOD applied daily to the system per Kg of mixed liquor suspended solids (MLSS). F/M ratio affects BOD removal, oxygen requirements and bio mass production.
2. Sludge retention time or sludge age is the measure of the average retention time of solids in the system and it affects the degree of treatment and the production of waste sludge.
3. Hydraulic detention time determines the size of the aeration tank and
4. Oxygen requirements are based on the amount required for biodegradation of organic matter and the amount required for endogenous respiration of micro organisms.

Various modifications in activated sludge process are possible by changing one or more of the key parameters. Sequencing batch reactor is a form of the activated sludge process where aeration, sedimentation and decantation processes are performed in a single reactor.[23]

1. Biological filters - These filters provide a surface that is repeatedly exposed to wastewater and air and on which a microbial layer can grow.

2. In trickling filters treatment is provide by a fixed film of microbes that forms on the surface which adsorbs organic particles and degrades them aerobically. Wastewater is distributed over a bed made of rock or plastic and flows over the media by gravity.
3. In a rotating biological contactor which consists of a series of corrugated plastic discs 40percent of the area is immersed in waste water and the remainder of the surface is exposed to atmosphere, provide a surface for microbial slime layer. The alternating immersion and aeration of a given portion of the disc enhance growth of the attached micro organisms and facilitate oxidation of organic matter in a relatively short time and provide a high degree of treatment.
4. Anaerobic treatment systems- They are rarely used in wastewater treatment systems except as a means for sludge stabilisation. These processes more slowly than aerobic degradation and when sulphur is present obnoxious hydrogen sulphide gas is generated. But many toxic organic compound specially chlorinated hydrocarbons that are not amenable to aerobic degradation can be anaerobically treated.

2.5.3 Tertiary treatment

The influent is generally first disinfected with chlorine, oxidants, or ultraviolet light irradiation. Filters such as sand, micron and active carbon are used to absorb excess chlorine, colour and organics. Membranes are pressure dependent processes that can withstand varying operating conditions. They are capable of separating all types of suspended and dissolved inorganic and organic contaminants. Membranes such as micro filtration (MF), ultra filtration (UF) and nano filtration (NF) have varying pore sizes, which determines the extent to which contaminants are removed.[4]

2.5.4 Polishing unit[4]

It is used only when the recycled water is used for purposes that require very safe and high quality water. It can produce ultra pure water, which is defined as water that is either free or has a very low content of particles, organic and colloidal matter. Reverse osmosis (RO) is one of the examples of a polishing device. It is an advanced form of membrane technology used to purify water for drinking purposes. It is a costly unit to maintain due to its high-energy requirements and requires extensive pretreatment of the wastewater, as it is easily susceptible to damage.

2.5.5 Sludge Management[4]

The sludge, mainly composed of water, is thickened, stabilised, dewatered and disinfected before it is disposed. Depending on the wastewater that is treated, sludge can contain substances that are harmful to the ecology such as heavy metals and chemicals. Therefore it cannot always be disposed off through incineration and landfills or even reused in any form.

Depending on the wastewater and the technology used in a particular plant, some of these steps might be omitted or be unnecessary. For instance wastewater from an electroplating industry contains only inorganic contaminants. Therefore secondary treatment, which is used to treat only the organic wastes, will not be included for the treatment process. Also filters can be excluded when certain membranes are used, and primary treatment need not always include clarifiers or chemically modify influents.

2.7 Legal requirements

Requirements to be complied with by the CETP may include the following:

1. Consent (for establishing, for operating and for continuing to operate) under the water (prevention and control of pollution) act, 1974 .[24]

2. Authorization of the State Pollution Control Board (SPCB) under the Hazardous wastes (management and handling) rules, 1989 [25].

3. Discharge/effluent standards prescribed under the Environment (protection) rules, 1986 [26]

4. Standards prescribed for DG sets (which may be used as captive power units) under the Environment (protection) Rules, 1986 [27]

5. Annual environmental statement under the Environment (protection) Rules[26], 1986.

6. Installation of water meters as prescribed under the Water (prevention and control of pollution) Cess Rules, 1977. [28,29]

7. Submission of water consumption returns to the prescribed authority under the Water (prevention and control of pollution) cess rules, 1977. [28,29]

8. Maintenance of hazardous waste records under the Hazardous wastes (management and handling) rules, 1989.[30]

9. Compliance with the requirements related to handling of hazardous chemicals under the Manufacture, storage and import of hazardous chemicals rules, 1989.[31,32]

10. Inspections of the regulatory agencies under the water act, 1974 and Environmental (protection) act, 1986.[33]

11. Compliance with the provisions of the Noise pollution (regulation and control) rules, 2000.[34]

2.7 Subsidies and funds for CETPs

Central assistance upto 25percent of the total cost of the CETP would be provided as a grant to CETP on the condition that state government gives a matching condition and the remaining cost should be met by equity contribution by the industries and the loans from financial institutions.

Central assistance will be provided for only capital cost and not for recurring costs. The assistance will be released in three equal installments. The first assistance of 25percent will be released when a body has been identified for the purpose of implementing of the project, financial arrangements have been tied up, institutional arrangements have been finalised, consent has been obtained from the State Pollution Control Board and state government has committed it’s contribution.

The second installment of 50percent and the last installment of 25percent will be realised after the utilisation of the previous money and adequate progress of work subject to release of their proportionate shares by state government. Central assistance will be limited to 25percent of the capital cost of the project or 25 lacs, whichever is less. However assistance upto 50 lacs can be considered subject to other conditions such as matching grant of the state government etc.[35] The World Bank aided “ **Industrial Pollution Control**” project was approved in 1991 to assist Government of India's effort to prevent environmental degradation caused by industrial operations and assist in the attainment of the short and medium-term targets of its environmental policy. Under the project following activities were financed:

- An institutional component designed to strengthen the Central and State Pollution Control Boards in the state of Gujarat, Maharastra, Tamil Nadu and Uttar Pradesh.
- An investment component designed to support efforts by industry to comply with regulations including support for the setting up of common treatment facilities.
- A technical assistance component designed to support the MoEF and the Development Finance Institutions in providing specialised technical assistance for the evaluation of environmental problems and the assessment of their solutions[36].

There is a provision of loan and grant assistance for proposals of construction of CETP for treatment of effluents from a cluster of industries particularly of small-scale. A total of $24 million loan assistance and $12 million grant assistance is available under this component.[37] The proposal from project proponents should be forwarded for evaluation by a select group of officials which include Deputy Director, World Bank Implementation Cell MoEF, New Delhi; GM or Manager, IDBI, Mumbai; Head Wastewater Engineering Division, NEERI, Nagpur and Chairman of respective State Pollution Control Board.

2.8 Advantages of CETP[6]

1. Saving in capital and operational cost of treatment plant. Combined treatment is always cheaper than small scattered treatment units.
2. Large land needed if industry goes for individual treatment plant. This is particularly important in case of existing old industries which simply do not have any space.
3. Contribution of nutrient and diluting potential, making the complex industrial waste more amenable to degradation.
4. The neutralization and equilasation of heterogeneous waste makes its treatment techno-economically viable.
5. Disposal of treated waste water & sludge becomes more organised.
6. Ensuring pollution control requirement becomes easy for various regulatory authorities.

7. To minimise the problem of lack of technical assistance and trained personnel as fewer plants require fewer people.

2.9 Limitations of CETP

Common effluent treatment plants (CETPs) were perceived to be a feasible solution for abatement of industrial wastewater pollution. However complexities involved with practical application and logistics proved not to be as appealing as it was perceived. For example the wastewater from electroplating industries might be low in quantity but is highly toxic and hazardous in nature and can be even lethal when contacted. Mixing this with effluents from other industries such as textiles and pharmaceuticals, which discharge a large amount of wastewater with a low pollution load, will only dilute the effluent. This weakens the effects of treatment and may not reduce the pollution content by any amount. Operational performance of CETPs in India is shown in **Table 6.**

A study on water pollution in Tiruppur showed that most of the parameters (except for pH and sulfate) of treated effluent that was discharged from 8 CETPs increased after treatment.[41]

Another repressive feature of CETPs is the constant variation in the volume of influent. The performance of 52 CETPs operational around India during the year 2002-03 was surveyed by the CPCB[42] (Central Pollution Control Board). One of the main observations was that the average inflow in 41 CETPS was in the range of 25-65% of the design capacity and only 11 CETPs were receiving more than 90% of the design inflow quantity of industrial effluents. Treatment plants lose their effectiveness when constantly used to treat a volume of effluent that is much below its designed capacity.

Central Pollution Control Board studied performance of 78 CETPs operating throughout the country. It is observed that of the total 78 CETPs studied, only 20 complied with the prescribed limits for general parameters pH, BOD, COD and TSS but 15 of these were

Table 6: Operational performance of CETPs(India)

State	Nos. of CETPs studied	CETPs complying pH, BOD, COD, TSS and TDS standards		CETPs complying pH, BOD, COD and TSS but not complying TDS standard	
		Number	**CETP**	**Number**	**CETP**
Andhra Pradesh	2	0	-	0	-
Delhi	10	3	Mayapuri, GTK, Badli	6	Wazirpur, Mangolpuri, Jhilmil, SMA, Nangloi, Okhla Industrial Area
Gujrat	15	0	-	2	Ankleshwar, Sachin (0.5MLD)
Haryana	1	1*	Kundli-I	0	-
Karnataka	2	0	-	1	Pai & Pai
Maharashtra	9	0	-	3	Thane-Belapur, Ambernath, Patalganga
Madhya Pradesh	1	0	-	0	-
Punjab	1	1	Phillore	0	-
Rajasthan	5	0	-	1	Jodhpur**
Tamilnadu	29	0	-	2	Thiruvai Karur***, TALCO Ambur Thuthipet
Uttar Pradesh	3	0	-	0	-
Total	**78**	**5 (6.4 %)**	**-**	**15 (19.2 %)**	

Source: CPCB, Highlight 2005

*TDS not determined but likely to be within limits;

CETP was under trial; TDS not determined but chloride exceeded;*TSS not determined not able to comply with the prescribed limit for TDS. Thus, only 5 (i.e. 6.4%) CETPs were complying all general parameters including TDS. In general, the performance of CETPs has been found very unsatisfactory, largely because of poor operation and maintenance. Therefore, the State Pollution Control Boards have been advised to conduct regular monitoring of CETPs, persuade the operating agencies for proper operation and maintenance and initiate actions against negligent agencies & willful defaulters.

High TDS in treated effluent is observed a widespread problem as, in all, 69 (i.e. 88.5%) out of the 78 CETPs did not complied with TDS standards. Reduction in release of TDS contributing chemicals from problem industries by adopting cleaner production technologies and recovery and recycling of chemicals from the waste streams is the most important action required to tackle this problem. State Boards may consider prescribing location specific regulations for the control of TDS at the industry level.[43]

The CPCB concludes that the objective of setting up industrial estates to provide for pollution control by sharing of common facilities has not been achieved due to the following reasons: -

1. Improper management of abatement units installed for combined pollution control.
2. CETPs set up in some of the industrial estates have not been able to treat the effluent to the desired level. The varied nature and scale of the industries, along with the addition of industries in a haphazard manner, without proper planning, has worsened the situation. No provision is made to tackle the extra pollution load.
3. Separate treatment facilities, which are required to deal with hazardous and toxic effluents, have not been installed.

CHAPTER 3: REVIEW OF LITERATURE

REVIEW OF LITERATURE

Review of literature was limited to on the following aspects:

1. CETPs and their performance and management
2. Technological aspect of CETP
3. Regulatory requirements applicable to CETP

Internet search using Google search, Science direct, Yahoo search and e-journal and DCE library were used for the literature search.

Whether a CETP is a solution or a problem in itself was discussed by **Maheswari *et al.* [2000]**[12]. The work stated that the concept of CETP which was hyped as a solution to manage water pollution has failed because of the heterogeneous nature of the effluent from different industries. It has only compounded the toxic content to larger volumes. And also with the changing nature of effluent many toxic substances like organochlorines, polychlorinated biphenyls (PCBs) and heavy metals have found their way into the waste stream. The various standards formulated for inlet and outlet effluent has no mention of these toxic chemicals and other volatile fugitives. The management of Persistent Organic Pollutants (POPs) and inorganic residues in fluid form goes beyond the capacity of primary and secondary treatment in CETPs. Reverse Osmosis, Granulated Activated Carbon, Ultra-filtration, ion exchange and other tertiary treatment methods which could be effective in this case are not used by CETPs mainly for economic reasons. This concept also faced many operational and institutional problems as many participating industries started withdrawing from the scheme. With the growing pace of industrialization these CETPs are unable to cater to the need of the industrial clusters, which has resulted in bypassing the treatment and directly discharging the untreated effluent in water bodies. The sludge which get settled in aeration tanks having concentrated amounts of heavy metals and organochlorines, is disposed openly as in the case of both Vapi and Kanpur CETPs. The work also suggests that there is a need to approach this problem of waste generation at each stage of product life cycle, starting from the types of chemicals used, technology, final product, waste minimization and its proper disposal. The waste management hierarchy would seem to work best in individual waste-generator cases. Logically, after receptor-related treatment is ensured, waste minimisation efforts are taken up with the objective of progressively reducing the need for individual treatment. In India the paradox of starting backwards is legally enforced in that, no industry of the ‘Red’ or ‘Orange’ category can commence operations unless and until the end-of pipe hardware is in place. Till this year, end-of-pipe pollution control hardware costs could be depreciated 100percent in the first year and import of ETP related equipment still get through with low duties. The same subsidy is not available for waste minimisation or preventive measures related hardware and software. These incentives coupled with command and control enforcement of standards, shifts the whole focus away from waste minimisation towards operation of treatment and disposal systems.

Sangeeth Aiyappa[2004][4] has compared the two technology in his study. The BDA plant features the technologically advanced membrane bioreactor (MBR), which incorporates a submerged UF membrane. It replaces the conventional activated sludge (CAS) treatment by combining clarification, aeration and filtration. This makes it a compact unit that is most suited for areas with space constraints, like crowded urban areas. It also allows for convenient modifications of the plant capacity in the case of variations in effluent quantity, as membranes can be added in modules. Due to the automated controls, labour requirement and supervision along with maintenance will be at its lowest. On an average there is 1 mechanical/electrical fitter per shift and minimal manual labour for housekeeping. Although not conclusive, research studies reveal that MBRs produce a higher quality of water than the CAS process, which is especially low in COD, solids, organic suspensions, turbidity and pathogens. As membranes also prevent the waste-consuming microorganisms from passing through, higher concentrations of MLSS (mixed liquor suspended solids) can be maintained. The higher MLSS, which averages around 10-20 gm/lt. for a typical MBR as against 2-3 gm/lt. for CAS, fastens the degradation of organic wastes. Although this feature may raise the requirement and costs of oxygen transfer it also circumvents the need for a return activated sludge pipe. Although limited in number, the majority of MBR systems around the world have been installed in industries such automotive, metal fabrication, food processing etc. and also used for treating landfill leachate. This fact portrays not only its versatility but also its potential capacity. However, at present, the municipal plant (Cubbon Park) being the first of its kind to install an MBR in India raises doubts about its commercial/financial viability in India in the near future. Besides the capital costs, even the working costs in terms of energy requirements, pretreatment devices and replacements could be a substantial figure. Local availability of the product is very low and importing the product will only add to the already forbidding costs. The solution lies not only in adopting cost effective and advanced technology but also placing them in the right environment. The plant must be financially and logistically capable of providing the required energy, labour, technical support and maintenance. Neglecting the operation and maintenance (O&M), which includes pretreatment of influents, servicing and cleaning, can reduce plant life by 50 to 60% and incapacitate the units.

Every treatment process and technology adopted has a set of pros and cons. However the terms - ‘pros’ and ‘cons’, are a relative concept, which means that a positive feature for one plant might be a negative for another. The most suitable treatment method is one that optimally exploits the abundant factors and minimizes the requirement of the scarce resources of a particular treatment plant.

P.GOVINDASAMY *et al.*[49] have studied performance of a CETP at Pallavaram, now a part of CMDA and less than 3 kilometers from south of Chennai Airport, has cluster of 152 tanneries predominantly processing raw to wet blue. Though it was away from residential areas when the tanneries came up nearly a century ago, now it has become a part of the city with With the increasing demand for leather and leather products, both for indigenous use as well as for export, population is quite high and land is scarce. Therefore, designing and creating a CETP for tanneries in this location was an absolute need and challenge to protect the future needs of the environmental sustainability in that area. Water samples were collected at different stages of treatment units and analysed for the major water quality parameters, such as pH, biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS) and total dissolved solids (TDS). The performance efficiency of each unit in treating the pollutants was calculated. The generated data presented evidence to that the common effluent treatment plant has been working with the norms of TNPCB and meeting the discharge standard limits.

Eswaramoorthi *et al.* (2004)[13] have studied performance of a CETP at Manickapurampudur, Tirupur, which is handling dying effluent from over 900 small-sclae dying units, and found that the treated effluent, except for TDS, is in compliance with the effluent discharge norms of the Tamil Nadu Pollution Control Board. The authors have suggested a multitude of technologies, such as the following, for tackling the water pollution problems:

Reverse osmosis for water reuse

nano-filtration for salt recovery

Multiple effect evaporator and solar evaporation ponds for reject management

Kurian (2004)[14, 15] in the context of the Manikkapuram-pudur CETP, suggested Cleaner Production (CP) approach for tackling the two principal issues of concern, namely, TDS and colour. A combination of low material to liquor ratio dyeing machines and low salt (LS) reactive dyes along with dye bath segregation according to the author would reduce the salt consumption and TDS to 50% of its original level in the effluents.

Vinod Tare *et al.* (2003)[16] compared cost and quality of treatment of tannery wastewater by two CETPs both serving tannery clusters in Uttar Pradesh. One CETP is at Jajmau and it is UASB based. The other one is at Unnao and it is activated sludge treatment process. Against the general perception, the ASP-based plant was found superior to the UASB based plant.

Pophali *et al.* [2003][8] have studied the influence of hydraulic shock loads and total dissolved solids (TDS) on the performance of three large-scale common effluent treatment plants (CETPs) of Rajasthan (two at Pali and one at Balotra) treating textile effluents.

Ramakrishna1 [2000][9] has attempted to assess potential causes for the improper waste management by Industry and made a few suggestions with regards to the role and responsibility of the Statutory Boards in discharging their duties. He also emphasized the need and importance of co-ordination among the polluting industries, the local administration, the regulatory agencies and the public.

Pathe *et al.* [2004][11] was evaluated performance of an existing CETP serving a cluster of small scale tanneries and suggested measures and modifications for improving the performance. The participating tanneries share operation and maintenance expenses of the CETP.

According to **Kathuria [2003][10],** mere supply of an institution does not ensure sustainability of a CETP. Sustainability of a CETP actually hinges on: low rate of time discount, less rewards for defection and high degree of mutual trust among players. In Kundli, Gujrat, arrangements made for the sustained use of CETP have collapsed within 3 years and the CETP was converted to a sewage treatment plant. The author has analysed the factors that triggered the collapse of the CETP and highlighted the lessons learnt.

CHAPTER 4: CETP, MANGOLPURI

CETP, MANGOLPURI

There are 28 recognised industrial estate in Delhi. Mangolpuri industrial estate is one of them which is having small and medium scale industries comprising mainly the foot wear industries. CETP, Mangolpuri which served the Mangolpuri industrial area phase I and II was built in the year 2001. The CETP has designed capacity of 2.4 MLD. Running capacity of the CETP for the first half of month July 2009 was found around 60% of its designed capacity. All the technical detail of the plant is given in the **Table 7**. Schematic diagram of the CETP is shown in **Fig 1**.

4.1 Treatment Process

Primary treatment

Wastewater collected in REPH (raw effluent pump house) is pumped into receiving chamber then passed through a mechanically cleaned bar screen (10mm bar spacing) which is effective in reducing the floating matter. Bar screen was found rusted and spacing between bar was not uniform. The effluent is then passed through a grit chamber (3 No. of channels including 1 standby) to equalisation tank. Grit channels have provisions for the removal of inorganic particle (specific gravity about 2.65).[50] Equalisation tank provided with three mixers facilitates the disturbance of settling, there by homogenize the effluent. The purpose of equalisation is to minimize the wide fluctuation in effluent flow rate and variation in composition of the effluent. No treatment is achieved in equalisation itself. However, the uniformity of effluent produced by this process improves the consistency of performance in subsequent treatment.[45] With the help of pumps wastewater from the equalization tanks is pumped into primary clarifier.

Secondary Treatment

For secondary treatment activated sludge process (ASP) with extended aeration method is used. The overflow from the primary clarifier is admitted into one aeration tank of volume 1296 m^3 having 4 aerator and subjected to mechanical aeration for around 12 hour. Activated sludge is biologically active and can oxidize organic matter. It is obtained by settling sewage from secondary clarifier and contains numerous aerobic bacteria and other form of microorganisms that facilitate the digestion of organic matter

Table 7: Technical detail of Mangolpuri, CETP

Units	**Sizes**	**Design detail based on design flow**
Flow	2.4MLD	-
Bar screen	No. 3, Bar size 10 x 50 mm	10mm bar spacing
Grit chamber	5m x 0.6m x 1.75m Gate 300 x 300mm	3 No. of channels including 1 standby
Equalization basin	20m x 10m x 4m	HRT : 8 h
Primary clarifier	9.6m dia , 3m depth	Flow: 100 m^3/hr
Aeration tank	20m x 20m with 3.75m SWD Air rerequirement: 17.78 m^3/min No. of aerators: 4, 7.5 HP each	HRT:12hr MCRT: 30 days MLSS:3000 mg/l
Secondary clarifier	15m dia , 3m depth	Flow:2400m^3/day Detention time 2hr
Sludge thickener	2.5m dia , 2.5m depth, No. 1	Sludge flow- 23.6 m^3/d
Dual media filter	No. 3, 3 m dia , 2m depth, Media depth 1.25 m	Design pressure 7kg/cm^2
Activated carbon filter	3 m dia,2 m deep vessel, No.2 , Media depth 1.25 m	Capacity 50^3/hr Head 30m
Vacuum filter	0.5 m dia,1 m length No. 1, Filtration area 4.7 m^2	Capacity- 23.6 m^3/d Quantity of sludge to be handled- 500kg/d
Clear water sump	18m x 18m x 4m	Retention time-12 hr

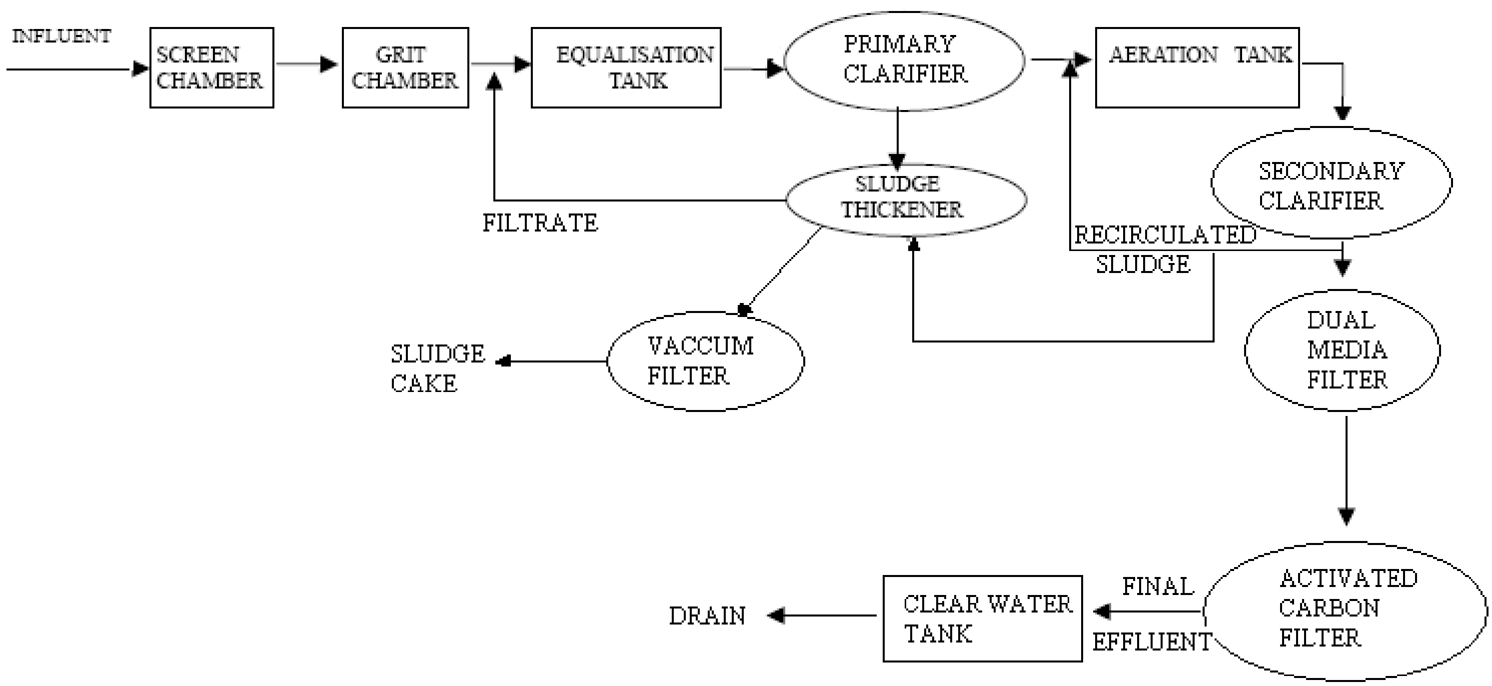

Fig 1 A schematic diagram of treatment unit at CETP Mangolpuri

present in the wastewater. These microorganisms are capable of aerobically decomposing organic matter into CO_2 and H_2O. Sulphur containing compounds are oxidized into sulphate and nitrogen containing components into nitrates[47]. Peavy[48] reported that mechanical aerators produce turbulence at the air and liquid interface and this turbulence entrain air into the liquid. BOD and COD are reduced at shorter period by the aeration process. Here the removal of BOD and COD is found to be maximum.

The overflow from the aeration tanks with active biological solids is admitted into secondary clarifiers of 2 hr detention time having 15m diameter and 3m depth. The settled sludge in the secondary clarifier is pumped back to the aerations tank to maintain the bacteriological population. Here all settled sludge from the secondary clarifier is being pumped back to the aerations tank to maintain the bacteriological population in the aeration tank. In the clarifier tanks, the microorganisms come into contact with both soluble and insoluble organic materials. The soluble material passes through bacterial cell walls and the solid material sticks to the surface of the cells.

Tertiary treatment

The overflow from the secondary clarifier is the partially treated effluent, which is admitted into tertiary treatment process. The effluent from the secondary clarifier is collected on separate DMF (dual media filter)holding tank. It is pumped with 7kg/cm^2 to 3 number of DMF for removal of residual suspended solid. Each DMF have diameter 3m, height 2m and media depth is 1.25m. Finally effluent goes into 2 number of activated carbon filter (through ACF holding tank) for colour and residual BOD removal. Each ACF has 3m diameter and 2m deep. The organic compounds in the effluent can be removed by primary and secondary treatment but complete removal is not possible in these processes and hence the effluent is passed through the adsorbing medium like activated carbon filter. Activated carbon has the ability to reduce the level of organic matter as well as levels of specific trace organics. Hence, considerable amount of organic matter is removed from the effluent, when it is passed through the activated carbon filter.

The activated carbon filter acts as an excellent medium for absorbing odourents. This is mainly due to the diffusion of sulphide ions to surface of the activated carbon, which makes oxidation of sulphide at the carbon surface.[51]

Sludge Removal

The sludge settled in the primary clarifier, secondary clarifier and wasted sludge is taken to sludge well and then pumped to the sludge thickener having 2.5m diameter and 2.5m depth and can handle 23.6 m^3 of sludge per day. The thickened sludge is then dewatered in a vacuum filter. Here vacuum filter was not working so thickened sludge was dewatered by spreading it on the ground. Finally dried sludge is stored at the temporary shed within plant premises itself because of non availability of proper sludge-dumping site. The average sludge production is found to be around 40 kg per day. Treated effluent from the tertiary treatment units is collected in clear water sump of size 18m × 18m × 4m and finally discharged into near by drain through a pressure pipeline.

CHAPTER 5: METHODOLOGY

METHODOLOGY

The survey was carried out over various visits of Mangolpuri, CETP. During the survey design drawings and operation and maintenance manual of the CETP were reviewed. Further all the facilities and provisions of the CETP were physically examined and their dimensional details and capacity details were obtained. Even operation of the CETP was also critically examined. On the basis of the survey process description and process flow diagram of the CETP was obtained. Further, monitoring and experimentation for performance evaluation of the CETP was finalized on the basis of this survey. The observed problems and deficiencies of the CETP were also recorded.

5.1 Analysis techniques

Analysis of the samples has been done by instrumental method. For pH and TDS (total dissolved solids) multiparameter (Make: HACH) is used. Chemical oxygen demand is calculated using COD digester (Make: WTW) and colorimeter (Make: LA-MOTTE). For dissolved oxygen DO meter (LDO, Make: HACH) is used. MLSS (mixed liquor suspended solids) is calculated using gravimetric method.

For conducting tests Environmental Engineering laboratory of Delhi College of Engineering have been used. Design data are used from the “ phase II report (volume II), NEERI, Design of CETP for Mangolpuri Industrial Area , June 7 1996”.

5.2 Performance evaluation

Performance evaluation of the CETP is carried out by taking samples at the four different locations of the CETP and then conducting tests on each sample for pH, TDS, COD, DO, BOD. In addition to that MLSS of the sample in the aeration tank, effluent from secondary clarifier and activated sludge is carried out. The results obtained from performance evaluation studies were compared with the effluent standards prescribed in order to assess compliance with the latter.

CHAPTER 6: RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

After evaluating the analysis result, treated effluent is by and large complying with the effluent standards (given in **Table 8**). Comparison of the result of analysis of the treated effluent with the standards indicates non-compliance with respect to TDS.

Table 8: Comparison of treated effluent with the standards under EPA Rules

Parameter	Raw wastewater	Treated wastewater	EPA standard (Into inland surface water)
pH	8.06	7.96	5.5-9.0
BOD_5 (mg/L) at 20^o C	178	16	30
COD (mg/L)	410	70	250
TDS (mg/L)	3557	2990	2100

Source: Schedule-1 of EP Rules, 1986

The receiving effluent is biodegradable, as BOD to COD ratio is 0.43, are in the range of 0.3-0.8.[19] After subsequent treatment stages i.e. primary, secondary and tertiary treatment the BOD to COD ratio is found to be 0.49, 0.24 and 0.23 respectively which resembles the effluent to the municipal waste water.[19] Further BOD to COD ratio is less than 0.6 suggests the requirement of acclimatisation before biological treatment i.e. gradual exposure of the waste water in increasing concentration to the seed or initial microbiological population under controlled condition.[50] The significant decrease in BOD to COD ratio after secondary treatment shows secondary treatment unit is working efficiently.

The MLSS concentration in the aeration tank is found to be 2110. At the actual flow of 1.49 MLD the food to microorganism ratio (F/M) is calculated as 0.058 which is on the lower side of the prescribed range (0.05-0.15) for the extended aeration**.**[44] The removal efficiency for BOD in the secondary treatment is 78.57% while it should be little bit high. The low value of removal efficiency can be attributed to the low value of F/M ratio. The value of F/M ratio can be increased by decreasing the MLSS concentration in the aeration tank. The MLSS concentration of activated sludge is found to be 8695. Recirculation ratio is calculated as 0.32, not lying in the prescribed range (0.5-1.0).[50] Volumetric organic loading is calculated as 0.22 kg BOD_5 per m^3 per day, touching the lower side of the prescribed range (0.2-0.4). The MLSS concentration of effluent from secondary clarifier is calculated as 34 mg/ L using this, sludge age or solid retention time (SRT) or mean cell residence time (MCRT) is calculated as 49 days not lying in the permissible range. The high value of SRT is due to all sludge from secondary clarifier is re circulated to the aeration tank.

The removal efficiency at different stages of the treatment for BOD, COD and TDS has shown in **Table 9**. The overall efficiency for BOD, COD and TDS removal is 91.01%, 82.92% and 15.94% respectively which is satisfactory except for TDS. The overall treatment of BOD, COD and TDS is shown in **Table 10.**

Table 9: Efficiency of different treatment units

Parameter	Primary treatment	Secondary treatment	Tertiary treatment	Overall treatment
BOD (mg/L)	44.94%	78.57%	23.80%	91.01%
COD (mg/L)	50.73%	57.42%	18.60%	82.92%
TDS (mg/L)	0.2%	1.97%	14.08%	15.94%

Table 10: Character of effluent at different stages of CETP

Parameter	Raw	Primary clarifier outlet	Secondary clarifier outlet	Tertiary clarifier outlet
pH	8.06	8.09	8.32	7.96
BOD (mg/L)	178	98	21	16
COD (mg/L)	410	202	86	70
TDS (mg/L)	3557	3550	3480	2990
DO (mg/L)	0.5	0.4	3.74	4.18

The value of pH at subsequent stage is shown in **Table 10**. which shows the effluent is slightly alkaline. But it is not a matter of concern since it lies well within permissible range.

The CETP is designed for 2.4 MLD capacities. However the average quantity of effluent received during study period is around 1.49 MLD, which shows that the capacity of the CETP is under utilized. The reason of less flow reaching the CETP sites may be due to untapped industrial discharge or choked or silted collection system or deficiencies in conveyance system.

The DO concentration in aeration tank has been found 4.25. The sudden increase of DO level in aeration tank shows that the mechanical aeration is quite effective. In general, the dissolved oxygen concentration in the aeration tank should be maintain at about 1.5 to 2 mg/L in all areas of aeration tank. Higher DO concentration (>2 mg/L) may improve nitrification rates in the reactor with high load. Values above 4 mg/L do not improve operation significantly, but increase the aeration costs considerably.[19]

The final effluent has DO 4.18 which certainly will help to reduce the BOD further and improve nitrification rate. The variation of DO concentration at different stage of treatment is shown in **Fig. 2**.

The overall removal efficiency for TDS is quite low 15.94%, since there is no any specific method is being used for TDS removal. The value of TDS in the treated effluent is 2990 mg/L greater than the prescribed standard shown in **Table 8**. By doing survey in some industrial units this has been found that most of the industrial unit using ground water for their industrial activity which is already having high value of TDS. Location specific regulations at the industry level can be done.

Around 40 kg sludge per day is being produced in the plant. The approximate value of total sludge till 6th July 2009 from the first day of its inception is 60199 kg. Due to non availability of proper sludge-dumping site all the sludge collected till date is stored in the temporary shed at CETP premises itself. This is matter of grave concern.

The removal of BOD, COD and TDS at the different stage of treatment is shown in **Fig. 3, 4 and 5** respectively.

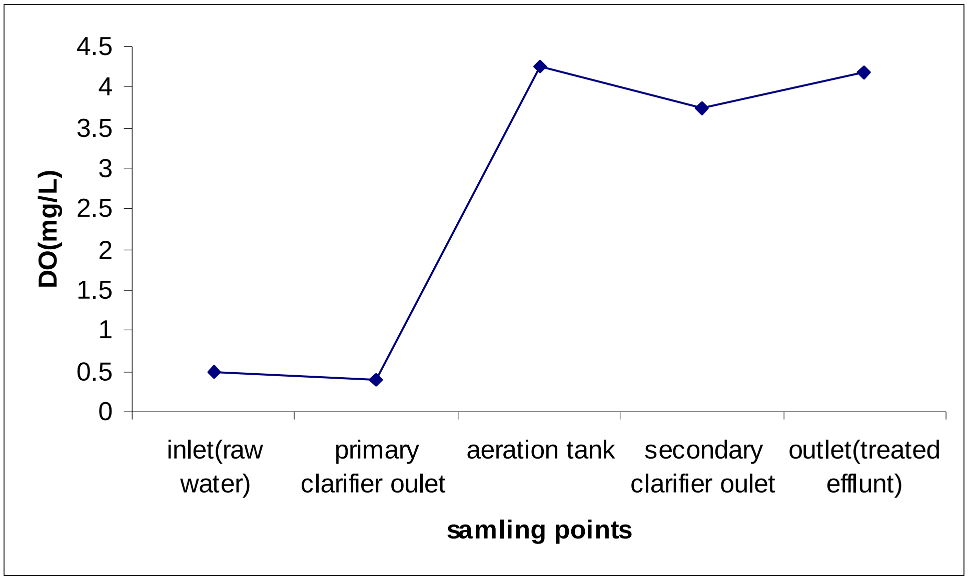

Fig 2: DO level at different stages of treatment

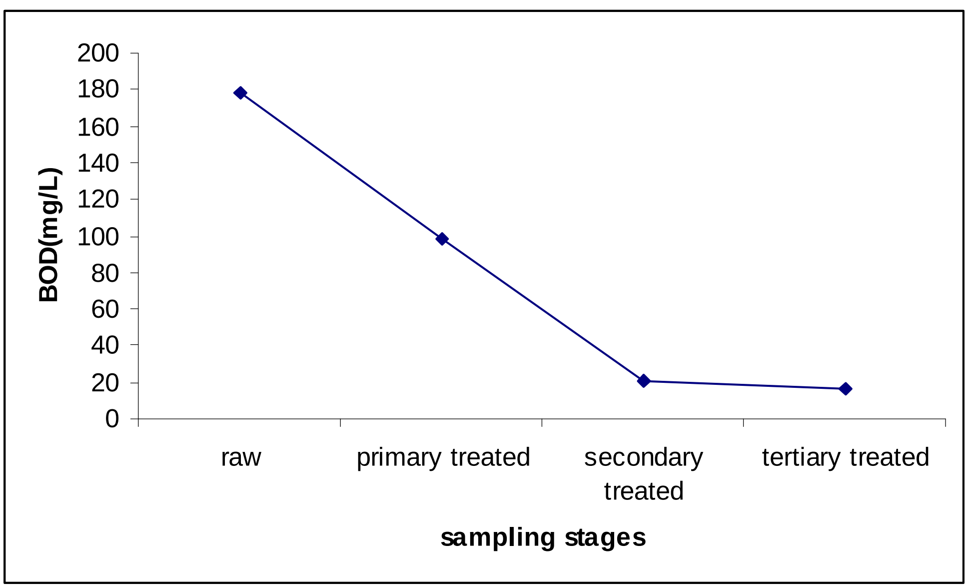

Fig 3: BOD at different stages of treatment

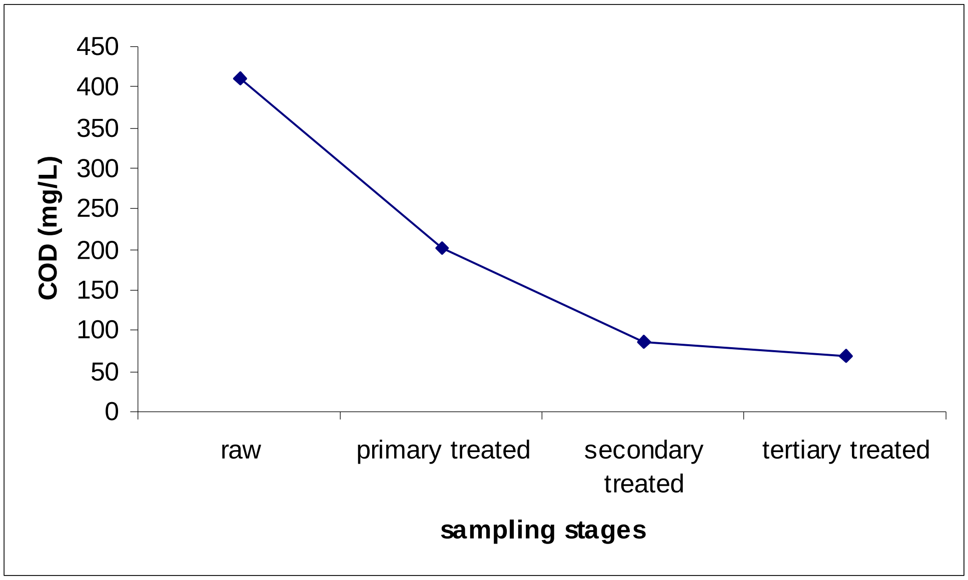

Fig 4: COD at different stages of treatment

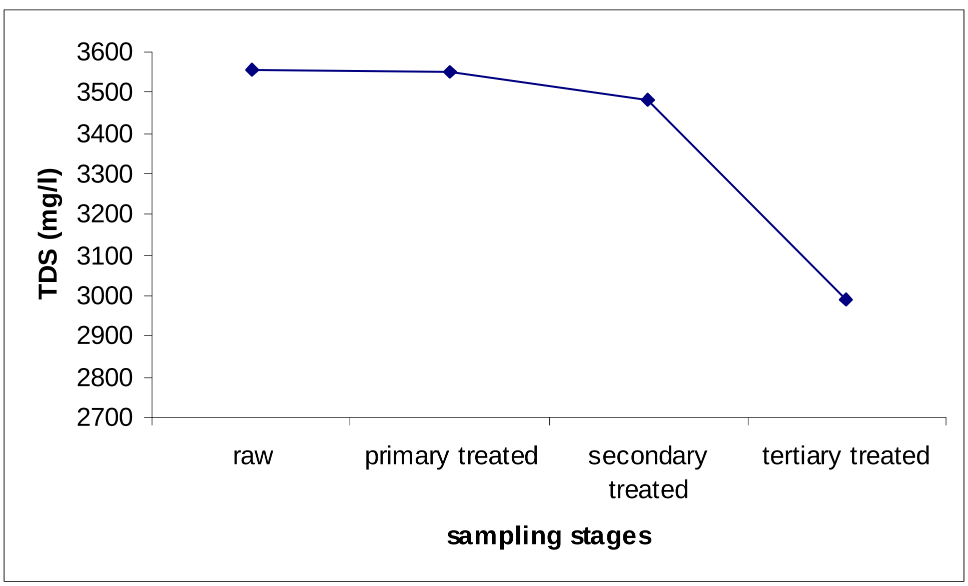

Fig 5: TDS at different stages of treatment

CHAPTER 6: CONCLUSION

CONCLUSION

The study indicates that all the major pollutants (pH, BOD, COD and TDS) were significantly reduced during the treatment process except for TDS. The pH, BOD, COD and TDS of the raw effluent were recorded to be 8.06 mg/L, 178mg/L, 410mg/L, 3557 mg/L respectively while the mean value of the same parameter in the treated effluent estimated to be 7.95 mg/L, 16mg/L, 70mg/L, 2990mg/L respectively. The percentage removal in throughout the whole treatment is calculated to be 91.01% for BOD, 82.92% for COD and 15.94% for TDS.

Reduction BOD/COD ratio reduced to 0.23 in the treated effluent from 0.43 in the raw effluent showing significant removal of organic matters. At the same time BOD/COD ratio in the raw effluent 0.43 suggests acclimatisation of waste water can be done before biological treatment.

The percentage of BOD removal in the secondary treatment is found to be 78.57%. Slightly lower BOD removal efficiency of secondary treatment can be attributed to low value of food to microorganism ratio (F/M) in the aeration tank. The F/M ratio can be increased by decreasing the MLSS concentration in the aeration tank. This will also help in decreasing the SRT (solid retention time) which is currently high (49 days).

The DO concentration in aeration tank has been found 4.25. While its value should be lied between 1.5 to 2 mg/L. The value greater than 4 mg/L increases the cost of aeration.

The value of effluent received during study period is found to be 50-60% of its design capacity. Necessary action should be taken to increase the in flow of waste to CETP.

All the sludge produced has been found to be stored in the temporary shed in the plant premises. Necessary action should be taken to either look for some utilisation of sludge or ensure the availability of proper sludge-dumping site at the earliest.

The percentage removal of TDS is found to be comparatively low than other parameter at the same time its value in the treated effluent is not meeting the standard limit. As industrial units using ground water for their need we can think about recycling the waste after proper treatment.

The following methods may be considered for removal of TDS:

1. **Nanofiltration(NF):** Nanofiltration, also known as "loose" RO or low pressure RO (LPRO), can reject particles as small as 0.001 µm. The membrane is made up of cellulose acetate coated with thin layer of another polymer often a polymide. It is used for removal of selected dissolved constituents from wastewater such as the multivalent metallic ions responsible for hardness.[19] Because both inorganic and organic constituents and bacteria and viruses are removed and water can be reuse for gardening or recycled back to industries..

It can operate at pressures as low as 500 kPa and can be as high as 1,000 kPa with rate of flux 200-815 L/m^2.d. While RO operates at pressure in the range of 850-7000 kPa and rate of flux in the range of 200-815 L/m^2.d. From the energy point of view NF requires 5.3 kWh/m^3 while RO needs 10.3 kWh/m^3. [19]

Due to the lower operating pressure and higher flow rates, nanofiltration is inexpensive when compared to reverse osmosis. It require less energy, less capital and membrane replacement cost than RO. This method becomes more effective when water is pretreated with UF (ultra filtration).[52] NF provides high treatment barrier efficiency towards micro-organisms.

The fractionation of secondary wastewater showed that a significant fraction of organics has molecular weight below 10,000, [54] they cannot be removed by UF, but most of them can be retained by NF membranes. The inorganic salts by loose NF membranes are removed by the charge effect of the membranes and ions. Membranes can be installed in modules as; flat sheet, spiral wound, tubular, capillary, hollow fiber. Nevertheless, the NF membrane has productivity loss which occurs due to the following mechanisms:

(i) biological fouling which is the growth of biological species on the membrane surface at the feed side. In time this might hamper the selectivity and productivity of the separation process.

(ii) colloidal fouling which results in a loss of flow through the membrane,

(iii) Organic fouling which may occur and can hardly be predicted, and

(iv) scaling which is defined as the formation of mineral deposits precipitating from the feed stream to the membrane surface.

The low pressure driven NF unit with pre-treatment like adsorption and ultra filtration (UF) can successfully be used in wastewater reuse with practically no membrane fouling.[53]

Ion exchange method: This is an unit process in which ions of a given species are displaced from an insoluble exchange material by ions of different species in solution. The key component of a water softener is the ion-exchange resin contained inside a tank. The tank can have manual or automatic controls to regenerate the ion-exchange resin Ion-exchange resin is manufactured from polystyrene that is cross-linked with divinylbenzene. It consists of small plastic spheres about the size of the head of a common pin. The resin has positively charged sodium cations held on the resin surfaces by electrostatic charges. The sodium cations are exchanged for cations of calcium, magnesium, and dissolved iron in the water. Once all of the sodium cations are exchanged, the resin is exhausted. It must be replaced with new resin or be regenerated (reversing the process) by flowing concentrated sodium chloride brine through the resin. Naturally occurring ion-exchange material, known as zeolites, are widely used for softening for water.

For the reduction of TDS, both anionic and cationic–exchange resins must be used. The wastewater is first passed through a cation exchanger where the positively charged ions are replaced by hydrogen ions. The cation-exchanger effluent is then passed over anionic-exchange resins where the anions are replaced by hydroxide ions. Thus, the dissolved solids are replaced by hydrogen and hydroxide ions that reacts to form water molecules. Wastewater application rates range from 0.20 to 0.40 m^3/m^2.min. Typical bed depths are 0.75 to 2.0m. [19] In reuse applications, certain portion of the treated wastewater by ion exchange, followed by blending with wastewater not treated by ion exchange, would possibly reduce the dissolved solid.

CHAPTER 7: FURTHER SCOPE FOR STUDY

FURTHER SCOPE FOR STUDY

Since the sludge does not contain any toxic/hazardous substance the study can be taken by mixing the sludge with municipal solid waste for composting.

The further study regarding co-firing with municipal solid waste for energy recovery can be done.

Since most of the industrial units are using huge ground water for their industrial process. The study regarding the recycling of effluent for industrial processes after allowing further treatment like reverse osmosis, nano filtration, ion exchange etc.

The study regarding under utiisation of plant capacity can be done.

Attempt can be taken to convert the sludge in to activated carbon.

REFERENCES:

1. National Environment Policy. (2004), Ministry of Environment and Forests, Government of India, New Delhi (Draft).
2. Prasad B.M. (2000) “An overview of CETP’s in India”. CPCB, Delhi.
3. World Bank. (1991), “Industrial Pollution Control Projects, India: Feasibility Assessment of Common Treatment Facilities in Gujarat, Maharashtra and Tamil Nadu”. Prepared for the World Bank by Chemcontrol A/S, Denmark.
4. Sangeeth Aiyappa (2004), Working Paper Series, No. 2,Common Effluent Treatment Plants Technology & Treatment Process: The Alternative Strategies
5. Design of CETP for Industrial estate in NCT of Delhi, Volume II, phase II report, page no. 5, National Environmental Engineering Research Institute (NEERI), June 7,1996
6. D. Biswas. (2000), “Performance evaluation of Common Effluent Treatment Plants”, CPCB
7. CPCB. (2001), “Common Effluent Treatment Plants”. Parivesh Newsletter, January 2001, Central Pollution Control Board, Delhi.
8. Pophali, G. R.; Kaul, S. N. and Mathur, S. (2003), “Influence of hydraulic shock loads and TDS on the performance of large-scale CETPs treating textile effluents in India” Water Reaserch volume37 issue 2 Pages 353-361
9. Ramakrishna1, V. and Babu, B. V. (2000), “Positive Decision Making in Waste Management towards Achieving Sustainable Development”. Birla Institute of Technology & Science, Pilani, Rajasthan, India. http://bvbabu.50megs.com
10. Kathuria, V. (2003), “Failure of Collective Action as an Institution – Lessons from Kundli, Haryana”. Institute of Economic Growth, Delhi,
11. Pathe, P.P.; Kumar, S.; Kharwade, M.; and Kaul, S.N. (2004), “Common Effluent Treatment Plant (CEPT) for Wastewater Management from a Cluster of Small Scale Tanneries”. Environmental Technology, Volume 25, Number 5, pp. 555-563
12. M. and Dubey, S. (2000), “Common Effluent Treatment Plant a solution or a problem in itself” Toxics Link (a non profit environmental organization)

13. Eswaramoorthi, S.; Dhanapal, K. and Karpagam, J. (2004), “Zero Discharge - Treatment Options for Textile Dye Effluent: A Case Study at

14. Kurian, J. (2000), “Studies on Hosiery Textile dyeing Effluents for minimization of Total Dissolved Solids by Low Salt Dyeing at Low Liquor Ratio and Decolourisation by Physico chemical Treatment”. Ph.D Thesis, Centre for Environmental Studies, Anna University, Chennai.

15. Kurian, J. (2004), “A cleaner production approach for minimization of total dissolved solids in reactive dyeing effluents". Centre for Environmental Studies, Anna University, Chennai.

16. Tare, V.; Gupta, S. and Bose, P. (2003), “Case Studies on Biological Treatment of Tannery Effluents in India”. Environmental Engineering and Management Program, Department of Civil Engineering, Indian Institute of Technology, Kanpur, India J. Air & Waste Manage. Association. vol 53: 976–982, ISSN 1047-3289

17. Manjari Maheswari and Sunita Dubey, Common Effluent Treatment Plant, A solution or a problem in itself, Toxic Link, November 2000

18. US EPA “ Centralized Treatment Facility for Hazardous and Non-Hazardous Waste generated by Small and Medium Scale Industries in Newly Industrialized Countries. EPA/625/K-95/001.

19. Metcalf and Eddy. (2003), “Wastewater Engineering: Treatment and reuse” McGraw-Hill, Inc., Singapore.

20. American Society of Civil Engineers/ Water Pollution Control Federation,. “ Design and Construction of Sanitary and Storm Sewers”, Manual of Practice 9, ASCE, New York.

21. U.S. EPA 1995. Development Document for proposed Effluent Limitations, Guidelines and Standards for Centralized Waste Treatment Industry. EPA/821/R-95/006, Washington.

22. U.S. EPA. 1977a, Operator Manual : Stabilization Ponds, EPA/430/9-77/005, Washington & U.S.EPA. 1981b, Generic Facilities Plan for a Small Community: Stabilization Pond & Oxidation Ditch, EPA/430/09-81/007, Washington.

23. R.L, 1985, Technology Assessment of Sequencing Batch Reactors, EPA/600/2-85-007.
24. Ministry of Environment and Forests (MOEF). (1974), “The Water (Prevention and Control of Pollution) Act, 1974, amended 1988”. No.6 of 1974, [23/3/1974]
25. Ministry of Environment and Forests (MOEF). (1989), “The Hazardous Wastes (Management and Handling) Rules, 1989”. S.O.594 (E), [28/7/1989]
26. of Environment and Forests (MOEF). (1986), “The Environment (Protection) Rules, 1986”. S.O.844 (E), [19/11/1986].
27. Ministry of Environment and Forests (MOEF). (2004), “The Environment (Protection) Second Amendment Rules 2004” G.S.R.448 (E), [12/07/2004]
28. Ministry of Environment and Forests (MOEF). (1977), “The Water (Prevention and Control of Pollution) Cess Act, 1977, amended 1992”. No.36 of 1977, [7/12/1977]
29. of Environment and Forests (MOEF). (2003), “The Water (Prevention Control of Pollution) Cess (Amendment) Act, 2003”. No. 19 of 2003, [17/3/2003]
30. of Environment and Forests (MOEF). (2000), “The Hazardous Wastes Management and Handling) Amendment Rules, 2000” S.O.24 (E), [6/1/2000]
31. Ministry of Environment and Forests (MOEF). (1989), “The Manufacture, and import of Hazardous Chemical Rules, 1989”. S.O.966 (E), 27/11/1989]
32. Ministry of Environment and Forests (MOEF). (2000), “The Manufacture, Storage and Import of Hazardous Chemical (Amendment) Rules, 2000”. S.O.57 (E), [19/1/2000]
33. Ministry of Environment and Forests (MOEF). (1974), “The Water (Prevention and Control of Pollution) Act, 1974, amended 1988”. No.6 of 1974, [23/3/1974]
34. Ministry of Environment and Forests (MOEF). (2000), “Noise Pollution Regulation and Control) Rules 2000”. S.O.123 (E), [14/2/2000]
35. Central Pollution Control Board, Delhi

36. Bank 1991, Industrial Pollution Control Projects, India: Feasibility Assessment of Common Treatment Facilities in Gujarat, Maharashtra and Tamil Nadu. Prepared for the World Bank by Chemcontrol A/S, Denmark.
37. Common Effluent Treatment Plant, NEERI Report, Pg. No. 2-13
38. The Hindu (Aug 06, 2004), on CETPs in New Delhi
39. Report of the visit of the SCMC to Tamilnadu (September 20-22,2004)
40. The Statesman (24 September 2000), with regard to 'The Kaul Committee' report on Control of Pollution in Kali Nadi Basin.
41. Economic Assessment of Environmental Damage: A Case Study of Industrial Water Pollution in Tiruppur; By Paul P.Appasamy with Prakash Nelliyat, N.Jayakumar and R.Manivasagan; Madras School of Economics, Chennai.URL - http://coe.mse.ac.in/eercrep/abs/appasamy_abs.pdf
42. Refer: - CPCB Annual Report 2002 – 2003: Chapter X. URL - http://www.cpcb.nic.in/ar2003/ar2-3ch10-1.htm
43. CPCB Report, Highlight 2005
44. G.L. Karia and R.A Christian, (2006) Waste Water treatment: Concept and Design Approach, Prentice-Hall of India Pvt. Ltd.
45 Curtis C., Penzer and Komanowsky M., Waste treatment strategy : A guide through the Maze., J. Am. Leather Chemists Assoc., 80, 167-149 (1985).
46. Vasicek, P.R., Use of a kinetic study to optimise the activated sludge process, J.Water Poll.Cont.Fed., 54 (8), (1982).
47. Klemenc,B. and A.Gantar, Odour control in leather production, J. Society Leather Tecno. Chemists., 50, 11-14 (1995).
48. Peavy, H.S., Rrowe D.R. and Tchobanoglous.G., Environmental Engineering, Mc Graw Hill , Singapore (1987).
49. P.Govindasamy, S.D.Madhavan, S.Revathi and Shanmugam(2006) Performance evaluation of common effluent treatment plant for tanneries at Pallavaram, Journal of environ. Science & engg. Vol 48,no 3, p. 213-220,July 2006
50 S.K.Garg, (2007), Sewage Disposal and Air Pollution Engineering, Khanna Publishers

51. Sekaran,G.K.Chitra and M.Mariappan,. Removal of sulphide in tannery efluent by wet oxidation, J. Sci. Leathr Techno.Chemists. 79,123-126 (1995).

52. Membrane process for TDS reduction, evaluating the feasibility, efficiency and limitation of using RO or NF, Eric R. Mortensen, Y. Cath, Keith E. Dennett and Amy E. Childress.HDR waterscapes, vol 19, issue 1

53. Low pressure nanofiltration with adsorption as a pretreatment in tertiary wastewater treatment for reuse, H. K. Shon.1, S. Vigneswaran.,H. H. Ngo. and Ben Aim , Faculty of Engineering, University of Technology, Sydney, P.O. Box 123, Broadway, NSW 2007, Australia.

54. D. Abdessemed, G. Nezzal and R. Ben Aim, Fractionation of a secondary effluent with membrane separation. Desalination, 146 (2002), 433-437 vel can be one way to control TDS.