

PERFORMANCE EVALUATION OF COMMON EFFLUENT TREATMENT PLANTS OF DELHI

A DISSERTATION

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(With Specialization in Industrial Pollution Abatement)

By

KAMLESH SINGH



**DEPARTMENT OF CHEMICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ROORKEE -247 667 (INDIA)
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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
CANDIDATE'S DECLARATION

I hereby declare that the work, which is being presented in the dissertation entitled "PERFORMANCE EVALUATION OF COMMON EFFLUENT TREATMENT PLANTS OF DELHI" in the partial fulfillment of the requirements of the award of the degree of Master of Technology in **CHEMICAL ENGINEERING** with specialization in **INDUSTRIAL POLLUTION ABATEMENT**, submitted in the Department of Chemical Engineering, Indian Institute of Technology Roorkee, Roorkee, is an authentic record of my own work carried out during the period from July 2007 to June 2008 under supervision of **Dr. B. PRASAD**, Associate Professor, Department of Chemical Engineering, Indian Institute of Technology, Roorkee, Roorkee.


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

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Place: IIT Roorkee


26/6/08
(KAMLESH SINGH)

CERTIFICATE

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


(Dr. B. PRASAD)

Associate Professor,
Department of Chemical Engineering
Indian Institute of Technology Roorkee
Roorkee - 247667 (India)

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(KAMLESH SINGH)

Date:

ABSTRACT

The concept of effluent treatment, by means, of a collective effort, has assumed reasonable gravity by being especially purposeful for cluster of small scale industrial units. Common effluent treatment plant (CETP) not only helps the industries in easier control of pollution, but also act as a step towards cleaner environment and services to the society at large. Establishment of CETP shows positive approach of industries Associations towards pollution control. Performance evaluation can help in continual improvement in performance of CETPs.

The present study relates to performance evaluation of 11 Common effluent treatment plants treating the effluents generating from cluster of small scale industry in the Delhi region. Wastewater from about 7,000 thousand small-scale industries is treated in these CETPs. The chemical parameters which were monitored are pH, COD, BOD, TSS, TDS, and Oil & Grease. It was found that most of the CETPs were under utilized as they were receiving effluent very low than their design capacity. The industrial units were not providing desired primary treatment before sending to CETP. It was found that only three CETPs viz. GT Karnal Road, Badli, and Narela were complying the stipulated standards in all respect. All the CETPs were in operation but the Wazirpur CETP was closed due to high level of pH (<2) in the effluent wastewater. Biological treatment has been carried out only in Mangolpuri CETP. After treatment, the effluent is disposed off in Yamuna through drain. The groundwater samples were taken from each of the CETP area to find out the Total dissolved solid (TDS) in the groundwater. The TDS level in Mangolpuri, Lawrence Road, Nangloi, and Jhilmil groundwater samples were not complying the prescribed standards.

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INTRODUCTION

1.1 GENERAL

Our biosphere is under constant threat from continuing environmental pollution. Impact on its atmosphere, hydrosphere and lithosphere by anthropogenic activities on water, air and land have negative influence over biotic and abiotic components on different natural eco-systems. In recent years different approaches have been discussed to tackle man made environmental hazards. Clean technology, eco-mark and green chemistry are some of the most highlighted practices in preventing and or reducing the adverse effect on our surroundings.

Urbanisation and need for better living has increasingly generated requirement of consumer goods and infrastructural inputs. Within market potential and easy finance available, the mushrooming rise in the number of small scale industries can be seen in any Indian city. Besides being a resource for market economy and production of large number of consumer items, it is generally observed that, either due to their economies of scale coupled with their unplanned growth and dearth of affordable and cost-effective treatment technology, efforts by small scale units in achieving the environmental compilation have not been effective. There large number and diverse trade has further aggravated the problem. Under these constraints, setting-up of individual full fledged treatment device is no longer feasible. Hence the desirable option is of the shared or combined treatment, wherein, managerial and operational aspects are collectively addressed and the cost of treatment, becomes affordable as enunciated in the scheme of the common effluent treatment plants, which are providing to be a boon especially for small entrepreneurs, given the methodical planning, regular operation and equitable contribution of member units, Such common facilities also facilitate proper management of effluent and compliance of the effluent quality standards [CPCB, 2001].

The concept of effluent treatment, by means, of a collective effort, has assumed reasonable gravity by being especially purposeful for cluster of small scale industrial units. Common effluent treatment (CETP) not only helps the industries in easier control of pollution, but also act as a step towards cleaner environment and services to the society at large. Small scale industries, by their very nature of job cannot benefit much from economies of scale and therefore the burden of installing pollution-control equipment, falls heavy on them. Realising this practical problem, under the policy statement for abatement of pollution the Govt. felt to extend the scheme for promoting combined facilities for treatment of effluent and management of solid waste for clusters of small scale industrial units and also to provide technical support to them. Accordingly, Ministry of Environment & Forests, Govt. of India, had instructed various State Pollution Control Boards, to examine the possibilities of establishing CETPs in various industrial estates in the respective states [CPCB, 2001].

Wastewaters are waterborne solids and liquids discharged into sewers that represent the wastes of community life. Wastewater includes dissolved and suspended organic solids, which are putrescible or biologically decomposable. Two general categories of wastewaters, not entirely separable, are recognized: domestic and industrial.

Wastewater may be classified into four categories:

- **Domestic:** wastewater discharged from residences and commercial institutions and similar facilities
- **Industrial:** wastewater in which industrial waste predominates
- **Infiltration/Inflow:** extraneous water that enters the sewer system through indirect and direct means such as through leaking joints, cracks, or porous walls. Inflow is storm water that enters the sewer system from storm drain connections, roof headers, foundation and basement drains or through manhole covers.
- **Storm water:** runoff resulting from flooding due to rainfall [Metcalf & Eddy (2003)].

1.2 CATEGORIZATION OF WASTEWATER

The two main sources of wastewater are domestic and industrial wastewater and are obviously derived largely, from the pattern of water consumption.

1.2.1 DOMESTIC WASTEWATER

Domestic wastewater is composed of human body waste (faeces and urine) and sullage, which is the wastewater resulting from washing, laundry, food preparation and the cleaning of kitchen utensils.

1.2.2 INDUSTRIAL WASTEWATER

The characteristics of industrial wastewaters can differ considerably both within and among industries. The impact of industrial discharges on disposal sites depends not only on their collective characteristics such as biochemical oxygen demand and the amount of suspended solids, but also on their content of specific inorganic and organic substances. Three options are available in controlling industrial wastewater. Control can take place at the point of generation in the plant; wastewater can be pre-treated for discharge to municipal treatment sources; or wastewater can be treated completely at the plant and either reused or discharged directly into receiving waters.

Industrial wastewater is the discharge of industrial plants and manufacturing processes. Industrial wastewaters can represent, collectively, an important part of community wastewaters and must be considered for successful wastewater treatment plant operation. In some locations industrial wastewater discharge is collected together with other community wastewaters and the mixed wastes are treated together. In other instances, industries may provide some pretreatment or partial treatment of their wastewaters prior to discharge to the municipal sewers sanitary wastewater per person per day. In addition to equivalent populations, it is desirable to express the quantity of

wastewater produced per unit of raw material processed or finished product manufactured [Metcalf & Eddy (2003)].

1.3 CHARACTERISTICS OF INDUSTRIAL WASTEWATER

Industries with prescribed limits ordinarily discharge their wastewater to the city's common treatment system after pre treatment. In joint processing of wastewater, the CETP accepts responsibility of final treatment and disposal. The majority of manufacturing wastes are more amenable to biological treatment after dilution with domestic wastewater; however, large volumes of high-strength wastes must be considered in sizing of a municipal treatment plant. Uncontaminated cooling water is directed to the storm sewer.

The concerned approach of joint or common effluent treatment provisions has many advantages. Wastewater of individual industries often contain significant concentration of pollutants; and to reduce them by individual treatment upto the desired concentration, become techno-economically difficult. The combined treatment provides a better and economical option because of the equalization and neutralization-taking place in the CETP.

Other important issues for the merit of common treatment include, scarcity of land at the industry's level and a comparatively easier availability of professional and trained staff for the operation of CETP, which an otherwise be difficult, at the individual industry level. For the regulatory authorities also, common treatment facility offers a comparatively easier means of ensuring compliance of stipulated norms. The handling and disposal of solid-waste also becomes increasingly easier as the infrastructure is created in the project itself. The concept of common effluent treatment, based on feasibility, should be part of the new industrial estates as essential component of infrastructure, In fact, nature of activity are located in a cluster which in turn can facilitate in providing common treatment [Hammer & Hammer (2002)].

1.4 WASTEWATER TREATMENT

Wastewater treatment is a process in which the solids in wastewater are partially removed and partially changed by decomposition from highly complex, putrescible, organic solids to mineral or relatively stable organic solids. Primary and secondary treatment removes the majority of BOD and suspended solids found in wastewaters.

Wastewater obtained from industries are generally much more polluted than the domestic or even commercial waste waters. Still, however, several industries try to discharge their effluents into our natural river streams, through unauthorized direct discharges. Such a tendency on the part of the industries may pollute the entire river to a grave extent, thereby making its purification almost an impossible task. Sometimes, the industries discharge their polluted waste water into municipal sewers, thereby making the task of treatment that municipal sewage, a very difficult and a cost exercise.

The industries are, therefore, generally prevented by legal laws, from discharging their untreated effluents. Its, therefore, becomes necessary for the industries to treat their waste waters in their individual treatment plants, before discharging their effluents either on land or lakes or rivers, or in municipal sewers, as the case may be [Metcalf & Eddy (2003)].

Industrial waste waters usually contain several chemical pollutants and toxic substances in too large proportions. The characteristics of the produced waste water will usually vary from industry to industry, and also vary from process to process even in, the same industry. Such industrial waste water cannot always be treated easily by the normal methods of treating domestic wastewater, and certain specially designed methods or sequence of method', may be necessary.

In order to achieve this aim, it is generally always necessary and advantageous to isolate and remove the troubling pollutants from the wastewaters, before subjecting them to usual treatment processes. The sequence of treatment processes adopted should also be

such as to help generate useful by-products. This will help economize the pollution-control measures, and will encourage the industries to develop such treatment plants [Garg (2002)].

Depending upon the quantum, concentration, toxicity and presence of non-biodegradable organics in an industrial wastewater, its treatment may consist of any one or more of the following processes:

1. Equalization;
2. Neutralization;
3. Physical Treatment;
4. Chemical treatment; and
5. Biological treatment;

COMMON EFFLUENT TREATMENT PLANT

2.1 COMMON EFFLUENT TREATMENT PLANT

The Ministry of Environment & Forests has undertaken a Centrally Sponsored Scheme for enabling the Small Scale Industries (SSI) to set-up Common Effluent Treatment Plants in the country for installation of pollution control equipment for treatment of effluents. The SSIs are polluting the environment through their effluents but some of them are unable to afford installation of pollution control equipment. In order to encourage use of new technologies for CETPs for existing SSI clusters of units a scheme for financial assistance has been formulated [CPCB, 2001].

In common effluent treatment plants, treatment system comprise of primary and secondary that meets the prescribed effluent standards for discharge on in land surface water. Primary treatment comprises a physico-chemical process, wherein a flash mixer and a clariflocculator are used to ensure substantial removal of COD and SS and to some extent BOD. Secondary treatment consists of an aeration tank and a secondary clarifier wherin BOD, COD, and SS are substantially removed.

Primary treatment removes the larger floating and suspended solid matter, grit and also much of the oil and grease content if present in an appreciable amount. Under normal circumstances primary treatment is considered to remove approx. 30 to 50% of the contaminants in the wastewater. The essential stages for treatment are:

- **Screening** - Screening is the very first operation carried out at a effluent treatment plant, and consists of passing the wastewater through different types of screens, so as to trap and remove the floating matter, such as pieces of cloth, paper, wood, cork, hair, fiber, kitchen refuse, fecal solids, etc. present in effluent. These floating materials, if

not removed, will choke the pipes, or adversely affect the working of the pumps. Thus, the main idea of providing screens is to protect the pumps and other equipments from the possible damages due to the floating matter of the effluent. Screens should preferably be placed before the grit chambers. However, if the quality of grit is not of much importance, as in the case of land filling, etc., screens may even be placed after the grit chambers themselves [Garg (2002)].

- **Grit removal** - Grit chambers, also called grit channels, or grit basins, are intended to remove the inorganic particles (specific gravity about 2.65), such as sand, gravel, grit, egg shells, bones, etc. of size 2mm or larger to prevent damage to the pumps, and to prevent their accumulation in sludge digesters. Grit chambers are, infact nothing but like sedimentation tanks, designed to separate the intended heavier inorganic materials by the process of sedimentation due to gravitational forces, and to pass forward the lighter organic materials. They may be placed either before or after the screens. A grit chamber is an enlarged or an long basin, in which the cross-section is increased, so as to reduce the flow velocity of sewage to such extent that the heavy inorganic materials do settle down by gravity, and the lighter organic materials remains in suspension, and, thus, go out along with the effluent of the grit basin. The importance point in the design of the grit basins is that the flow velocity should neither be too low as to cause the settling lighter organic matter, nor should it be so high as not to cause the settlement of the entire silt and grit present in effluent [Garg (2002)].

- **Equalisation** - Equalization consists of holding the wastewater for some pre-determined time in a continuously mixed basin, to produce a uniform wastewater. Such an arrangement will, of course be necessary when the wastewater produced by the industry varies in characteristics and quantity over the entire day. The effluents are not having similar concentrations at all the time; the pH will vary time to time. The effluents were stored from 8 to 12 hours in the equalization tank. This will result in a homogenous mixing of effluents and helps in neutralization. In addition, it eliminates shock loading on the subsequent treatment system. Continuous mixing also eliminates settling of solids within the equalization tank.

- **Flash mixer-** Coagulants were added to the effluents. They are Lime (800-1000ppm) -To raise the pH 8-9, Ferrous sulphate (200-300ppm) - to remove colour and to form flocs, and Poly electrolyte (0.2ppm) - to settle the suspended matters. According to the above proportions the chemicals were added and mixed with the effluents. The addition of the above chemicals by efficient rapid mixing facilitates homogeneous combination of flocculates to produce microflocs.

- **Sedimentation** - Sedimentation as we know is employed to separate the heavier settleable solids. And hence sedimentation tank may be provided only when the wastewater contains a high percentage of such heavy inorganic solids. This can be done with or without mechanical or chemical flocculation. The retention time depends on the further treatment processes, such as nitrification/denitrification

- **Primary clarifiers** - Primary clarifiers are settling tanks that separate the suspended solids from the primary effluent. The wastewater is also flocculated with additives like polymer and alum to fasten the settling process.

- **Aeration** - It consists of creation of fine air bubbles in the waste tank, by introduction of air into the tank from the bottom. The rising air bubbles, attach themselves to the fine suspended particles, increasing their buoyancy, and finally lifting them to liquid surface for consequent removal by skimming. Aeration tanks maintain microorganisms that consume the organic material for their enzymatic activities. As a result the effluent is purified of soluble biodegradable material. Oxygen is infused to energise microorganisms, either through surface aerators (e.g. mechanical propellers) or diffused aerators (which are submerged machines) [Garg (2002)].

- **Secondary clarifiers** - Secondary clarifiers are sedimentation tanks for the activated sludge, which are also used for flocculation. Secondary sludge contains microorganisms that are washed out with the contaminants. A certain volume of sludge, referred to as 'return activated sludge' (RAS), is redirected to the aeration basins, for

reusing the surviving microorganisms. The remaining excess activated sludge' (EAS) is sent to the sludge-handling unit [Aiyappa (2005)].

- **Sludge Management** – 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. Some part of the sludge is directed to drying beds and a small portion is recycled for re-treatment [Aiyappa (2005)].

2.2 MANAGEMENT SYSTEM

In order to ensure smooth functioning of the Common effluent Treatment Plant (CETPs), there is a need for a comprehensive management plan. The management system shall comprise the following components:

- a) Membership to the CETP
- b) Wastewater collection system
- c) Monitoring and performance of treatment units
- d) Manpower requirement
- e) Maintenance

2.3 COLLECTION SYSTEM

It has been observed that there are two type of collection systems existing in our country. One is by transportation and other by lying sewer/ pipe lines. The following norms shall be considered for the both collection systems:

A. Conveyance system: The major objective of the conveyance system through sewers/ pipelines is to protect the sewer/pipeline from corrosion & silting/choking Explosion besides ensuring the compliance of pre-treatment standard for discharging of

effluent into CETPs. Each industry shall have a collection tank within their premises before discharging the effluent into conveyance system. The CETP Management shall have a collect the sample from such tank of each industry, once in a month for non-toxic and / or non-biodegradable effluent and one in a week for toxic and /or non-persistent organic effluent. In case when CETP is to receive heterogeneous effluents, the SPCBs shall grant consent once in three years and shall monitor the effluents at least once in six months for non-toxic degradable effluent, for industries discharging wastewater less than 25 kl/day. In case of volume of wastewater discharge is more than 25kl/day, the validity of the consent shall be limited for an year and the monitoring by SPCB shall be done at least once in a three months. The same frequency shall be maintained for sampling in case of toxic and/ or persistent effluent. The penal charges for offense of non-compliance of treatment standards shall be applied, as indicated in para 2 (a), (b) and (c). SPCB may direct for closure of the industry, if a member unit is a continuing offender. In that case, consent shall be refused by SPCB for discharge of effluent to CETP and outlet be sealed [CPCB, 2001].

B. Collection through tankers: The CETP Management should have dedicated tankers, duly labeled in accordance with the Motor Vehicle Act (with regard to transportation of hazardous waste), to collect following the manifest system. The manifest system shall be applicable to all the member industries sending their effluent to CETP by tankers.

2.4 GUIDELINES for OPERATION OF VARIOUS UNITS OF CETP

a. Receiving sump(s): The receiving sump(s) at CETP should be adequate capacity and should have arrangement for minimum three pumps, keeping one as stand-by. The pumps are required to have regular maintenance adopting preventive maintenance system. The operator(s) are required to maintain a logbook for duration of operation of each pump and also the flow/ quantity of wastewater pumped.

There should be separate sumps provided if a CETP has provisions to treat wastewater separately for chemical treatment system as removal of toxic metals and separately for biological system (anaerobic and aerobic).

b. Equalization tank: The equalization tank of minimum 24 hours detention time is a must for heterogeneous wastewater i.e. various kinds of industries, having varying quality of wastewater, discharging their effluent to CETP.

In case, where CETP receives wastewater from a particular sector of industry such as textile or tannery or dyeing/ printing etc. the equalization tank of minimum 8 hours detention period shall be provided. To prevent the settling of suspended matter, the equalization tank should have an arrangement of either compressed air for agitation or mechanical agitator. The equalization tank should be fitted with a pumping arrangement for a regulated feed to the subsequent treatment units. There should be one stand-by pump provided. For the wastewater from the chemical manufacturing units, it is desirable that there should be two equalization tank each of 24 hours detention period. While one is getting filled, the other should be used for pumping at a regulated flow and to ensure homogenized wastewater as a feed to subsequent treatment units [CPCB, 2001].

c. Arrangement of mixing sewage to industrial waster:

The mixing of sewage in appropriate ratio with industrial effluent helps in biodegradability of effluent and also providing needed nutrient for better microbial activity for treating organic waste. Therefore, an arrangement to bring sewage by tankers or through a conveyance system should be provided, as necessary, depending on the treatability studies conducted.

d. Primary treatment: The basic objective of the primary treatment is to remove suspended and /or colloidal matters for this purpose, clarifloculator or air flotation units are provided. The coagulants are normally used for enhancing removal of suspended and colloidal matter. There should be a proper chemical/ coagulant dosing system provided,

preferably with an automatic arrangement. Arrangement for pH correction, where necessary shall be provided. Adequate storage of chemical, for a minimum of three month requirement, shall be made and regular supply of power shall be ensured with arrangement of DG set of adequate capacity.

For handling the sludge from such unit(s), there should be a proper dewatering system (either centrifuge or vacuum drum filter). The dewatered sludge shall be transported to the designated area through trolleys or tankers for storing and final disposal, as per authorization obtained from concerned SPCB.

e. Biological treatment unit(s): The biological treatment unit can comprise anaerobic system, aerated lagoon, activated sludge process, extended aeration, trickling filter et. For operation of these systems, it is necessary to ensure that the wastewater is within the required range of pH, Total Dissolved Solids (TDS) and designed value of Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and hydraulic load (flow). It is also to ensure that there is no toxic constituent, which could hamper microbial activity in the biological treatment unit plant. As the input of sewage to the biological treatment unit enhances the treatability besides providing nutrient for biological activity, the addition of sewage at the inlet of biological system is advisable, wherever feasible. The proportion of industrial to domestic sewage should be based on availability of sewage and minimum requirement of sewage to effluent ratio.

The various operating parameters such as pH, sewage to industrial effluent ratio (where applicable), Mixed Liquor Suspended Solids (MLSS) and Mixed Liquor Volatile Suspended Solids (MLVSS) and minimum Dissolved Oxygen(DO) in case of aerobic system should be maintained as per design. There is also necessity to record these parameters on day to day basis/ Proper aeration throughout the area of the aeration tank needs to be ensured. The diffused aeration system ensures such distribution of aeration throughout the aeration tank.

The success of biological treatment depends upon secondary settling system for proper removal of suspended solids (biomass) sludge recycling / removal and dewatering system. The operator should maintain all the operating parameters as per design and also for recirculation of the sludge and its removal periodicity (to have active biomass). The removed sludge should be dewatered and such quantity recorded on the logbook. The sludge be transported to an appropriate place as prescribed by concerned SPCB in the consent order under Water (Prevention & Control of Pollution) Act or as per authorization under Hazardous Waste (Management & Handling) Rules [CPCB, 2002].

f. Tertiary system: The effluent may be required to be further treated before disposal, depending upon the recipient system and the local conditions and also in case of treated wastewater is to be reused. The tertiary system may comprise activated carbon and / or color removal system by polyelectrolyte etc. or recovery of water through reverse osmosis with an arrangement for rejects to be subjected to evaporation for disposal as residue (solid waste).

All the operating parameters, as per the manual of CETP, should be maintained and the readings entered into the logbook including final wastewater quantity (flow) disposed of and / or reused.

g. Treatment of high TDS Wastewater: The CETP may also have a separate treatment system for segregated wastewater of high Total Dissolved Solids (TDS) content sent by industries either through separate tankers or separate conveyance system, for the purpose of giving specific treatment. The treatment of such wastewater may comprise solar evaporation or forced evaporation or multiple effect operators. It is desirable that such system should be installed at least one meter above ground water. The sludge from evaporation system should be stored and disposed of as per authorization obtained from the concerned SPCB.

2.5 ADVANTAGES OF COMMON TREATMENT

The advantages of common treatment are as follows:

- ❖ Saving in Capital and operating cost of treatment plant. Combined treatment is always cheaper than small scattered treatment units.
- ❖ Availability of land which is difficult to be ensured by all individual units in the event they go for individual treatment plants. This is particularly important in case of existing old industries which simply do not have any space.
- ❖ Contribution of nutrient and diluting potential, making the complex industrial waste more amenable to degradation.
- ❖ The neutralization and equalization of heterogeneous waste makes its treatment techno-economically viable.
- ❖ Professional and trained staff can be made available for operation of CETP which is not possible in case of individual plants.
- ❖ Disposal of treated wastewater & sludge becomes more organized.
- ❖ Reduced burden of various regulatory authorities in ensuring pollution control requirement.

The pre-requisite for the concept of common treatment is the treatment at low cost. With more and more improvisation and stress on in-house measures, it is now established that the nature of job in small scale industries has immense potential of not only adopting certain measures to control pollutants at source thereby reducing pollution load and cost of treatment but also to reap rich benefits [CPCB, 2006].

2.6 MANPOWER REQUIREMENT

The CETP shall be headed by a qualified Manager, who shall be ex-officio Member of the CETP Board of Directors, as a Secretary. He should have a through knowledge of CETP operation, maintenance aspects and the environmental law. He shall be assisted by a qualified team of supervisor(s), scientific & technical officers and skilled operators.

There should be separate laboratory. The assignment of the quality Control Group is to monitor and to do surveillance of the member industries and conducting performance evaluation of ETP on day-to-day basis. The Manager is solely responsible for records related to performance monitoring, maintenance and financial management of CETPs etc. A chemist shall head the Quality Control Group. Besides, there shall be an operation & Maintenance Group to be headed by an Engineer, who shall be assisted, be operators. The Manager should also be responsible for designing of training programme for Technicians, Chemist and operators, to be conducted on regular interval [CPCB, 2002]

2.7 MAINTENANCE

The Manager of CETP should ensure that preventive maintenance system is as followed for proper operation of all pumps, mechanical devices and monitoring equipment. Spare parts (commonly used) should be made available at the site. In case of break down, the same should be attended on urgent basis, and for that purpose adequate funds should be made available to the Manager of CETP.

2.8 TROUBLE SHOOTING

The operator of CETP generally faces problems in biological treatment plant. In order to deal with such problems, may be referred for troubleshooting.

For properly running the activated sludge plant, the operator has to maintain the environment very congenial and comfortable to the viable bacteria that are our skilled workers. The Ph between 6.8 to 7.4 and the temperature between 20 to 25 degree C and the DO around 2 to 2.5 mg/lit can be easily managed, but what is difficult to be managed is the incoming load. This is not in the hands of the environmental group. It depends on the production activities. The shock can arrive to ETP in any or many of the following ways:

1. The effluent flow the same, but BOD load is excess(say double)
2. The effluent flow is in excess and also the BOD.
3. The BOD is same as designed, but the flow is much is excess.

4. The BOD is the same as designed, but the nature of BOD is different (i.e. the biodegradability, hazard characteristics, BOD rate constant etc.)
5. All the variations as the first four possibilities above, but instead of BOD the consideration this time here is the SS suspended solids (load and settling nature).
6. All the variations as the first four possibilities or fifth (four) possibilities, but here all the parameters i.e. flow, BOD and SS are behaving erratic simultaneously).

The operators this way faces the difficulties in a number of ways (through it is not much appreciated by the production group).

The most delicate point in running an activated sludge plant is the Sludge. The trouble starts here only and hence the single most important thing an operator must keep under inspection is the sludge and any variation in its nature. The operator has to keep a watch on a number of parameters. These are inter alia its colour, odour, the water that is left behind in upper portion of the glass cylinder in the settlometer or SVI test, the speed of sludge settling in the test, any entrapped gas or bound water in the sludge, and the microscope scenario. By a combination of all these observations, it is possible to label that sludge in a specific type. If this sorting and placing it into a specific slot is possible, the further improvement will be somewhat easy. In order to make the topic simpler, some of our senior operators have thought it better to divide the sludge in ten classes such as:

2.9 MEASURES FOR OPTIMUM EFFICIENCY

Operation of CETP being a participatory mechanism, the primary requirement is hence to define the ultimate responsibility for the proper functioning of the plant after it is commissioned. The important issues which merit consideration are:

A. Aspect of Ownership

Various ownership alternatives include the plant owned by government, consortium of industries or by an independent body. Whatever be the case, the primary emphasis should be on responsiveness in terms of effective and optimal operation of the plant and

accountability. The member industries should also be made to realize that they are equally responsible for the sustenance of the plant.

B. Conveyance System

Different from the discharge characteristics of an integrated (big) industrial unit, small scale units usually generate higher proportion of floating or suspended particles in their effluent streams. At times their job operation result in high corrosive effluent. In either of these cases, to effectively convey their effluent to the CETP, it becomes necessary for individual units to set-up a 'pre-treatment' device. It is also necessary that the conveyance network be so designed as to ensure their periodic de-sludging. Care should also be taken to minimize on cost of operation by facilitating conveyance through gravity flow, instead of multistage pumping. In fact the location of CETP keeps the conveyance route as short as possible. The chances of flooding in monsoon and accidental surface run-off into the conveyance route should also be looked into. Conveyance by tankers is another option, provided the chances of leakages are effectively checked and their transit is strictly monitored in accordance to a properly laid down system [CPCB, 2002].

C. Cost of Treatment

The cost effective treatment supported with a system of regular collection / payment of treatment charges by each member unit, while maintaining its effluent quality within acceptable norms are some of the prerequisites. The system of payment should be legally supported to provide a check for non-payment of dues and to take steps against defaulters.

D. Criteria for Cost

The cost sharing should be decided in such a way that volume of effluent becomes an important norms, but its share in the total cost should not be such as to encourage bypassing of dilute streams and conveying highly toxic / non- biodegradable waste to

CETP. The treatability factor should also be given due consideration in cost estimation. An effort by the industry to segregate toxic, highly acidic/highly basic, or toxic metal bearing waste be made to explore the possibility to de-toxify / neutralize or to attempt the recovery of metals by installing recovery plants, which are feasible and economically viable on accounts of their pay-back potentials.

E. Plant Design

The approach to provide treatment at low cost, an important factor in common treatment, depends on appropriate design of CETP. In keeping with the diverse nature and scale of operations, typical of small scale units, low capital investment and lower operation and maintenance cost incurred on treatment is a prime factor. In such a situation mechanical and chemical processes are advantageous over bio-logical systems. And the least preferred are conventional anaerobic processes on account of huge space requirements and least flexibility. Though, the advanced UASB techniques with less hydraulic retention and space requirement being significantly low, anaerobic system is also possible option. In order to obviate the need of excessive civil work at CETP in making huge equalization and settling units, the member units should also provide settling and neutralization of their individual waste [CPCB, 2002].

In order to minimize on the electrical cost, the possibility of substituting bio-energy should be explored to the extent possible. Proper management of sludge with its nutritive value would mobilize resources to substitute the operational cost. While designing the plant it would be of additional advantage to keep manpower requirement as low as possible but huge in technical skills to reduce down-time for maintenance.

2.10 DESIGN CRITERIA FOR CETP

The design criteria for CETP involves following steps:

- Inventory of Industries
- Quantitative and Qualitative characterization of wastewater from industries
- Classification of industries based on wastewater generation

- Classification of wastewater based on bio-degradability
- Site-specific, effective and easy-to-maintain design of conveyance system
- Bench Scale and Pilot scale treatability study
- Segregation of wastewater
- Pretreatment of wastewater Assessment of appropriate treatment technology
- Waste minimization and resource recovery
- Disposal mechanism of treated effluent and sludge
- Estimation of treatment cost
- Cost benefit analysis
- Selection of best suited cost sharing pattern
- Stress on cleaner technologies

2.11 GOVERNMENT INCENTIVES AND REGULATIONS

The concept of common effluent treatment in itself is in the phase of development. As regards conceptualization of project, construction, operation, and achieving the, required treatment efficiency the entire mechanism has to be viewed in totality. Moreover the CETP for all practical and techno-economic consideration is a viable treatment option for small scale industrial units, wherein the member units and CETP management share equal responsibilities for achieving desired efficacy.

The proposal from project proponents may be sent to the State Pollution Control Board and the State Govt. for their approval and State subsidy and to Ministry of Environment & Forest, Govt. of India for the Central Subsidy. The project proponent for CETP (company) may also obtain loan from any nationalized bank [CPCB, 2002].

a. Criteria for Assistance

Ordinarily in industrial estate or cluster of SSIs one CETP will be promoted. This may vary on case to case basis. Central assistance will be available only for cluster of SSIs.

Project for assistance will be prioritized on the basis of

- Toxicity of pollutant

- Pollution load treated
- Number of units covered

The project should be self-financing for servicing of the loan and meeting operation & maintenance cost. The project must formulate adequate institutional arrangement for the cost sharing, recovery of dues and management and ensure observance of prescribed standards. The scheme must have the technical recommendation of the State pollution control board.

b. Pattern of assistance

Central assistance up to 25 percent of the total cost of the CETP would be provided as a grant to the common effluent treatment plants on the condition that the State Govt. gives a matching contribution. The remaining cost should be met by equity contribution by the industries & loans from financial institutions. Central Assistance will be provided only for capital cost. No assistance will be provided for recurring cost. The assistance will be released in installments. Central Assistance will generally be limited to 25% of the capital cost of the project, subject to other conditions such as matching grant of the State Govt. It may be of advantage to combine some components of CETP with the municipal system. On such scheme the municipalities have also to contribute their share of cost.

c. Procedure

The company will obtain loan from the IDBI or any other financial institutions. The project proponent for CETP (company) will approach the State Govt/ Central Govt. for their contribution of their subsidy. The subsidy would be released into the account of the company opened in the IDBI (or any other financial institutions).

TABLE 2.1 Status of Operational CETP Projects in India:

Name/Location		Treatment Capacity (MLD)	Member Units		Capital Cost (Rs in million)	Operating Agency
			No.	Type		
Andhra Pradesh						
1	Jeedimetla	1.5	109	Drug Chemicals &	25	M/s Jedimetla E.T.P.Ltd
2	Pattencheru	7.50	72	Drug Chemicals &	62.4	M/s Patancheru E.T.P.Ltd.
3	Bollaram	0.25	26	Drug Chemicals &	25	M/s Progressive ET Ltd.
Gujarat						
1	Vatva, Ahmedabad	16	437	Textile, Distillery, Pharmaceutical, Chemicals	300	The Green Env. Services C.O. Ltd
2	Odhav, Ahmedabad	1.20	57	Dye & Dye Intermediate	41.5	Odhav Enviro Projects Ltd.
3	Ankleshwar	1.00	200	Dye & Dye Intermediate, Textile, Pharmaceutical, Pesticides, Pigments	68	Enviro Technology Ltd., Ankleshwar
4	Vapi	55	615	Chemical, Plastic, Pharmaceuticals, Paper, Garments, Engineering	204	Vapi Industries Association
5	Jetpur, Rajkot	20	2000	Dyeing & Printing	50	Jetpur Dyeing & Printing Assocn.
6	Nandesari, Vadodara	5	-	Chemicals, Dyes & Dye Intermediate	-	Nandesari Industrial Association
7	Sarigam, Valsad	0.40	07	-	-	Perfect Enviro Control System Ltd. GIDC, Sarigam.
8	Gumsav, Odhav, Ahmedabad	1.00	-	-	15	Gujrat Vepari Mahamandal S.A.V.Ltd. Ahmedabad
9	Dharmeshwar,	0.15	19	-	-	Dharmeshwar GIDC

	Jetpur, Rajkot					Vistar Asscn, Rajkot
Haryana						
1	Sonepat, Kundli	-	-	-	-	
Karnataka						
1	Kadugondana halli	-	14	Tannery	16	M/s Lidkar Enviro Control System Ltd.
2	Kumbalgod	-	40	Tannery	11.3	M/s Pai & Pai Chemicals (I) Ltd.
Maharashtra						
1	Thane-Belapur (Navi Mumbai)	12.00	400	Dyes & dye Intermediates, Pharmaceuticals, Chemicals, Drugs & Drug Intermediates	45	CETP(T-B) Asscn. MIDC Navi - Mumbai
2	Dombivili	1.50	331	Dyes & dye Intermediates, Pharmaceuticals, Chemicals, Drugs & Drug Intermediates	26	Dombivili CETP MIDC Phase-II Dombilvili (East)
3	Tarapur, Boisar	1.00	208	Chemicals, Pharmaceuticals, Dyes & dye Intermediates, Paint & Textiles	33	TIMA Co-op. Society Ltd., MIDC Boisar, Thane
4	Ambernath	-	-	-	-	M/s ACMA CETP Society
5	Jaysinghpur	-	-	-	-	M/s L.K.Akiwate Indl. Co-op Estate
Punjab						
1	Jullundhar	1.50	29	Tanneries	9.6	M/s Punjab Small Scale Leather Export Corpn., Jullundhar
Rajashtan						
1	Pali Unit-1	6.75	-	Textile units	-	
2	Pali Unit-2	6.75	-	Textile units	-	
Tamil Nadu						
1	Ranipet	-	86	-	29.5	M/s Ranipet SIDCO
2	Ayyampeettai	-	-	-	-	M/s Ayyampet-

						Muthialpet
3	Salem	-	64	-	0.45	M/s Selem Medical Waste Management Co. Ltd.
4	Thirumanialai yur	-	-	-	-	M/s Selem Medical Waste Management Co. Ltd.
5	Amravathinagar	-	-	-	-	M/s Karur, Thiruvai
6	Melivishram		-	-	-	M/s Amravathi Pollutech
7	Dindigul	-		-	-	M/s Vishram Tanners
8	Madhavaram	-		-	-	M/s Madhvaram Leathers
9	Malligai Thope	-		-	-	M/s Ambur Tannery
10.	Andipalyam Thirupur	-		-	-	M/s Andipalyam CETP
11.	Mannarai Thirupur	-		-	-	M/s Mannarai CETP
12.	Manickpuram Thirupur	-		-	-	M/s Manickpuram CETP
Uttar Pradesh						
1.	Jajmau, Kanpur	36.00	354	Tanneries	220.8	U.P.Jal Nigam
2.	Unnao	2.15	21	Tanneries	19.5	M/s UTPCCL, Unnao
3.	Mathura	6.25	30	Textile Dyeing	-	M/s Mathura A.K.P.N..Co. Ltd

Source: Ministry of Environment & Forests, Govt. of India

2.12 OBJECTIVE

Our main objective is the characterization of wastewater and evaluates the performance of Common Effluent Treatment Plants (CETP) of Delhi region.

2.13 SPECIFIC OBJECTIVES

- To study the physico-chemical characteristics of wastewater from various CETPs.
- To review the functioning of CETPs and to monitor the performance of different CETPs.
- To determine the overall efficiency of treatment plants.
- To determine the TDS level in the ground water of every industrial area.
- To suggest suitable recommendations to improve efficiency of existing treatment plant.

LITERATURE SURVEY

Ganczarczyk (1969) evaluated plant efficiency based on the analysis of almost 200 performance data of the activated sludge treatment plant for Kraft pulp mill effluent in Ostroieka. The relationships between the treated and untreated wastewater quality factors were carried out on graphs with log-normal distribution scales. The scatter of these data was calculated as the ratio of the median and values equal to or less than 84 per cent of the data. The treated effluents from the Ostroieka Treatment Plant are discharged via a channel 1-2 km long to the River Narew which has an average low flow of 35.9 m³/sec.

The effluents from the pulp mill in Ostroirka are first collected in an equalization tank with a surface area of 1.6 ha and a volume of 14,000 m³, and then conveyed through a 5 km long pipe-line to the treatment plant. The pulp mill effluent is then mixed with the flow of primary treated town sewage, enriched with mineral nutrients in the ratio BOD :N:P -- 100:4:0.7, and mixed with the return sludge. The effluent from the aeration tanks in the Ostroteka plant is directed to 3 clarifiers of the Dorr-Oliver type having a diameter of 29 m, and a volume of 1600 m³ each. All the clarifiers are equipped with scrapers moving at a speed of 2 rev/hr. For the aerobic digestion of excess activated sludge, as already mentioned, it is intended to aerate this in one of the double aeration tanks for a period of more than 7 days. After this, the digested sludge is discharged via a thickener of one day's capacity to drained sludge-drying beds.

In order to obtain more detailed information about plant performance 99 series of measurements were taken in the Period I (20 June-22 July, 1967) (Ganczarczyk, 1968), and an identical number of measurements in the Period II (1 June-3 July, 1968). In Period I the treated waste water contained an average of 85.7 per cent of industrial effluent and 14.3 per cent of primary treated town sewage. In the Period II these constituents were 79.4 and 20.6 per cent respectively.

In Period I the average BOD and COD of untreated waste water decreased from 399 ppm to 38 ppm (90.5%) and 867 ppm to 291 ppm (66.5%). In Period II the average BOD and COD of the untreated waste water decreased from 308 ppm to 28 ppm (90.9%) and 675 ppm to 279 ppm (58.6%). Comparing the results obtained in the two periods it was observed that the BOD of both decreased, the untreated by 22-6 per cent, and the treated by 26.3 per cent and in the same way the average decrease of the COD untreated waste water was over 20 per cent; treated, over 4 percent.

The average value of sludge volume indexes measured during the Period I was 181 ml/g, and the respective value for the return sludge was 135 ml/g. In Period II the average value of the sludge volume indexes was 208 ml/g and their median was 196 ml/g. This corresponds to the increase by 13 per cent of the average volume indexes in the Period I.

Rusten et al. (1998) designed a biological pretreatment plant for poultry processing wastewater using an aerated equalization tank followed by two high-rate moving bed biofilm reactors (MBBRs) in series. No solids separation and sludge handling was installed. The solids from the pretreatment plant were discharged to the municipal sewer together with the pretreated wastewater. The pretreatment plant performed well, even at organic loads significantly higher than the design values. With a specific biofilm surface area of $250 \text{ m}^2/\text{m}^3$ and a total volumetric organic load of $30\text{--}45 \text{ kg COD}/\text{m}^3 \times \text{d}$ on MBBR1, the removal of filtered COD was as high as 80% over MBBR1 and 90–95% over MBBR1 plus MBBR2.

Nakajima et al. (1999) evaluated performance of on-site treatment facilities. Effluent qualities and removal efficiencies were surveyed in actual treatment facilities for wastewater from households, hotels and restaurants. On-site treatment facilities in Japan are fundamentally built according to the structural standards. They have a pretreatment process (sedimentation separation tank, anaerobic filter or equalization tank with screens) followed by an aerobic process (contact aeration, activated sludge, etc.). Small-scale

facilities for individual household wastewater showed good performance of BOD removal with their effluent BOD below 20 mg/l. They also exhibited nitrogen removal efficiency when they were operated in mixed liquor recycle mode. The facilities applied to wastewater from hotels, restaurants and stores showed good performance when the influent oil (hexane extracts) concentration had been decreased below 30 mg l⁻¹ by using pretreatment. Nitrogen removal performance was high in the facilities which treated wastewater from a residential area or a condominium when they were operated in intermittent aeration mode. But resort condominiums of which influent BOD load was extremely low showed low performance of nitrogen removal even though they were operated in intermittent aeration mode because of the low BOD/N ratio in the influent. An equation was proposed to estimate the amount of methanol to be added in facilities in which the influent BOD/N ratio is low.

Rajkumar et al. (2000) evaluated the performance of effluent treatment plant of edible oil refinery. Industry manufacturing refined edible oil with a capacity of 18000 tones/annum generated wastewaters and solid wastes (viz. spent earth, chemical and biological sludges). The wastewater streams were mainly from vat house after soap splitting, floor washing, cooling tower, boiler and filter press. The chemical composition of the wastewater from cooling tower and boiler sections and solid wastes indicated that these wastes could be recycled and reused in the process after preliminary treatment. The combined wastewater from other streams was being treated in the existing effluent treatment plant (ETP) and the treated effluent was not conforming to the limits prescribed for discharge into inland surface water as stipulated by Central Pollution Control Board, Government of India.

The ETP comprises of the following units, viz. equalization basin, neutralization unit, clariflocculator, primary clarifier, aeration basin, secondary clarifier, and filter press. The wastewater is first pumped into an equalization basin, where the floating oil is skimmed out. About 25 kg of oil is skimmed out in 7 days and reused in the process along with the raw materials. The wastewater is neutralized with addition of lime (16.6 kg/day) and is pumped to a clariflocculator where alum is added at a rate of 5.12 kg/day.

The addition of alum results in fast settling of lime sludge, which is drained out and passed through the filter press. The overflow of supernatant from the clariflocculator is supplemented with diammonium phosphate (6.0 kg/day) as a nutrient and let into aeration basin for biological treatment.

The overflow of aeration basin for biological stabilization. The surface aerators are provided in aeration basins for oxygen transfer and mixing of biomass with wastewater. The overflow from aeration basin passes through a clarifier. The residual colour of the treated effluent is removed by the addition of 12% sodium hypochlorite solution (1.8 kg/day). The settled sludge from secondary clarifier is partly recirculated to aeration basin in order to maintain a proper food/microorganism (F/M) ratio and the excess activated sludge produced in the process is taken to the filter press.

The wastewater generated at the industry was properly equalized in a basin. The floated oil was skimmed out manually and reused in the process. After removal of oil, the wastewater was pumped into lime unit for neutralization at a constant flow rate of 2.7 m³/h over a period of 24 h. The neutralized wastewater was subjected to biological treatment in aeration basin units of the ETP. The COD of the influent to the ETP was 8000 mg/l, while the value of COD in the treated effluent was 35 mg/l. The BOD in the inlet of the ETP was 3609.150 mg/l, while the treated effluent contained BOD with a mean value of 159.8 mg/l. Thus, the removal efficiency of the COD and BOD in the ETP, after adopting the mitigation measures, was 99.75 and 95.8%, respectively. The oil and grease could be removed to the extent of below the detection limit of less than 3.5 mg/l. Thus, the existing ETP was bio-augmented after adopting the suitable measures by maintaining the required F/M ratio as well as avoiding the contamination of the biomass with spent earth.

Nandy et al. (2002) evaluated the performance of ETP of a large scale paper industry manufacturing paper and paperboards. ETP was treating 42,903 m³ per day of wastewater based on average flow monitored. Performance evaluation of ETP indicates that

➤ The various unit processes and operations under existing operating conditions did not function at optimum level of performance as per its design. This is attributed mainly to poor operation and maintenance of the plant.

➤ The performance of ETP with the present wastewater flow and characteristics could be improved by optimizing the operating parameters in the individual units.

➤ Wastewater equalization and neutralization, and build-up of active biomass in the activated sludge system maintaining design F/M ratio will effectively treat the combined wastewater improving the performance of the plant.

➤ Proper maintenance of primary and secondary clarifiers must also achieve optimum performance of the ETP. Implementation of the afore-referred measures would enable to achieve treated effluent quality conforming to the prescribed Standards of the Statutory Board for inland surface water discharge.

Pophali et al. (2003) studied the influence of hydraulic shock loads and total dissolved solids (TDS) on the performance of three large-scale common effluent treatment plants (CETPs) treating textile effluents, which is generated from clusters of small-scale industries in the state of Rajasthan in India. Of the three CETPs, two having capacities 7.0 and 9.0 million liters per day (mld) are located in Pali and one of capacity 6.0 mld in Balotra, District Barmer. Wastewater from about one thousand small-scale industries is treated in these CETPs. The effects of hydraulic shock loads and TDS on effluent data from secondary clarifier for parameters biochemical oxygen demand (BOD) and suspended solids (SS) for CETPs at Pali, and chemical oxygen demand (COD) and SS for the CETP at Balotra were studied. It was observed that:

- the effluent BOD and SS remained within the prescribed limits for CETP Pali at 30% increased flow rate, whereas effluent COD and SS at 30% increased flow rate for CETP Balotra exceeded the prescribed limits and the CETP could sustain 20% increased flow rate.
- The shock loading analysis revealed that CETP Balotra had reduced capacity to sustain shock loads by 10% as compared to CETP Pali due to the presence of high TDS (15 000–20 000 mg/l).

- High TDS interfered with the oxygen transfer necessary for biological metabolism, thereby affected the efficiency of activated sludge process. Hence, activated sludge process treating high TDS effluents are more sensitive to hydraulic shock loads and prone to process upsets.

The results of this study indicate that the presence of high TDS (dissolved inorganic) influences the biological stability of an activated sludge process. The present study confirms the findings of Stover and Obayashi that biological systems treating high TDS wastewater are more sensitive to environmental changes (hydraulic shock load) and more prone to process upsets. The effluent parameters for BOD and SS for CETP Pali remained within the prescribed limits at 30% increased flow rate, hence confirming the capacity to sustain maximum shock loads, whereas the effluent parameters for COD and SS for CETP Balotra remained within the prescribed limits at 20% increased flow rate and indicated the maximum shock load that CETP could sustain. The presence of high TDS concentration in the wastewater reduced oxygen transfer efficiency in the aeration tank and affected biological metabolism.

Colmenarejo (2006) evaluated eight small-scale municipal wastewater treatment plants over a period of 19 months in the suburb of Las Rozas in Madrid (Spain). Four plants used compact extended aeration, two used conventional activated sludge, two used conventional extended aeration, one used a rotary biodisc reactor and the other used a peat bed reactor. The best results were obtained from the plants that used conventional technologies and the biodisc. Conventional activated sludge and extended aeration had higher removal efficiencies for ammonia, TSS, COD and BOD₅ and produced good quality final effluents for final disposal in accordance with the discharge standard. Empirical equations that correlated the concentration of dissolved oxygen in the effluents with the efficiencies of TSS, ammonia, COD and BOD₅ removals for all plants evaluated were obtained. The performance of the plants using compact extended aeration was affected more than those using conventional technologies or rotary biodisc when the capacity exceeded that of its initial design.

The final effluents of the MWWTPs were evaluated taking into account the standards for disposal recommended by the European Union. Three parameters were considered: BOD₅, COD and TSS. The plants with the highest percentages of samples with acceptable values were 'Entremontes' and 'Golf', with percentages higher than 70% for all parameters considered. In the case of 'Pen~ ascales', around 90% of the samples for TSS and COD were lower than the standards, although in the case of BOD₅ the percentage decrease used to around 60%. In the case of 'Pryca', the percentages of samples with acceptable values were approximately 82%, 64% and 55% for TSS, COD and BOD₅, respectively. The remaining plants did not produce acceptable effluents with respect to all three parameters. It was studied that 25% of the MWWTPs evaluated could be considered to be working well, 25% were working acceptably and 50% were performing poorly.

Hafez et al. (2007) carried out two sets of experiments by using laboratory separation unit with maximum pressure of 7 bars and pilot plant membrane separation unit with maximum pressure of 14 bars. Based on the analyses of collected samples, a hydration model was used to determine the combined salts in the wastewater. The combined salts were used in the preparation of a synthetic solution simulated to the wastewater of El Nile Company. The experiments were divided into two parts: the first part was concerned with the application of membrane separation experiments to synthetic solutions and the second part was concerned with the pretreatment and membrane separation experiments of the industrial wastewater. The first part was carried out by using NF followed by RO membrane separation technology. Best performance for NF process is observed in separation of divalent ions and the less in separation of monovalent ions, NF membrane succeeded in 30% removal of divalent and trivalent ions, while RO membrane proved separation of 99% of sulphate ions, 96% of iron, 93% of bicarbonate, 90% of sodium, magnesium and sulphide ions, 86% of potassium, 73% of phosphate and 25% of calcium ions.

The second part was concerned with industrial wastewater, where oil and grease were completely removed by floatation, 11% of TSS and 12% of COD were removed by

clarification, while coagulation by using 2 mg/l of anionic polymer removed 93% and 30% of TSS and COD respectively. The pretreated wastewater was allowed to pass through NF membrane at 14 bars followed by RO membrane at pressure of 14 bars. The separation efficiencies of monovalent, divalent and trivalent ions were nearly 2-3% less than that in case of synthetic solutions, while COD and BOD were completely removed. The water resulted from NF may be used in industrial processes and low pressure boilers while the water resulted from RO membrane may be used for high pressure boilers. Based on the previous results, preliminary techno-economic evaluation for 1200 m³/day treatment plant was performed.

Moosvi et al. (2007) studied the treatment of wastewater collected from equalization tank of Common Effluent Treatment Plant (CETP), which was a mixture of waste coming from 525 small-scale industries manufacturing textile and dyestuff intermediate, pigments and pharmaceuticals. Initially a pretreatment using ferric chloride and lime was carried out to increase the biodegradability (BOD₅/COD) of the effluent, which showed color removal of 74% and COD reduction of 75% at a concentration of 10 and 4 mg/l respectively. The biological treatment system using anaerobic fixed film reactor was investigated as secondary treatment. A mixture of bacterial consortium DMAB and cowdung slurry was used for the formation of biofilm. The effect of hydraulic retention time (HRT) and organic loading rate (OLR) on the efficiency of treatment of anaerobic reactor was analysed. Subsequent aerobic treatment after anaerobic step using aerobic culture *Pseudomonas aeruginosa* helped in further removal of COD and color. Formation of aromatic amines during anaerobic treatment was mineralized by sequential aerobic treatment.

Overall performance of the experimental treatment system was analysed at each treatment step and compared with the existing treatment at the plant. The existing CETP treatment plant consisted of an equalization tank and aeration tank. The final COD removal achieved after the aerobic treatment of the CETP was 40–45% and color removal was 35–40%. Overall decolorization and COD removal achieved when the

effluent was pretreated by coagulation using FeCl_3 and lime followed by anaerobic and aerobic treatment was 89% and 94%, respectively.

Sajidu et al. (2007) evaluated the water quality in streams and wastewater treatment plants (WWTP) in the City of Blantyre, Malawi. It also assesses the efficiencies of wastewater treatment by industries and the wastewater treatment plants themselves. Study locations included Limbe WWTP, Soche WWTP, Limbe, Mudi and Nasolo streams. Water samples were collected by grab sampling technique in February 2005. Phosphates, nitrates and sulphates were determined by vanadomolybdophosphoric acid colorimetric, salicylate colorimetric and turbidimetric methods, respectively. Metals were analysed using atomic absorption spectroscopy.

Concentrations of lead, cadmium, iron, manganese, zinc, chromium and nickel were much higher than the World Health safe limits for drinking water in all the sampled streams after they had passed through industrial areas. Nitrates and sulphates concentrations at all sampling points were found to be lower than the safe limits for drinking water of 50 mg/l and 250 mg/l, respectively. However, phosphate concentrations were above the safe limit of 0.5 mg/l. It was also observed that biochemical oxygen demand (BOD₅) levels were above the World Health Organisation limit of 20 mg/l at all sites except Mudi and Limbe streams before passing through industrial areas. This was an indication of pollution in the streams. Values of pH and total dissolved solids (TDS) were within the recommended standards. The results suggest that streams in Blantyre City get polluted by heavy metals and nutrients which could be due to uncontrolled industrial waste disposal, vehicular emissions and agricultural activities. Regular monitoring of the water quality and enforcement of environmental protection laws are needed in order to control pollution in the city.

It was concluded from the results that some of the Blantyre City streams are presently polluted with metal pollutants such as lead, chromium, cadmium, nickel and manganese, and nutrients such as phosphates making it unsafe for human use as well as unsupportive to aquatic organisms. Wastewater treatment plants in the city do not

significantly reduce heavy metals in wastewater. There is therefore a dire need to properly manage wastes in the city and control as well as monitor industrial and human.

Nery et al. (2007) evaluated the performance and process stability of a full-scale poultry slaughterhouse wastewater treatment plant in removing organic matter over a 4-year operation. The wastewater treatment system is composed of rotary and static screens, an equalization tank, a dissolved-air flotation (DAF) system and two up flow anaerobic sludge blanket (UASB) reactors. The operating strategy for UASB reactors to treat slaughterhouse wastewater involves the use of a tank to dampen fluctuations in flow and organic load, a DAF system to remove oil and grease (O&G) and suspended solids (SS) and an intermittent operation. Surface-loading rates of $1.6 \pm 0.4 \text{ m}^3/\text{m}^2 \text{ h}$ applied to the DAF system in the operation under study resulted in O&G and SS removal efficiencies of $51 \pm 16\%$ and $37 \pm 16\%$, respectively. The organic loading rate of $1.6 \pm 0.4 \text{ kg COD}/\text{m}^3 \text{ day}$ and the upflow velocities of $0.3 \pm 0.1 \text{ m/h}$ applied to the UASB reactors resulted in a similar and satisfactory performance, showing total chemical oxygen demand and soluble chemical oxygen demand removal efficiencies of 67% and 85%, respectively. Although the organic matter removal efficiencies of the treatment plant reached about 90%, the nutrients concentrations in the treated effluent pointed to the need for advanced wastewater treatment.

Al-Mutairi et al. (2008) investigated use of physical/chemical processes and the application of contact-assisted activated sludge process. These tests were carried out in a 310-m³/d plant. The analysis of plant performance was based on the quality of treated water produced and the cost of the plant relative to each configuration. The results show that:

- Two stage dissolved air flotation units combined with contact-assisted activated sludge process would enable the plant to meet the discharge standards proposed by the Kuwait Environmental Protection Authority.
- Fat/oil/grease is reduced by about 84 %; suspended solids are reduced by about 72% across the 1st stage DAF. Substantial amounts of total suspended solids are removed during the 2nd stage DAF process.

- The contact-assisted activated sludge reduces the final effluent COD to less than 250 mg/L.

Ghoualem et al. (2008) evaluate quantitatively and qualitatively urban water of the commune of Zeralda situated at the west (30 km) of Algiers. This water is rejected without treatment in the sea. This study has been to investigate in a first time to the parameters of pollution which influence the biological treatment of water. This study has been to investigate in a first time to the parameters of pollution which influence the biological treatment of water. Among these parameters, they have determinate, pH, water–air temperature, MES, COD, BOD₅, turbidity, conductivity, etc. The results of the analysis of physical and chemical parameters of pollution showed that their content exceed widely the standards of rejection. In a second time, they tested a biological treatment by language. This study is based on the analysis of organic matter and nutritive substances in the aqueous phase. The obtained results showed an important increase of the dissolved oxygen and 97, 94.5 and 79.2% for turbidity, NH₄⁺ and PO₄³⁻ respectively. After the obtained results this effluent can be treated, recycled and developed what constitutes an adequate solution to cure the problems of pollution, it will be able thus to safeguard the quality of the natural environment.

Sowmeyan et al. (2008) studied the treatment of effluent in a molasses based distillery. Distillery effluent is a contaminated stream with high chemical oxygen demand (COD) varying from 45,000 to 75,000 mg/l and low pH values of between 4.3 and 5.3. Different processes covering aerobic, anaerobic as well as physico-chemical methods which was employed to this effluent has been given in this review paper. Among the different methods available, it was found that “An Inverse Anaerobic Fluidization” to be a better choice for treating effluent from molasses-based distillery industries using an inverse anaerobic fluidized-bed reactor (IAFBR). This technology has been widely applied as an effective step in removing 80–85% of the COD in the effluent stream. Therefore, in this review, attention has been paid to highlight in respect of fluidization phenomena, process performance, stability of the system, operating parameters, configuration of inverse anaerobic fluidization and suitable carrier material

employed in an inverse anaerobic fluidized-bed reactor especially for treating this effluent.

Rajaram and Das (2008) studied the water pollution by industrial effluent in India and the probable future scenarios of industrial effluent discharge behavior under various market enforcement conditions. Around the world as countries are struggling to arrive at an effective regulatory regime to control the discharge of industrial effluents into their ecosystems, Indian economy holds a double edged sword of economic growth and ecosystem collapse. This situation if mishandled can cause irreparable ecological harm in the long term well masked by short term economic prosperity. Considering that Industries comply with environmental regulations based on the level of enforcement and their ability to spend for waste treatment, this paper endeavours to sketch probable industrial effluent discharge scenarios under various market-enforcement conditions and proposes possible strategies for effective regulatory regime in India. The authors point out that as India moves towards stricter regulation of industrial effluents to control water pollution greater efforts are required to reduce the risk to public health as toxic pollutants which are mainly colourless and odourless can be expected to be released into the ecosystems. Examples of emerging cases like Tiruppur and Plachimada are presented to assert that ecosystem specific discharge standards is the solution and local communities are ready to participate in environmental decision making to safeguard their resources.

METHODOLOGY

4.1 pH

4.1.1 Principle

The basic principle of electrometric pH measurement is determination of the activity of the hydrogen ions by potentiometric measurement using a standard hydrogen electrode and a reference electrode. The hydrogen electrode consists of a platinum electrode across which hydrogen gas is bubbled at a pressure of 101 kPa. Because of difficulty in its use and the potential for poisoning the hydrogen electrode, the glass electrode commonly is used. The electromotive force (emf) produced in the glass electrode system varies linearly with pH. This linear relationship is described by plotting the measured emf against the pH of different buffers. Sample pH is determined by extrapolation. Because single ion activities such as a_{H^+} cannot be measured, pH is defined operationally on a potentiometric scale.

The pH measuring instrument is calibrated potentiometrically with an indicating (glass) electrode and a reference electrode using National Institute of Standards and Technology (NIST) buffers having assigned values [Cleceri et al. (1998)].

The operational pH scale is used to measure sample pH and is defined as

$$F(E_X - E_S)$$

$$\text{pH}_x = \text{pH}_B \pm$$

where:

pH_x = potentiometrically measured sample pH,
F = Faraday: 9.649×10^4 coulomb/mole,
 E_x = Sample emf, V,
 E_s = buffer emf, V,
R = Gas constant; 8.314 joule/(mole °K), and
T = absolute temperature, °K.

4.1.2 Apparatus

➤ A pH meter consisting of

1. Potentiometer
2. A glass electrode
3. A reference electrode
4. A temperature-compensating device.

➤ Beakers: Preferably use polyethylene bags or glass beakers.

➤ Stirrer: Use either a magnetic, TFE-coated stirring bar or a mechanical stirrer with inert plastic-coated impeller.

➤ Flow chamber: Use for continuous flow measurements or for poorly buffered solutions.

4.1.3 Reagents

➤ Buffer solution: Calibrate the electrode system against standard buffer solutions of known pH. Because buffer solutions may deteriorate as a result of mold growth or contamination, prepare fresh as needed for accurate work by weighing the amounts of chemicals specified in Table 4500-H⁺:I, dissolving in distilled water at 25°C, and diluting to 1000 mL. This is particularly important for borate and carbonate buffers.

Boil and cool distilled water having a conductivity of less than 2 $\mu\text{mhos/cm}$. To 50 mL add 1 drop of saturated KCl solution suitable for reference electrode use. If the pH of this test solution is between 6.0 and 7.0, use it to prepare all standard solutions.

Dry KH_2PO_4 at 110 to 130°C for 2 h before weighing but do not heat unstable hydrated potassium tetroxalate above 60°C nor dry the other specified buffer salts.

Although ACS-grade chemicals generally are satisfactory for preparing buffer solutions, use certified materials available from the National Institute of Standards and Technology when the greatest accuracy is required. For routine analysis, use commercially available buffer tablets, powders, or solutions of tested quality. In preparing buffer solutions from solid salts, insure complete solution.

As a rule, select and prepare buffer solutions classed as primary standards. Reserve secondary standards for extreme situations encountered in wastewater measurements. Consult Table 4500- H⁺:II for accepted pH of standard buffer solutions at temperatures other than 25°C. In routine use, store buffer solutions and samples in polyethylene bottles. Replace buffer solutions every 4 weeks.

- Saturated potassium hydrogen tartrate solution: Shake vigorously an excess (5 to 10 g) of finely crystalline $\text{KHC}_4\text{H}_4\text{O}_6$ with 100 to 300 mL distilled water at 25°C in a glass-stoppered bottle. Separate clear solution from undissolved material by decantation or filtration. Preserve for 2 months or more by adding one thymol crystal (8 mm diam) per 200 mL solution.
- Saturated calcium hydroxide solution: Calcine a well-washed, low-alkali grade CaCO_3 in a platinum dish by igniting for 1 h at 1000°C. Cool, hydrate by slowly adding distilled water with stirring, and heat to boiling. Cool, filter, and collect solid Ca(OH)_2 on a fritted glass filter of medium porosity. Dry at 110°C, cool, and pulverize to uniformly fine granules. Vigorously shake an excess of fine granules with distilled water in a stoppered polyethylene bottle. Let temperature come to 25°C

after mixing. Filter supernatant under suction through a sintered glass filter of medium porosity and use filtrate as the buffer solution. Discard buffer solution when atmospheric CO₂ causes turbidity to appear [Cleceri et al. (1998)].

- Auxiliary solutions: 0.1N NaOH, 0.1N HCl, 5N HCl (dilute five volumes 6N HCl with one volume distilled water), and acid potassium fluoride solution (dissolve 2 g KF in 2 mL conc H₂SO₄ and dilute to 100 mL with distilled water).

4.1.4 Procedure

1. Instrument calibration: In each case follow manufacturer's instructions for pH meter and for storage and preparation of electrodes for use. Recommended solutions for short-term storage of electrodes vary with type of electrode and manufacturer, but generally have a conductivity greater than 4000 μmhos/cm. Tap water is a better substitute than distilled water, but pH 4 buffer is best for the single glass electrode and saturated KCl is preferred for a calomel and Ag/AgCl reference electrode. Saturated KCl is the preferred solution for a combination electrode. Keep electrodes wet by returning them to storage solution whenever pH meter is not in use.
2. Before use, remove electrodes from storage solution, rinse, blot dry with a soft tissue, place in initial buffer solution, and set the isopotential point (2a above). Select a second buffer within 2 pH units of sample pH and bring sample and buffer to same temperature, which may be the room temperature, a fixed temperature such as 25°C, or the temperature of a fresh sample. Remove electrodes from first buffer, rinse thoroughly with distilled water, blot dry, and immerse in second buffer. Record temperature of measurement and adjust temperature dial on meter so that meter indicates pH value of buffer at test temperature (this is a slope adjustment).
3. Use the pH value listed in the tables for the buffer used at the test temperature. Remove electrodes from second buffer, rinse thoroughly with distilled water and dry electrodes as indicated above. Immerse in a third buffer below pH 10, approximately

3 pH units different from the second; the reading should be within 0.1 unit for the pH of the third buffer. If the meter response shows a difference greater than 0.1 pH unit from expected value, look for trouble with the electrodes or potentiometer.

4. The purpose of standardization is to adjust the response of the glass electrode to the instrument. When only occasional pH measurements are made standardize instrument before each measurement. When frequent measurements are made and the instrument is stable, standardize less frequently. If sample pH values vary widely, standardize for each sample with a buffer having a pH within 1 to 2 pH units of the sample.
5. Sample analysis: Establish equilibrium between electrodes and sample by stirring sample to insure homogeneity; stir gently to minimize carbon dioxide entrainment. For buffered samples or those of high ionic strength, condition electrodes after cleaning by dipping them into sample for 1 min. Blot dry, immerse in a fresh portion of the same sample, and read pH.
6. With dilute, poorly buffered solutions, equilibrate electrodes by immersing in three or four successive portions of sample. Take a fresh sample to measure Ph [Cleceri et al. (1998)].

4.2 BIOLOGICAL OXYGEN DEAMAND

4.2.1 Principle

The method consists of filling with sample, to overflowing, an airtight bottle of the specified size and incubating it at the specified temperature for 5 d. Dissolved oxygen is measured initially and after incubation, and the BOD is computed from the difference between initial and final DO. Because the initial DO is determined shortly after the dilution is made, all oxygen uptake occurring after this measurement is included in the BOD measurement. [Cleceri et al. (1998)]

Samples for BOD analysis may degrade significantly during storage between collection and analysis, resulting in low BOD values. Minimize reduction of BOD by analyzing sample promptly or by cooling it to near-freezing temperature during storage. However, even at low temperature, keep holding time to a minimum. Warm chilled samples to $20 \pm 3^{\circ}\text{C}$ before analysis.

1. **Grab samples** – If analysis is begun within 2 h of collection, cold storage is unnecessary. If analysis is not started within 2 h of sample collection, keep sample at or below 4°C from the time of collection. Begin analysis within 6 h of collection; when this is not possible because the sampling site is distant from the laboratory, store at or below 4°C and report length and temperature of storage with the results. In no case start analysis more than 24 h after grab sample collection. When samples are to be used for regulatory purposes make every effort to deliver samples for analysis within 6 h of collection
2. **Composite samples** – Keep samples at or below 4°C during compositing. Limit compositing period to 24 h. Use the same criteria as for storage of grab samples, starting the measurement of holding time from end of compositing period. State storage time and conditions as part of the results.

4.2.2 Apparatus

1. **Incubation bottles:** Use glass bottles having 60 mL or greater capacity (300-mL bottles having a ground-glass stopper and a flared mouth are preferred). Clean bottles with a detergent, rinse thoroughly, and drain before use. As a precaution against drawing air into the dilution bottle during incubation, use a water seal. Obtain satisfactory water seals by inverting bottles in a water bath or by adding water to the flared mouth of special BOD bottles. Place a paper or plastic cup or foil cap over flared mouth of bottle to reduce evaporation of the water seal during incubation.

2. Air incubator or water bath, thermostatically controlled at $20 \pm 1^\circ\text{C}$. Exclude all light to prevent possibility of photosynthetic production of DO.

4.2.3 Reagents

Prepare reagents in advance but discard if there is any sign of precipitation or biological growth in the stock bottles. Commercial equivalents of these reagents are acceptable and different stock concentrations may be used if doses are adjusted proportionally.

- Phosphate buffer solution: Dissolve 8.5 g KH_2PO_4 , 21.75 g K_2HPO_4 , 33.4 g $\text{Na}_2\text{HPO}_4 \cdot 7\text{H}_2\text{O}$, and 1.7 g NH_4Cl in about 500 mL distilled water and dilute to 1 L. The pH should be 7.2 without further adjustment. Alternatively, dissolve 42.5 g KH_2PO_4 or 54.3 g K_2HPO_4 in about 700 mL distilled water. Adjust pH to 7.2 with 30% NaOH and dilute to 1 L.
- Magnesium sulfate solution: Dissolve 22.5 g $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ in distilled water and dilute to 1 L.
- Calcium chloride solution: Dissolve 27.5 g CaCl_2 in distilled water and dilute to 1 L.
- Ferric chloride solution: Dissolve 0.25 g $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ in distilled water and dilute to 1 L.
- Acid and alkali solutions, 1N, for neutralization of caustic or acid waste samples.
 - 1) Acid – Slowly while stirring, add 28 mL conc sulfuric acid to distilled water. Dilute to 1 L.
 - 2) Alkali – Dissolve 40 g sodium hydroxide in distilled water. Dilute to 1 L.
- Sodium sulfite solution: Dissolve 1.575 g Na_2SO_3 in 1000 mL distilled water. This solution is not stable; prepare daily.
- Nitrification inhibitor, 2-chloro-6-(trichloromethyl) pyridine.

- Glucose-glutamic acid solution: Dry reagent-grade glucose and reagent-grade glutamic acid at 103°C for 1 h. Add 150 mg glucose and 150 mg glutamic acid to distilled water and dilute to 1 L. Prepare fresh immediately before use.
- Ammonium chloride solution: Dissolve 1.15 g NH₄Cl in about 500 mL distilled water, adjust pH to 7.2 with NaOH solution, and dilute to 1 L. Solution contains 0.3 mg N/mL [Cleceri et al. (1998)].
- Dilution water: Use demineralized, distilled, tap, or natural water for making sample dilutions.

4.2.4 Procedure

1. Preparation of dilution water: Place desired volume of water in a suitable bottle and add 1 mL each of phosphate buffer, MgSO₄, CaCl₂, and FeCl₃ solutions/L of water. Seed dilution water, if desired. Test dilution water so that water of assured quality always is on hand.
2. Before use bring dilution water temperature to 20 ± 3°C. Saturate with DO by shaking in a partially filled bottle or by aerating with organic-free filtered air. Alternatively, store in cotton-plugged bottles long enough for water to become saturated with DO. Protect water quality by using clean glassware, tubing, and bottles.
3. Dilution water storage: Source water may be stored before use as long as the prepared dilution water meets quality control criteria in the dilution water blank. Such storage may improve the quality of some source waters but may allow biological growth to cause deterioration in others. Preferably do not store prepared dilution water for more than 24 h after adding nutrients, minerals, and buffer unless dilution water blanks consistently meet quality control limits.

Discard stored source water if dilution water blank shows more than 0.2 mg/L DO depletion in 5 d.

4. Glucose-glutamic acid check: Because the BOD test is a bioassay its results can be influenced greatly by the presence of toxicants or by use of a poor seeding material. Distilled waters frequently are contaminated with copper; some sewage seeds are relatively inactive. Low results always are obtained with such seeds and waters. Periodically check dilution water quality, seed effectiveness, and analytical technique by making BOD measurements on a mixture of 150 mg glucose/L and 150 mg glutamic acid/L as a "standard" check solution. Glucose has an exceptionally high and variable oxidation rate but when it is used with glutamic acid, the oxidation rate is stabilized and is similar to that obtained with many municipal wastes. Alternatively, if a particular wastewater contains an identifiable major constituent that contributes to the BOD, use this compound in place of the glucose-glutamic acid.
5. Determine the 5-d 20°C BOD of a 2% dilution of the glucose-glutamic acid standard check solution . Adjust concentrations of commercial mixtures to give 3 mg/L glucose and 3 mg/L glutamic acid in each GGA test bottle.
6. Seeding
 - Seed source – It is necessary to have present a population of microorganisms capable of oxidizing the biodegradable organic matter in the sample. Domestic wastewater, unchlorinated or otherwise-undisinfected effluents from biological waste treatment plants, and surface waters receiving wastewater discharges contain satisfactory microbial populations. Some samples do not contain a sufficient microbial population (for example, some untreated industrial wastes, disinfected wastes, high-temperature wastes, or wastes with extreme pH values). For such wastes seed the dilution water or sample by adding a population of microorganisms. The preferred seed is effluent or mixed liquor from a biological

treatment system processing the waste. Where such seed is not available, use supernatant from domestic wastewater after settling at room temperature for at least 1 h but no longer than 36 h.

- When effluent or mixed liquor from a biological treatment process is used, inhibition of nitrification is recommended. Some samples may contain materials not degraded at normal rates by the microorganisms in settled domestic wastewater. Seed such samples with an adapted microbial population obtained from the undisinfected effluent or mixed liquor of a biological process treating the waste. In the absence of such a facility, obtain seed from the receiving water below (preferably 3 to 8 km) the point of discharge. When such seed sources also are not available, develop an adapted seed in the laboratory by continuously aerating a sample of settled domestic wastewater and adding small daily increments of waste. Optionally use a soil suspension or activated sludge, or a commercial seed preparation to obtain the initial microbial population. Determine the existence of a satisfactory population by testing the performance of the seed in BOD tests on the sample. BOD values that increase with time of adaptation to a steady high value indicate successful seed adaptation.

- Seed control – Determine BOD of the seeding material as for any other sample. This is the seed control. From the value of the seed control and a knowledge of the seeding material dilution (in the dilution water) determine seed DO uptake. Ideally, make dilutions of seed such that the largest quantity results in at least 50% DO depletion. A plot of DO depletion, in milligrams per liter, versus milliliters of seed for all bottles having a 2-mg/L depletion and a 1.0-mg/L minimum residual DO should present a straight line for which the slope indicates DO depletion per milliliter of seed. The DO-axis intercept is oxygen depletion caused by the dilution water and should be less than 0.1 mg/L. Alternatively, divide DO depletion by volume of seed in milliliters for each seed control bottle having a 2-mg/L depletion and a 1.0-mg/L residual DO. Average the results for all bottles meeting minimum depletion and residual DO criteria. The DO uptake

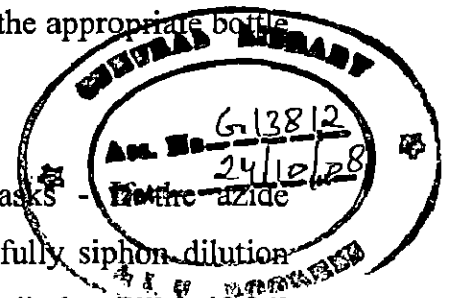
attributable to the seed added to each bottle should be between 0.6 and 1.0 mg/L, but the amount of seed added should be adjusted from this range to that required to provide glucose-glutamic acid check results in the range of 198 ± 30.5 mg/L. To determine DO uptake for a test bottle, subtract DO uptake attributable to the seed from total DO uptake.

7. Sample pretreatment: Check pH of all samples before testing unless previous experience indicates that pH is within the acceptable range.

- Samples containing caustic alkalinity ($\text{pH} > 8.5$) or acidity ($\text{pH} < 6.0$) - Neutralize samples to pH 6.5 to 7.5 with a solution of sulfuric acid (H_2SO_4) or sodium hydroxide (NaOH) of such strength that the quantity of reagent does not dilute the sample by more than 0.5%. The pH of dilution water should not be affected by the lowest sample dilution. Always seed samples that have been pH-adjusted.
- Samples containing residual chlorine compounds - If possible, avoid samples containing residual chlorine by sampling ahead of chlorination processes. If the sample has been chlorinated but no detectable chlorine residual is present, seed the dilution water. If residual chlorine is present, dechlorinate sample and seed the dilution water. Do not test chlorinated/dechlorinated samples without seeding the dilution water. In some samples chlorine will dissipate within 1 to 2 h of standing in the light. This often occurs during sample transport and handling. For samples in which chlorine residual does not dissipate in a reasonably short time, destroy chlorine residual by adding Na_2SO_3 solution. Determine required volume of Na_2SO_3 solution on a 100- to 1000-mL portion of neutralized sample by adding 10 mL of 1 + 1 acetic acid or 1 + 50 H_2SO_4 , 10 mL potassium iodide (KI) solution (10 g/100 mL) per 1000 mL portion, and titrating with Na_2SO_3 solution to the starch-iodine end point for residual. Add to neutralized sample the relative volume of Na_2SO_3 solution determined by the above test, mix, and after 10 to 20 min check sample for residual chlorine.

- Samples containing other toxic substances - Certain industrial wastes, for example, plating wastes, contain toxic metals. Such samples often require special study and treatment.
 - Samples supersaturated with DO - Samples containing more than 9 mg DO/ L at 20°C may be encountered in cold waters or in water where photosynthesis occurs. To prevent loss of oxygen during incubation of such samples, reduce DO to saturation at 20°C by bringing sample to about 20°C in partially filled bottle while agitating by vigorous shaking or by aerating with clean, filtered compressed air.
 - Sample temperature adjustment - Bring samples to $20 \pm 1^\circ\text{C}$ before making dilutions.
 - Nitrification inhibition - If nitrification inhibition is desired add 3 mg 2-chloro-6-(trichloro methyl) pyridine (TCMP) to each 300-mL bottle before capping or add sufficient amounts to the dilution water to make a final concentration of 10 mg/L. (NOTE: Pure TCMP may dissolve slowly and can float on top of the sample. Some commercial formulations dissolve more readily but are not 100% TCMP; adjust dosage accordingly.) Samples that may require nitrification inhibition include, but are not limited to, *biologically treated effluents, samples seeded with biologically treated effluents, and river waters.* Note the use of nitrogen inhibition in reporting results.
8. Dilution technique: Make several dilutions of sample that will result in a residual DO of at least 1 mg/L and a DO uptake of at least 2 mg/L after a 5-d incubation. Five dilutions are recommended unless experience with a particular sample shows that use of a smaller number of dilutions produces at least two bottles giving acceptable minimum DO depletion and residual limits. A more rapid analysis, such as COD, may be correlated approximately with BOD and serve as a guide in selecting dilutions. In the absence of prior knowledge, use the following dilutions: 0.0 to 1.0% for strong industrial wastes, 1 to 5% for raw and settled wastewater, 5 to 25% for biologically treated effluent, and 25 to 100% for polluted river waters. Prepare dilutions either in graduated cylinders or volumetric glassware, and then transfer to BOD bottles or

prepare directly in BOD bottles. Either dilution method can be combined with any DO measurement technique. The number of bottles to be prepared for each dilution depends on the DO technique and the number of replicates desired. When using graduated cylinders or volumetric flasks to prepare dilutions, and when seeding is necessary, add seed either directly to dilution water or to individual cylinders or flasks before dilution. Seeding of individual cylinders or flasks avoids a declining ratio of seed to sample as increasing dilutions are made. When dilutions are prepared directly in BOD bottles and when seeding is necessary, add seed directly to dilution water or directly to the BOD bottles. When a bottle contains more than 67% of the sample after dilution, nutrients may be limited in the diluted sample and subsequently reduce biological activity. In such samples, add the nutrient, mineral, and buffer solutions directly to individual BOD bottles at a rate of 1 mL/L (0.33 mL/ 300-mL bottle) or use commercially prepared solutions designed to dose the appropriate bottle size.



- Dilutions prepared in graduated cylinders or volumetric flasks - modification of the titrimetric iodometric method s used, carefully siphon dilution water, seeded if necessary, into a 1- to 2-L-capacity flask or cylinder. Fill half full without entraining air. Add desired quantity of carefully mixed sample and dilute to appropriate level with dilution water. Mix well with a plunger-type mixing rod; avoid entraining air. Siphon mixed dilution into two BOD bottles. Determine initial DO on one of these bottles. Stopper the second bottle tightly, water-seal, and incubate for 5 d at 20°C. If the membrane electrode method is used for DO measurement, siphon dilution mixture into one BOD bottle. Determine initial DO on this bottle and replace any displaced contents with sample dilution to fill the bottle. Stopper tightly, water-seal, and incubate for 5 d at 20°C.

- Dilutions prepared directly in BOD bottles - Using a wide-tip volumetric pipet, add the desired sample volume to individual BOD bottles of known capacity. Add appropriate amounts of seed material either to the individual BOD bottles or to the dilution water. Fill bottles with enough dilution water, seeded if necessary, so that

insertion of stopper will displace all air, leaving no bubbles. For dilutions greater than 1:100 make a primary dilution in a graduated cylinder before making final dilution in the bottle. When using titrimetric iodometric methods for DO measurement, prepare two bottles at each dilution. Determine initial DO on one bottle. Stopper second bottle tightly, water-seal, and incubate for 5 d at 20°C. If the membrane electrode method is used for DO measurement, prepare only one BOD bottle for each dilution. Determine initial DO on this bottle and replace any displaced contents with dilution water to fill the bottle. Stopper tightly, water-seal, and incubate for 5 d at 20°C. Rinse DO electrode between determinations to prevent cross-contamination of samples.

- Use the azide modification of the iodometric method or the membrane electrode method to determine initial DO on all sample dilutions, dilution water blanks, and where appropriate, seed controls.
 - If the membrane electrode method is used, the azide modification of the iodometric method (Method 4500-O.C) is recommended for calibrating the DO probe.
9. Determination of initial DO: If the sample contains materials that react rapidly with DO, determine initial DO immediately after filling BOD bottle with diluted sample. If rapid initial DO uptake is insignificant, the time period between preparing dilution and measuring initial DO is not critical but should not exceed 30 min [Cleceri et al., 1998].
10. Dilution water blank: Use a dilution water blank as a rough check on quality of unseeded dilution water and cleanliness of incubation bottles. Together with each batch of samples incubate a bottle of unseeded dilution water. Determine initial and final DO j . The DO uptake should not be more than 0.2 mg/L and preferably not more than 0.1 mg/L. Discard all dilution water having a DO uptake greater than 0.2 mg/L and either eliminate source of contamination or select an alternate dilution water source.

11. Incubation: Incubate at $20^{\circ}\text{C} \pm 1^{\circ}\text{C}$ BOD bottles containing desired dilutions, seed controls, dilution water blanks, and glucose-glutamic acid checks. Water-seal bottles
 Determination of final DO: After 5 d incubation determine DO in sample dilutions, blanks, and checks 5.

4.2.5 Calculations

For each test bottle meeting the 2.0-mg/L minimum DO depletion and the 1.0-mg/L residual DO, calculate BOD_5 as follows:

When dilution water is not seeded:

$$D_1 - D_2$$

$$\text{BOD}_5, \text{mg/L} = P$$

When dilution water is seeded:

$$(D_1 - D_2) - (B_1 - B_2)f$$

$$\text{BOD}_5, \text{mg/L} =$$

where:

D_1 = DO of diluted sample immediately after preparation, mg/L,

D_2 = DO of diluted sample after 5 d incubation at 20°C , mg/L,

P = decimal volumetric fraction of sample used,

B_1 = DO of seed control before incubation, mg/L,

B_2 = DO of seed control after incubation mg/L, and

f = ratio of seed in diluted sample to seed in seed control = (% seed in diluted sample)/(% seed in seed control).

If seed material is added directly to sample or to seed control bottles:

$f = (\text{volume of seed in diluted sample})/(\text{volume of seed in seed control})$ [Cleceri et al. (1998)]

4.3 CHEMICAL OXYGEN DEMAND (OPEN REFLUX METHOD)

4.3.1 Principle

Most types of organic matter are oxidized by a boiling mixture of chromic and sulfuric acids. A sample is refluxed in strongly acid solution with a known excess of potassium dichromate ($K_2Cr_2O_7$). After digestion, the remaining unreduced $K_2Cr_2O_7$ is titrated with ferrous ammonium sulfate to determine the amount of $K_2Cr_2O_7$ consumed and the oxidizable matter is calculated in terms of oxygen equivalent. Keep ratios of reagent weights, volumes, and strengths constant when sample volumes other than 50 mL are used.

The standard 2-h reflux time may be reduced if it has been shown that a shorter period yields the same results. Some samples with very low COD or with highly heterogeneous solids content may need to be analyzed in replicate to yield the most reliable data. Results are further enhanced by reacting a maximum quantity of dichromate, provided that some residual dichromate remains. [Cleceri et al., 1998]

4.3.2 Apparatus

1. Reflux apparatus, consisting of 500- or 250-mL erlenmeyer flasks with ground-glass 24/40 neck and 300-mm jacket Liebig, West, or equivalent condenser with 24/40 ground-glass joint, and a hot plate having sufficient power to produce at least 1.4 W/cm^2 of heating surface, or equivalent.
2. Blender.
3. Pipets,

4.3.3 Reagents

- Standard potassium dichromate solution, 0.04167M: Dissolve 12.259 g $K_2Cr_2O_7$, primary standard grade, previously dried at 150°C for 2 h, in distilled water and dilute to 1000 mL. This reagent undergoes a six-electron reduction reaction; the equivalent concentration is 6 X 0.04167M or 0.2500N.
- Sulfuric acid reagent: Add Ag_2SO_4 , reagent or technical grade, crystals or powder, to conc H_2SO_4 at the rate of 5.5 g Ag_2SO_4 /kg H_2SO_4 . Let stand 1 to 2 d to dissolve. Mix.
- Ferroin indicator solution: Dissolve 1.485 g 1,10-phenanthroline monohydrate and 695 mg $FeSO_4 \cdot 7H_2O$ in distilled water and dilute to 100 mL. This indicator solution may be purchased already prepared.
- Standard ferrous ammonium sulfate (FAS) titrant, approximately 0.25M: Dissolve 98 g $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ in distilled water. Add 20 mL conc H_2SO_4 , cool, and dilute to 1000 mL. Standardize this solution daily against standard $K_2Cr_2O_7$ solution
- Mercuric sulfate, $HgSO_4$, crystals or powder.
- Sulfamic acid: Required only if the interference of nitrites is to be eliminated
- Potassium hydrogen phthalate (KHP) standard, $HOOC C_6H_4 COOK$: Lightly crush and then dry KHP to constant weight at 110°C. Dissolve 425 mg in distilled water and dilute to 1000 mL. KHP has a theoretical COD¹ of 1.176 mg O_2 /mg and this solution has a theoretical COD of 500 $\mu g O_2$ / mL. This solution is stable when refrigerated, but not indefinitely. Be alert to development of visible biological growth. If practical, prepare and transfer solution under sterile conditions. Weekly preparation usually is satisfactory [Cleceri et al. (1998)].

4.3.4 Procedure

1. Treatment of samples with COD of >50 mg O_2/L : Blend sample if necessary and pipet 50.00 mL into a 500-mL refluxing flask. For samples with a COD of >900 mg O_2/L , use a smaller portion diluted to 50.00 mL. Add 1 g $HgSO_4$, several glass beads, and very slowly add 5.0 mL sulfuric acid reagent, with mixing to dissolve $HgSO_4$. Cool while mixing to avoid possible loss of volatile materials. Add 25.00 mL 0.04167M $K_2Cr_2O_7$ solution and mix. Attach flask to condenser and turn on cooling water.
2. Add remaining sulfuric acid reagent (70 mL) through open end of condenser. Continue swirling and mixing while adding sulfuric acid reagent. CAUTION: Mix reflux mixture thoroughly before applying heat to prevent local heating of flask bottom and a possible blowout of flask contents.
3. Cover open end of condenser with a small beaker to prevent foreign material from entering refluxing mixture and reflux for 2 h. Cool and wash down condenser with distilled water. Disconnect reflux condenser and dilute mixture to about twice its volume with distilled water. Cool to room temperature and titrate excess $K_2Cr_2O_7$ with FAS, using 0.10 to 0.15 mL (2 to 3 drops) ferroin indicator. Although the quantity of ferroin indicator is not critical, use the same volume for all titrations.
4. Take as the end point of the titration the first sharp color change from blue-green to reddish brown that persists for 1 min or longer. Duplicate determinations should agree within 5% of their average. Samples with suspended solids or components that are slow to oxidize may require additional determinations. The blue-green may reappear. In the same manner, reflux and titrate a blank containing the reagents and a volume of distilled water equal to that of sample.

5. Alternate procedure for low-COD samples: Follow procedure of 4a, with two exceptions: (i) use standard 0.004167M $K_2Cr_2O_7$, and (ii) titrate with standardized 0.025M FAS. Exercise extreme care with this procedure because even a trace of organic matter on the glassware or from the atmosphere may cause gross errors. If a further increase in sensitivity is required.

6. Concentrate a larger volume of sample before digesting under reflux as follows: Add all reagents to a sample larger than 50 mL and reduce total volume to 150 mL by boiling in the refluxing flask open to the atmosphere without the condenser attached. Compute amount of $HgSO_4$ to be added (before concentration) on the basis of a weight ratio of 10:1, $HgSO_4:Cl^-$, using the amount of Cl^- present in the original volume of sample. Carry a blank reagent through the same procedure. This technique has the advantage of concentrating the sample without significant losses of easily digested volatile materials. Hard-to-digest volatile materials such as volatile acids are lost, but an improvement is gained over ordinary evaporative concentration methods.

7. Determination of standard solution: Evaluate the technique and quality of reagents by conducting the test on a standard potassium hydrogen phthalate solution.

4.3.5 Calculations

$$(A - B) \times M \times 8000$$

COD as mg O_2/L = mL sample

where:

A = mL FAS used for blank,

B = mL FAS used for sample,

M = molarity of FAS, and

8000 = milliequivalent weight of oxygen X 1000 mL/L. [Cleceri et al. (1998)]

4.4 TOTAL SUSPENDED SOLIDS

4.4.1 Principle

A well-mixed sample is filtered through a weighed standard glass-fiber filter and the residue retained on the filter is dried to a constant weight at 103 to 105°C. The increase in weight of the filter represents the total suspended solids. If the suspended material clogs the filter and prolongs filtration, it may be necessary to increase the diameter of the filter or decrease the sample volume. To obtain an estimate of total suspended solids, calculate the difference between total dissolved solids and total solids.

4.4.2 Apparatus

1. Glass-fiber filter disks without organic binder.
2. Filtration apparatus: One of the following, suitable for the filter disk selected
3. Membrane filter funnel.
4. Gooch crucible, 25-mL to 40-mL capacity, with Gooch crucible adapter.
5. Filtration apparatus with reservoir and coarse (40- to 60- μm) fritted disk as filter support.
6. Suction flask, of sufficient capacity for sample size selected

4.4.3 Procedure

1. Preparation of glass-fiber filter disk: If pre-prepared glass fiber filter disks are used, eliminate this step. Insert disk with wrinkled side up in filtration apparatus. Apply vacuum and wash disk with three successive 20-mL portions of reagent-grade water. Continue suction to remove all traces of water, turn vacuum off, and discard washings.

Remove filter from filtration apparatus and transfer to an inert aluminum weighing dish. If a Gooch crucible is used, remove crucible and filter combination. Dry in an oven at 103 to 105°C for 1 h. If volatile solids are to be measured, ignite at 550°C for 15 min in a muffle furnace. Cool in desiccator to balance temperature and weigh. Repeat cycle of drying or igniting, cooling, desiccating, and weighing until a constant weight is obtained or until weight change is less than 4% of the previous weighing or 0.5 mg, whichever is less. Store in desiccator until needed [Cleceri et al. (1998)].

2. Selection of filter and sample sizes: Choose sample volume to yield between 2.5 and 200 mg dried residue. If volume filtered fails to meet minimum yield, increase sample volume up to 1 L. If complete filtration takes more than 10 min, increase filter diameter or decrease sample volume.

3. Sample analysis: Assemble filtering apparatus and filter and begin suction. Wet filter with a small volume of reagent-grade water to seat it. Stir sample with a magnetic stirrer at a speed to shear larger particles, if practical, to obtain a more uniform (preferably homogeneous) particle size. Centrifugal force may separate particles by size and density, resulting in poor precision when point of sample withdrawal is varied. While stirring, pipet a measured volume onto the seated glass-fiber filter. For homogeneous samples, pipet from the approximate midpoint of container but not in vortex. Choose a point both middepth and midway between wall and vortex. Wash filter with three successive 10-mL volumes of reagent-grade water, allowing complete drainage between washings, and continue suction for about 3 min after filtration is complete. Samples with high dissolved solids may require additional washings. Carefully remove filter from filtration apparatus and transfer to an aluminum weighing dish as a support. Alternatively, remove the crucible and filter combination from the crucible adapter if a Gooch crucible is used. Dry for at least 1 h at 103 to 105°C in an oven, cool in a desiccator to balance temperature, and weigh. Repeat the cycle of drying, cooling, desiccating, and weighing until a constant weight is obtained or until the weight change is less than 4% of the previous weight or 0.5 mg, whichever is less. Analyze at least 10% of all samples in duplicate. Duplicate determinations should agree within 5% of their average weight.

4.4.4 Calculation

$$\text{mg total suspended solids/L} = \frac{(A-B) \times 1000}{\text{sample volume, mL}}$$

where:

A = weight of filter + dried residue, mg, and
B = weight of filter, mg.

4.5 TOTAL DISSOLVED SOLIDS

4.5.1 Principle

A well-mixed sample is filtered through a standard glass-fiber filter, and the filtrate is evaporated to dryness in a weighed dish and dried to constant weight at 180°C. The increase in dish weight represents the total dissolved solids. This procedure may be used for drying at other temperatures [Cleceri et al. (1998)]

The results may not agree with the theoretical value for solids calculated from chemical analysis of sample (see above). Approximate methods for correlating chemical analysis with dissolved solids are available. The filtrate from the total suspended solids determination may be used for determination of total dissolved solids.

4.5.2 Apparatus

1. Glass-fiber filter disks without organic binder.
2. Filtration apparatus: One of the following, suitable for the filter disk selected
3. Membrane filter funnel.
4. Gooch crucible, 25-mL to 40-mL capacity, with Gooch crucible adapter.

5. Filtration apparatus with reservoir and coarse (40- to 60- μm) fritted disk as filter support.
6. Suction flask, of sufficient capacity for sample size selected
7. Drying oven, for operation at $180 \pm 2^\circ\text{C}$.

4.5.3 Procedure

1. Preparation of glass-fiber filter disk: If pre-prepared glass fiber filter disks are used, eliminate this step.
2. Insert disk with wrinkled side up into filtration apparatus. Apply vacuum and wash disk with three successive 20-mL volumes of reagent-grade water. Continue suction to remove all traces of water. Discard washings
3. Preparation of evaporating dish: If volatile solids are to be measured, ignite cleaned evaporating dish at 550°C for 1 h in a muffle furnace.
4. If only total dissolved solids are to be measured, heat clean dish to $180 \pm 2^\circ\text{C}$ for 1 h in an oven. Store in desiccator until needed. Weigh immediately before use.
5. Selection of filter and sample sizes: Choose sample volume to yield between 2.5 and 200 mg dried residue. If more than 10 min are required to complete filtration, increase filter size or decrease sample volume.
6. Sample analysis: Stir sample with a magnetic stirrer and pipet a measured volume onto a glass-fiber filter with applied vacuum.

7. Wash with three successive 10-mL volumes of reagent-grade water, allowing complete drainage between washings, and continue suction for about 3 min after filtration is complete.
8. Transfer total filtrate (with washings) to a weighed evaporating dish and evaporate to dryness on a steam bath or in a drying oven. If necessary, add successive portions to the same dish after evaporation.
9. Dry evaporated sample for at least 1 h in an oven at $180 \pm 2^\circ\text{C}$, cool in a desiccator to balance temperature, and weigh.
10. Repeat drying cycle of drying, cooling, desiccating, and weighing until a constant weight is obtained or until weight change is less than 4% of previous weight or 0.5 mg, whichever is less.
11. Analyze at least 10% of all samples in duplicate. Duplicate determinations should agree within 5% of their average weight. [Cleceri et al., 1998].

4.5.4 Calculation

$$(A - B) \times 1000 / \text{sample volume, mL} = \text{mg total dissolved solids/L}$$

where:

A = weight of dried residue + dish, mg, and

B = weight of dish, mg.

4.6 OIL AND GREASE

4.6.1 Principal

Dissolved or emulsified oil and grease is extracted from water by intimate contact with an extracting solvent. Some extractables, especially unsaturated fats and fatty acids, oxidize readily; hence, special precautions regarding temperature and solvent vapor displacement are included to minimize this effect. Organic solvents shaken with some samples may form an emulsion that is very difficult to break. This method includes a means for handling such emulsions. Recovery of solvents is discussed. Solvent recovery can reduce both vapor emissions to the atmosphere and costs [Cleceri et al. (1998)].

4.6.2 Apparatus

1. Separatory funnel
2. Distilling flask, 125-mL.
3. Liquid funnel, glass, Filter paper.
4. Centrifuge, capable of spinning at least four 100-mL glass centrifuge tubes at 2400 rpm or more. Centrifuge tubes, 100-mL, glass.
5. Water bath, capable of maintaining 85°C.
6. Vacuum pump or other source of vacuum.
7. Distilling adapter with drip tip.
8. Ice bath.

9. Waste receptacle, for used solvent.

10. Desiccator.

4.6.3 Reagents

1. Hydrochloric or sulfuric acid
2. n-Hexane, boiling point 69°C. The solvent should leave no measurable residue on evaporation; distill if necessary. Do not use any plastic tubing to transfer solvent between containers.
3. Methyl-tert-butyl ether (MTBE), boiling point 55°C to 56°C. The solvent should leave no measurable residue on evaporation; distill if necessary. Do not use any plastic tubing to transfer solvent between containers.
4. Sodium sulfate, Na_2SO_4 , anhydrous crystal.
5. Solvent mixture, 80% n-hexane/20% MTBE, v/v.

4.6.4 Procedure

1. Mark sample bottle at the water meniscus or weigh the bottle, for later determination of sample volume.
2. If sample has not been acidified previously, acidify with either 1:1 HCl or 1:1 H_2SO_4 to pH 2 or lower (generally, 5 mL is sufficient for 1 L sample).
3. Using liquid funnel, transfer sample to a separatory funnel.

4. Carefully rinse sample bottle with 30 mL extracting solvent (either 100% n-hexane, or solvent mixture, and add solvent washings to separatory funnel. Shake vigorously for 2 min. Let layers separate.
5. Drain aqueous layer and small amount of organic layer into original sample container.
6. Drain solvent layer through a funnel containing a filter paper and 10 g Na₂SO₄, both of which have been solvent-rinsed, into a clean, tared distilling flask.
7. If a clear solvent layer cannot be obtained and an emulsion of more than about 5 mL exists, drain emulsion and solvent layers into a glass centrifuge tube and centrifuge for 5 min at approximately 2400 rpm.
8. Transfer centrifuged material to an appropriate separatory funnel and drain solvent layer through a funnel with a filter paper and 10 g Na₂SO₄, both of which have been pre-rinsed, into a clean, distilling flask.
9. Recombine aqueous layers and any remaining emulsion or solids in separatory funnel.
10. For samples with <5 mL of emulsion, drain only the clear solvent through a funnel with pre-moistened filter paper and 10 g Na₂SO₄.
11. Recombine aqueous layers and any remaining emulsion or solids in separatory funnel.
12. Extract twice more with 30 mL solvent each time, but first rinse sample container with each solvent portion.
13. Repeat centrifugation step if emulsion persists in subsequent extraction steps.

14. Combine extracts in tared distilling flask, and include in flask a final rinsing of filter and Na_2SO_4 with an additional 10 to 20 mL solvent.
15. Distill solvent from flask in a water bath at 85°C for either solvent system.
16. To maximize solvent recovery, fit distillation flask with a distillation adapter equipped with a drip tip and collect solvent in an ice-bath-cooled receiver.
17. When visible solvent condensation stops, remove flask from water bath.
18. Cover water bath and dry flasks on top of cover, with water bath still at 85°C , for 15 min.
19. Draw air through flask with an applied vacuum for the final 1 min. Cool in desiccator for at least 30 min and weigh.
20. To determine initial sample volume, either fill sample bottle to mark with water and then pour water into a 1-L graduated cylinder, or weigh empty container and cap
21. Calculate the sample volume by difference from the initial weight (assuming a sample density of 1.00).

4.6.5 CALCULATIONS

If the organic solvent is free of residue, the gain in weight of the tared distilling flask is due to oil and grease. Total gain in weight, A, of tared flask, less calculated residue from solvent blank, B, is the amount of oil and grease in the sample: [Cleceri et al. (1998)]

$$\text{mg oil and grease/L} = \frac{(A-B) \times 1000}{\text{mL sample}}$$

CHAPTER 5

RESULTS AND DISCUSSION

5.1 GENERAL

This chapter deals with interpretation of results obtained from the work conducted for the evaluation of various Common Effluent Treatment Plants. The results obtained from the present study have been furnished in tables and the efficiency achieved in the reduction of various parameters as shown in the figures which shows the overall efficiency of the common effluent treatment plants in the reduction of different parameters.

The Delhi region has 11 operational CETPs and 1 under-construction CETP. The stage wise grab samples were collected at various points to evaluate the performance of CETPs.

5.2 SAMPLING POINTS:

The sampling points are S1, S2, S3, S4 and S5.

- S1- Raw Effluent / Before Equalization (S1)
- S2- After Equalization (S2)
- S3- After tube settler/primary clarifier /after aeration (S3)
- S4- After dual media filter (DMF) (S4)
- S5- After activated carbon filter (ACF) (S5)

Three Samples of ground water (GW) from each of the industrial area were also taken for TDS monitoring. The samples were collected and analyzed in water lab of Central Pollution Control Board (CPCB), Delhi.

5.3 LOCATIONS:

The 11 Common Effluent Treatment Plants of Delhi which were selected are:-

1. Lawrence Road
2. Mangolpuri
3. Jhilmil
4. Okhla
5. GT Karnal Road
6. Wazirpur
7. SMA
8. Narela
9. Mayapuri
10. Badli
11. Nangloi

Table 5.1 Location and capacity of CETPs in Delhi

S.No	Name of CETP	Industries estates served	Date of completion	Design capacity MLD
1.	Lawrence Road	Lawrence road Industrial Area	30.09.2004	12
2.	Mangolpuri	Mangolpuri Industrial Area, phase I & II	28.11.2001	2.4
3.	Jhimil	Jhilmil & Friends colony Industrial Area	22.08.2004	16.8
4.	Okhla	Okhla Industrial Area	30.04.2003	24
5.	GTK Road	GTK Road Industrial Area	01.12.2002	6
6.	Wazirpur	Wazirpur Industrial area	23.01.2003	24
7.	SMA	Rajasthan Udyognagar, SMA & SSI Industrial Areas	30.05.2003	12
8.	Narela	Narela Industrial Area	15.06.2003	24
9.	Mayapuri	Mayapuri Industrial Area, phase I & II	03.03.2003	12
10.	Badli	Badli Industrial Area	31.03.2003	12
11.	Nangloi	DSIDC, Nangloi & Udyognagar Industrial areas	30.05.2003	12

5.3.1 LAWRENCE ROAD CETP:

The CETP plant has the conventional chemical treatment facility to treat effluents from Industries such as Food industry, Textile Industry, Meat Processing, Public/Domestic toilets.

1. Date of monitoring: December 12, 2007

2. Industrial area (s) connected to the CETP: Lawrence road industrial area has about 450 industries.

3. Main units of treatment scheme:

- i. Screens,
- ii. Green channels,
- iii. Equalization tank,
- iv. Pre-chlorination contact tank,
- v. Tube settler, settling
- vi. Primary tank,
- vii. Aeration tank,
- viii. Secondary settling tank,
- ix. Dual media filters
- x. Activated carbon columns
- xi. Sludge thickener and
- xii. Rotary vacuum filter for sludge treatment

4. Design flow of CETP: 12MLD (500 m³/hr)

5. Observed flow reaching CETP: 2 MLD

Table 5.2: Unit sizes of main treatment units and operational conditions at Lawrence Road CETP

Treatment Unit	Collected Information
Equalization tank	Hourly influent rate: 500 m ³ /hr Volume: 4000 m ³
Tube Settler	Hourly influent rate: 500 m ³ /hr Total number of operational hours: 8-12 hr Surface area: 100 m ² Media depth: 1 m
Primary Settling tank	NA
Aeration tank	NA
Secondary settling tank	NA
Dual Media Filter (DMF)	Total units: 9, Diameter: 3.0 m Hourly influent rate: 100-250 m ³ /hr Total no. of operation hours: 6-8 hr No. of units in use: 5
Activated carbon columns:	Total units: 6, Diameter: 3.0 m Hourly influent rate: 100-250 m ³ /hr Total no. of operation hours: 6-8 hr. N. of units in use: 4
Sludge thickener	Daily hourly prim. sludge flow rates: 15 m ³ /hr Total no. of operation hours: 8-10 hrs Surface area: 701 m ²
Rotary vacuum filter	Thickened sludge pump capacity: 15 m ³ /hr Total no. of operation hours: 8-10 hr. Diameter: 1.8 m and width: 1.52 m Design loading: 14 kg/m ² /hr
Chemical dosing	Bleaching powder: 30 ppm, Alum: 400 ppm and Polyelectrolyte: 0.5 ppm

TABLE 5.3 Lab analysis report of Lawrence Road CETP:

Lawrence Road	Sample location	Ph	BOD	COD	TSS	TDS	O&G
Design flow rate: 12 MLD	Before equal. Tank	7.11	247	621	332	4350	122
	After equal. Tank	7.08	339	818	355	4120	
Observed flow: 2.0 MLD	After tube settler	6.55	190	408	164	4276	
	After dual media filter	6.65	203	414	180	4388	
	After activated carbon	6.50	186	361	158	4176	70

*All the parameters are in mg/l except pH

From the analysis results following are inferred:

1. The effluent received at CETP during study period was around 2.0 MLD, whereas the designed capacity of CETP is 12 MLD, which shows under utilization of the CETP.
2. The overall treatment efficiencies, in respect of BOD, COD, TSS and TDS were 24.69 %, 41.86%, 52.40% and 4% respectively which indicates no proper treatment to the organic load.
3. The CETP is not meeting the prescribed standards with respect to BOD, COD, TSS, TDS and Oil & Grease. The observed concentrations are 186, 361, 158, 4176 and 70 against the limit of 30, 250, 100, 2100 and 10 respectively.
4. Housekeeping practices of CETP premises were found to be poor especially with respect to sludge handling areas.
5. In primary clarifier and aeration tank, foam was generating considerably and was being removed manually. In aeration tank anti foaming agent was being mixed for reduction of foams.
6. Delhi Pollution Control Committee has taken the responsibility for the safe disposal of sludge generated during the process. At present it is being stored in open ground which may leads for ground water contamination.

5.3.2 MANGOLPURI CETP

The CETP plant has Biological treatment facility to treat effluents from Industries such as Plastics, Rubber, Automobiles, Foot wear and Vegetable waste sector.

1. Date of Monitoring/Inspection: December 13, 2007
2. Industrial area (s) connected to the CETP: Mangolpuri industrial area-530 industries
3. Main units of treatment scheme:
 - i. Screens,
 - ii. Green channels,

- iii. Equalization tank,
- iv. Primary settling tank,
- v. Aeration tank,
- vi. Secondary settling tank,
- vii. Dual media filters
- viii. Activated carbon columns
- ix. Sludge thickener and
- x. Rotary vacuum filter for sludge treatment

4. Design flow of CETP 2.4 MLD (110 m³/hr)

5. Average flow reaching CETP 1.2- 1.3 MLD

Table 5.4: Unit sizes of main treatment units and operational conditions at Mangolpuri CETP

Treatment Unit	Collected Information
Equalization tank (2)	Hourly influent rate: 500 m ³ /hr Volume: 800 m ³ (400 m ³ each)
Primary Settling tank	Hourly influent flow rate: 50 m ³ /hr Diameter: 9.6 m, Volume: 217 m ³
Aeration tank	Hourly influent flow rate: 50 m ³ /hr
Secondary settling tank	Hourly influent flow rate: 50 m ³ /hr Diameter: 15 m, Volume: 530 m
Dual Media Filter (DMF)	Total units: 3, Diameter: 3.0 m Media depth: 1.25 m Hourly influent rate: 50 m ³ /hr Total no. of operation hours: 24 hr No. of units in use: 2
Activated carbon columns:	Total units: 2, Diameter: 3.0 m Hourly influent rate: 50 m ³ /hr Total no. of operation hours: 24 hr. N. of units in use: 2
Sludge thickener	Hourly prim. sludge flow rates: 10-20 m ³ /hr Total no. of operation hours: 24 hrs Diameter: 2.5 m
Rotary vacuum filter	Thickened sludge pump capacity: 10-20 m ³ /hr Total no. of operation hours: 24 hr. Diameter: 0.75 m and width: 1.36 m Design loading: 14 kg/m ² /hr
Chemical dosing	NA

Table 5.5 Lab analysis report of Mangolpuri CETP:

Mangolpuri	Sample location	Ph	BOD	COD	TSS	TDS	O&G
Design flow rate: 2.4 MLD	Before equal. Tank	7.15	75	274	170	7694	89
	After equal. Tank	7.20	150	490	457	8536	
Observed flow: 1.2-1.3 MLD	After tube settler	7.32	44	148	124	8356	
	After dual media filter	7.27	34	114	50	8288	
	After activated carbon	6.69	22	96	36	8316	9

*All the parameters are in mg/l except pH

Fact and finding of the study carried out are as follows:

1. The CETP plant has Biological treatment facility to treat effluents from Industries such as Plastics, Rubber, Automobiles, Foot wear and Vegetable waste sector.
2. The Plant has 2 inlet pipes (Phase I and Phase II) and phase II was not working at the time of visit.
3. The overall treatment efficiencies, in respect of BOD, COD, TSS were 70.66 %, 64.96%, 78.82% respectively which indicates proper treatment to the organic load.
4. The species used in the Aeration tank is amylases along with the Protozoa in Mixed Liquor Suspended Solids and BOD:N:P ratio is 100:5:1
5. All the sludge drying beds were observed filled up with sludge, which shows inadequate capacity.
6. The higher concentration of TDS at the outlet may be due to higher doses of coagulant and lime.
7. The CETP do not have stand by power supply arrangement, which is essential for continuous operation of the biological plants.
8. The CETP in meeting the prescribed standards with respect to Ph, BOD, COD, TSS, TDS, and Oil & grease.

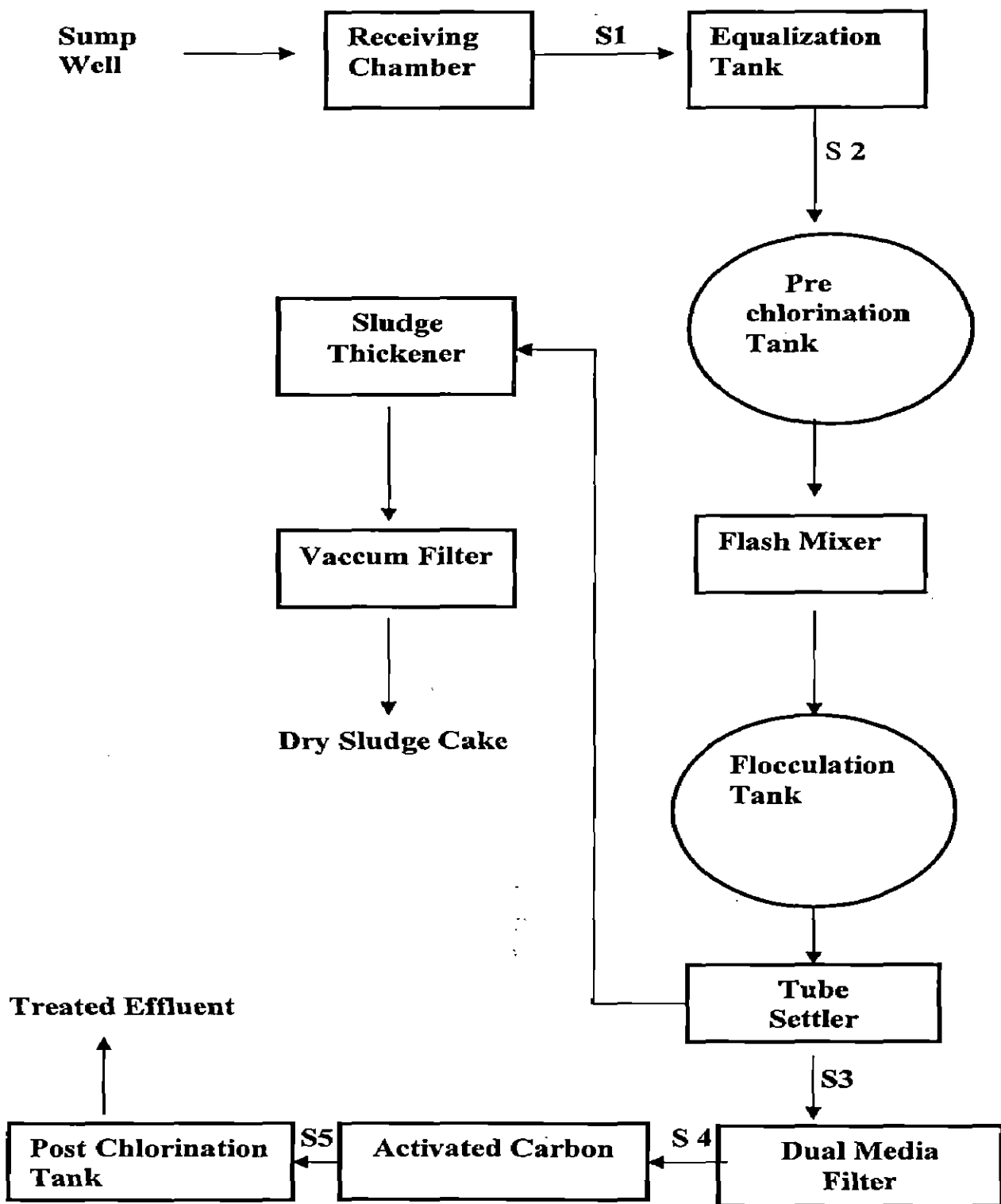


Fig. 5.1 Schematic diagram of CETP at Lawrence Road

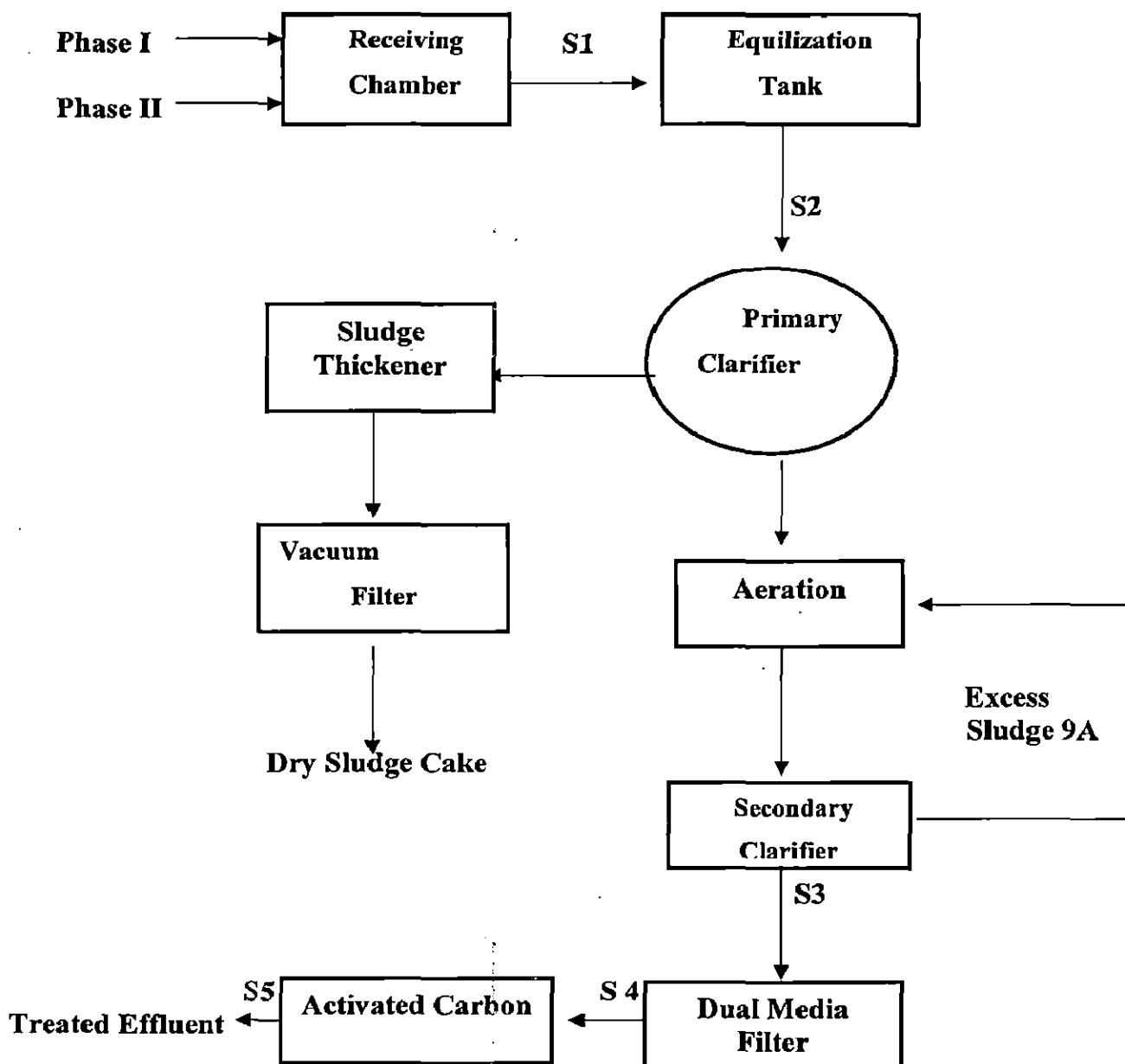


Fig. 5.2 Schematic diagram of CETP at Mangolpuri (Biological Treatment)

5.3.3 JHILMIL CETP

1. Date of Monitoring: December 14,, 2007
2. Industrial area (s) connected to the CETP: Jhilmil industrial area - 500 industries.
3. Main units of treatment scheme:
 - i. Screens,
 - ii. Green channels,
 - iii. Equalization tank,
 - iv. Pre-chlorination contact tank,
 - v. Tube settler,
 - vi. Dual media filters
 - vii. Activated carbon columns
 - viii. Sludge thickener and
 - ix. Rotary vacuum filter for sludge treatment
4. Design flow of CETP 16.8 MLD (500 m³/hr)
5. Average flow reaching CETP- 4.5-5 MLD

Table 5.6: Unit sizes of main treatment units and operational conditions at Jhilmil CETP

Treatment Unit	Collected Information
Equalization tank	Hourly influent rate: 350 m ³ /hr Volume: 3000 m ³
Tube Settler	Hourly influent rate: 350 m ³ /hr Total number of operational hours: 8-12 hr Surface area: 12X6 m ² , Media depth: 0.75 m
Dual Media Filter (DMF)	Total units: 17, Diameter: 3.0 m Hourly influent rate: 100-250 m ³ /hr Total no. of operation hours: 9-12 hr No. of units in use: 8-10
Activated carbon columns:	Total units: 10, Diameter: 3.0 m Hourly influent rate: 100-250 m ³ /hr Total no. of operation hours: 9-12 hr. N. of units in use: 6
Sludge thickener	Hourly primary sludge flow rates: 15 m ³ /hr Total no. of operation hours: 8-10 hrs Surface area: 701 m ² , diameter: 3.3 m
Rotary vacuum filter	Thickened sludge pump capacity: 15 m ³ /hr D: 1.8 m and W: 1.52 m Design loading: 14 kg/m ² /hr
Chemical dosing	Bleaching powder: 125-130 ppm, Alum: 90-110 ppm and Polyelectrolyte: 0.5 ppm.

Table 5.7 Lab analysis report of Jhilmil CETP:

Jhilmil	Sample location	Ph	BOD	COD	TSS	TDS	O&G
Design flow rate: 16.8 MLD Observed flow: 4.5-5.0 MLD	Before equal. Tank	6.75	109	313	136	2598	63
	After equal. Tank	6.34	29	135	78	3698	
	After tube settler	6.49	22	110	72	3714	
	After dual media filter	7.14	9	47	47	3298	
	After activated carbon	6.70	11	71	37	2780	10

*All the parameters are in mg/l except pH

Fact and finding of the study carried out are as follows:

1. The effluent received at CETP during study period was around 4.5-5.0 MLD, whereas the designed capacity of CETP is 16.8 MLD, which shows under utilization of the CETP.
2. The overall treatment efficiencies, in respect of BOD, COD, TSS and O&G were 89.9 %, 77.32%, 72.8% and 84.13% respectively which indicates proper treatment to the organic load.
3. The solid waste generated from the CETP needs scientific disposal. At present it is being stored in polythene bags.
4. Since power failure is the common phenomenon, stand by arrangement like DG set has not been installed.
5. Equalization tank were not clean since the time it was put under operation and around 50 to 60% of its capacity might have been exhausted by this time due to settling of solids at bottom. This clearly indicates the poor performance of equalization unit, which leads an adverse impact on overall efficiency of the CETP.

5.3.4 OKHALA CETP

1. Date of Inspection: December 14, 2007

2. Industrial area (s) connected to the CETP: Okhala Industrial Area - >1000 industries.

3. Main units of treatment scheme:

- i. Screens,
- ii. Green channels,
- iii. Equalization tank,
- iv. Pre-chlorination contact tank,
- v. Tube settler,
- vi. Dual media filters
- vii. Activated carbon columns
- viii. Sludge thickener and
- ix. Rotary vacuum filter for sludge treatment

4. Design flow of CETP: 24MLD (1000 m³/hr)

5. Average flow reaching: CETP 3.5 MLD

Table 5.8: Unit sizes of main treatment units and operational conditions at Okhala CETP

Treatment Unit	Collected Information
Equalization tank	Hourly influent rate: 400 m ³ /hr Volume: 8000 m ³ No. of Aerators: 4 Capacity of each aerators: 15 KW HP
Tube Settler	Hourly influent rate: 400 m ³ /hr Total number of operational hours: 8-12 hr Surface area: 216 m ² Media depth: 1.0 m
Primary Settling tank	NA
Aeration tank and secondary settling tank	NA
Dual Media Filter (DMF)	Total units: 24, Diameter: 3.0 m Hourly influent rate: 400 m ³ /hr Total no. of operation hours: 8-12 hr No. of units in use: 12
Activated carbon columns:	Total units: 15, Diameter: 3.0 m Hourly influent rate: 400 m ³ /hr Total no. of operation hours: 8-12 hr. N. of units in use: 7-8
Sludge thickener	Daily hourly primary sludge flow rates: 40 m ³ /hr Total no. of operation hours: 8 hrs Surface area: 701 m ² , diameter: 3.3 m
Rotary vacuum filter	Thickened sludge pump capacity: 900 m ³ /hr Total no. of operation hours: 8-9 hr. Diameter: 1.9 m and width: 2.5 m Design loading: 285 kg/m ² /hr
Chemical dozing	Bleaching powder:45 ppm, Alum:400 ppm And Polyelectrolyte: 0.3 ppm

Table 5.9 Lab analysis report of CETP at Okhla:

Okhla	Sample location	Ph	BOD	COD	TSS	TDS	O&G
Design flow rate: 24 MLD	Before equal. Tank	7.29	231	550	222	1756	44
	After equal. Tank	7.52	151	589	422	1798	
Observed flow: 3.5 MLD	After tube settler	7.25	95	192	33	1818	
	After dual media filter	7.31	90	197	22	1854	
	After activated carbon filter	7.16	76	193	15	1918	15

*All the parameters are in mg/l except pH

Fact and finding of the study carried out are as follows:

1. The effluent received at CETP during study period was around 3.5 MLD, whereas the designed capacity of CETP is 24 MLD; which shows under utilization of the CETP.
2. The overall treatment efficiencies, in respect of BOD, COD, TSS and O&G were 67.0 %, 64.9%, 93.24% and 65.9% respectively which indicates proper treatment to the organic load.
3. Industrial units are not providing the desired primary treatment to their effluent before sending to CETP.
4. There was no flow measurement facility and it was operated by pump flow.
5. From the result it is seen that the CETP is meeting the stipulated standard in terms of Ph, BOD, COD, TSS, TDS, and O & G.
6. It was also seen that most of the industries are not discharging their effluent to the CETP but directly into the drains.

5.3.5 GT KARNAL ROAD CETP

1. Date of Inspection: 15 December, 2007
2. Industrial area (s) connected to the CETP: GTK Road Industrial Area - about 420 –450 industries
3. Main units of treatment scheme:
 - i. Screens,
 - ii. Grit channels,
 - iii. Equalization tank,
 - iv. Pre-chlorination contact tank,

- v. Tube settler,
- vi. Dual media filters
- vii. Activated carbon columns
- viii. Sludge thickener and
- ix. Rotary vacuum filter for sludge treatment

4. Design flow of CETP: 6 MLD (1000 m³/hr)

5. Average flow reaching: CETP 1.7 MLD

Table 5.10: Unit sizes of main treatment units and operational conditions at GT Karnal Road CETP

Treatment Unit	Collected Information
Equalization tank	Hourly influent rate: 170 m ³ /hr Volume: 4000 m ³
Tube Settler	Hourly influent rate: 170 m ³ /hr Total number of operational hours: 10-12 hr Media depth: 2.55 Effective surface area: 2.05 m ³ /m ³
Primary Settling tank	NA
Aeration tank	NA
Secondary settling tank	NA
Dual Media Filter (DMF)	Total units: 6, Diameter: 3.0 m Hourly influent rate: 400 m ³ /hr Total no. of operation hours: 14 hr No. of units in use: 3
Activated carbon columns:	Total units: 4, Diameter: 3.0 m Total no. of operation hours: 9-14 hr. N. of units in use: 2
Sludge thickener	Total no. of operation hours: 9-12 hrs Diameter: 6.5 m
Rotary vacuum filter	Total no. of operation hours: 5 hr. Diameter: 1.9 m and width: 2.5 m Design loading: 28 kg/m ² /hr
Chemical dosing	Bleaching powder: 30 ppm, Alum: 400 ppm And Polyelectrolyte: 0.5 ppm

Table 5.11 Lab analysis report of CETP at GT Karnal Road:

GTK Road	Sample location	Ph	BOD	COD	TSS	TDS	O&G
Design flow rate: 6 MLD	Raw effluent	7.08	190	504	198	1066	17
Observed flow: 1.7 MLD	Before equal. Tank	7.33	157	397	184	1056	
	After equal. Tank	7.55	51	225	241	112	
	After tube settler	7.10	15	47	29	1170	
	After dual media filter	7.23	4	15	BDL	1854	
	After activated carbon	7.38	7	31	28	1180	BDL

* All the parameters are in mg/l except pH

Fact and finding of the study carried out are as follows:

1. The effluent received at CETP during study period was around 1.7 MLD, whereas the designed capacity of CETP is 6 MLD, which shows under utilization of the CETP.
2. The overall treatment efficiencies, in respect of BOD, COD, and TSS were 96.3 %, 93.8 %, and 85.8% respectively which indicates proper treatment to the organic load.
3. The final effluent quality is the best among all the CETPs final effluent. It shows the proper functioning and maintenance of CETP.
4. Sludge handling facilities was inadequate as polybags were broken.
5. Flow meter device were not installed.
6. A full fledged laboratory exist with a facility to monitor the operational parameters such as pH, BOD, COD, TSS, TDS, Oil and gas.

5.3.6 WAZIRPUR CETP

1. Date of Inspection: 15 December , 2007
2. Industrial area (s) connected to the CETP: Wazirpur Ind. Area-1100 Industries.
3. Main units of treatment scheme:

- i. Screens,
- ii. Green channels,
- iii. Equalization tank,
- iv. Pre-chlorination contact tank,
- v. Tube settler,
- vi. Dual media filters
- vii. Activated carbon columns
- viii. Sludge thickener and
- ix. Rotary vacuum filter for sludge treatment

4. Design flow of CETP: 24MLD

5. Average flow reaching: CETP 2.25 MLD

Table 5.12 Lab analysis report of CETP at Wazirpur:

Wazirpur	Sample location	Ph	BOD	COD	TSS	TDS	O&G
Design flow rate: 24 MLD Observed flow: 2.25MLD	Raw effluent	<2.0					
	Before equal. Tank	<3.0					
	After equal. Tank						
	After tube settler						
	After dual media filter						
	After activated carbon						

* All the parameters are in mg/l except pH

The Ph value of the raw effluent was less (around 1.0-2.0) which need NaOH at the early stage but due to carelessness it was not maintained as a result pH at the equalization tank was around 2- 3. As a result to protect the ACF and DMF recycling was going on to neutralize the pH. So the entire treatment plant was not in operation. So the samples were not collected for analysis.

5.3.7 SMA CETP

1. Date of Inspection: 16 December, 2007

2. Industrial area (s) connected to the CETP: SMA Industrial Area has about 500 industries (mainly pickling, dying)

3. Main units of treatment scheme:

- i. Screens,
- ii. Green channels,
- iii. Equalization tank,
- iv. Pre-chlorination contact tank,
- v. Tube settler,
- vi. Dual media filters
- vii. Activated carbon columns
- viii. Sludge thickener and
- ix. Rotary vacuum filter for sludge treatment

4. Design flow of CETP: 12MLD

5. Average flow reaching: CETP 1.5 MLD

Table 5.13: Unit sizes of main treatment units and operational conditions at SMA CETP

Treatment Unit	Collected Information
Equalization tank	Hourly influent rate: 400 m ³ /hr Volume: 44X22X4 m ³
Tube Settler	Hourly influent rate: 350 m ³ /hr Total number of operational hours: 8-12 hr
Primary Settling tank	NA
Aeration tank	NA
Secondary settling tank	NA
Dual Media Filter (DMF)	Total units: 9, Diameter: 3.0 m Total no. of operation hours: 8 hr No. of units in use: 4
Activated carbon columns:	Total units: 6, Diameter: 3.0 m Total no. of operation hours: 8 hr. N. of units in use: 3
Sludge thickener	Total no. of operation hours: 8 hrs Diameter: 1.8 m, width: 1.5 m
Rotary vacuum filter	Total no. of operation hours: 8-9 hr. Diameter: 1.9 m and width: 2.5 m Design loading: 285 kg/m ² /hr
Chemical dozing	Bleaching powder:25 kg/day, Alum:100 kg/day, Lime: 240 kg/day, And Polyelectrolyte: 1 kg/day

Table 5.14 Lab analysis report of CETP at SMA:

SMA	Sample location	Ph	BOD	COD	TSS	TDS	O&G
Design flow rate: 12 MLD	Before equal. Tank	2.82	58	221	179	5204	52
	After equal. Tank	5.63	10	31	369	3018	
Observed flow: 3.5 MLD	After tube settler	3.09	42	204	410	5404	
	After dual media filter	6.34	7	48	65	4086	
	After activated carbon	6.03	8	47	260	4054	BDL

* All the parameters are in mg/l except pH

Fact and finding of the study carried out are as follows:

1. The effluent received at CETP during study period was around 3.5 MLD, whereas the designed capacity of CETP is 24 MLD, which shows under utilization of the CETP.
2. The overall treatment efficiencies, in respect of BOD, COD, and TSS were 86.2 %, 78.7%, negative respectively..
3. Filter plate was not working due to damage of cloth.
4. The raw effluent pipe line was leaked, alternate system was made to send the effluent directly to equalization tank.
5. Red coloured water was stored near by the CETP's boundary wall.
6. The increase of suspended solid concentration from 179 mg/l to 260 mg/l at the outlet of CETP may be due to excess addition of lime solution for neutralization and also addition of raw domestic sewage in the aeration tank.

5.3.8 NARELA CETP

1. Date of Monitoring: 16 December, 2007
2. Industrial area (s) connected to the CETP: Narela Industrial Area has about 600 industry (mainly pickling,dying)

3. Main units of treatment scheme:

- i. Screens,
- ii. Grit channels,
- iii. Equalization tank,
- iv. Pre-chlorination contact tank,
- v. Tube settler,
- vi. Dual media filters
- vii. Activated carbon columns
- viii. Sludge thickener and
- ix. Rotary vacuum filter for sludge treatment
- x. Chlorination tank

4. Design flow of CETP: 12MLD

5. Average flow reaching CETP: 6.0-7.0 MLD

Table 5.15: Unit sizes of main treatment units and operational conditions at Narela CETP

Treatment Unit	Collected Information
Equalization tank	Hourly influent rate: 131 m ³ /hr Volume: 16.5 x 33.0x 3.3 m ³
Tube Settler	Hourly influent rate: 150-200 m ³ /hr Total number of operational hours: 8-12 hr Media depth: 1.5 m
Tube settler	Hourly influent flow rate: 800 m ³ /hr Total no. of operation: 8-12 hr
Dual Media Filter (DMF)	Total units: 20, Diameter: 3.0 m Total no. of operation hours: 12-14 hr No. of units in use: 16
Activated carbon columns:	Total units: 14, Diameter: 3.0 m Total no. of operation hours: 12-14 hr. N. of units in use: 3
Sludge thickener	Total no. of operation hours: 12-14 hrs Diameter: 4.0 m
Rotary vacuum filter	Total no. of operation hours: 12-14 hr. Diameter: 1.8 m and width: 1.52 m Design loading: 14 kg/m ² /hr
Chemical dozing	Bleaching powder: 18-25 kg/day, Lime: 56-70 kg/day, Polyelectrolyte: 2-3 kg/day

Table 5.16 Lab analysis report of CETP at Narela:

Narela	Sample location	Ph	BOD	COD	TSS	TDS	O&G
Design flow rate: 24 MLD	Before equal. Tank	7.47	59	230	167	-	40
	After equal. Tank	7.43	102	681	634	-	
Observed flow: 3.5 MLD	After tube settler	7.55	46	288	273	842	
	After dual media filter	7.35	24	100	65	982	
	After activated carbon	7.50	18	88	327	994	
	After Chlorination	7.47	28	97	75	768	BDL

* All the parameters are in mg/l except pH

Fact and finding of the study carried out are as follows:

1. The effluent received at CETP during study period was around 3.5 MLD, whereas the designed capacity of CETP is 24 MLD, which shows under utilization of the CETP.
2. The overall treatment efficiencies, in respect of BOD, COD, TSS and O&G were 67.0 %, 64.9%, 93.24% and 65.9% respectively which indicates proper treatment to the organic load.
3. No flow measuring device is attached in any of the channels
4. Over flow in the following stage
 - i) SST, ii) Tube Settler and iii) Grit sludge
5. Sludge after tube settler lying on the path. No proper sludge handling facility.
6. Grit sludge drained outside due to over flow.
7. Polyelectrolyte/lime was added to effluent from secondary settling tank for flocculation & proper settling of sludge in tube settlers from where the effluent goes to activated carbon/sand filters and finely to effluent channel. The effluent is finally disposed to the drain.

8. Equalization tank were not clean since the time it was put under operation and around 50 to 60% of its capacity might have been exhausted by this time due to settling of solids at bottom. This clearly indicates the poor performance of equalization unit, which leads an adverse impact on overall efficiency of the CETP.

9. All the parameters are well within acceptable limits.

5.3.9 MAYAPURI CETP

1. Date of Inspection: 17 December 2007

2. Industrial area (s) connected to the CETP: Mayapuri Industrial Area about 500 industries

3. Main units of treatment scheme:

- i. Screens,
- ii. Grit channels,
- iii. Equalization tank,
- iv. Pre-chlorination contact tank,
- v. Tube settler,
- vi. Dual media filters
- vii. Activated carbon columns
- viii. Sludge thickener and
- ix. Rotary vacuum filter for sludge treatment
- x. Chlorination tank

4. Design flow of CETP: 12 MLD

5. Average flow reaching CETP: 4.0 MLD

Table 5.17: Unit sizes of main treatment units and operational conditions at Mayapuri CETP

Treatment Unit	Collected Information
Equalization tank	Hourly influent rate: 400 m ³ /hr Volume: 4000 m ³
Tube Settler	Hourly influent rate: 150-250 m ³ /hr Total number of operational hours: 8-12 hr
Primary Settling tank	NA
Aeration tank	NA
Secondary settling tank	NA
Dual Media Filter (DMF)	Total units: 9, Diameter: 3.0 m Hourly influent rate: 200-300 m ³ /hr Total no. of operation hours: 8 hr No. of units in use: 4
Activated carbon columns:	Total units: 6, Diameter: 3.0 m Hourly influent rate: 200-300 m ³ /hr Total no. of operation hours: 8 hr. N. of units in use: 3
Sludge thickener	Daily hourly primary sludge flow rates: 150-250 m ³ /hr Total no. of operation hours: 8 hrs Diameter: 1.5 m
Rotary vacuum filter	Total no. of operation hours: 8-9 hr. Diameter: 1.8 m and width: 1.34 m Design loading: 15 kg/m ² /hr
Chemical dozing	Bleaching powder: 25 kg/day, NaOH:100 kg/day, Lime: 240 kg/day and Polyelectrolyte: 1 kg/day

Table 5.18 Lab analysis report of CETP at Mayapuri:

Mayapuri	Sample location	Ph	BOD	COD	TSS	TDS	O&G
Design flow rate: 12.0 MLD	Before equal. Tank	7.11	130	486	412	2308	222
	After equal. Tank	7.88	62	178	134	2412	
Observed flow: 4.0 MLD	After tube settler	7.85	58	145	82	2520	
	After dual media filter	7.73	50	133	79	2392	
	After activated carbon	7.71	46	144	22	2568	51

* All the parameters are in mg/l except pH

Fact and finding of the study carried out are as follows:

1. The effluent received at CETP during study period was around 4.0 MLD, whereas the designed capacity of CETP is 12 MLD, which shows under utilization of the CETP.
2. The overall treatment efficiencies, in respect of BOD, COD, TSS and O&G were 64.6 %, 70.3 %, 94.6 % and 77.0% respectively which indicates proper treatment to the organic load.
3. The TDS and O&G level is not meeting the prescribed standard.
4. Colour removal from effluent, which was being carried out by using carbon and sand bed filtration was not effective.
5. In primary clarifier and aeration tank, foam was generating considerably. There was more foam in primary clarifier and is being removed manually. In aeration tank antifoaming agent was being used for minimization of foam.
6. Sludge thickener was not found to be working properly.

5.3.10 BADLI CETP

1. Date of Inspection: 18 December, 2007.
2. Industrial area (s) connected to the CETP: Badli Industrial Area - about 600 industries
3. Main units of treatment scheme:
 - i. Screens,
 - ii. Grit channels,
 - iii. Equalization tank,
 - iv. Pre-chlorination contact tank,
 - v. Tube settler,
 - vi. Dual media filters

- vii. Activated carbon columns
- viii. Sludge thickener and
- ix. Rotary vacuum filter for sludge treatment
- x. Chlorination tank

4. Design flow of CETP: 1.5 MLD

5. Average flow reaching CETP: 4.0 MLD

Table 5.19: Unit sizes of main treatment units and operational conditions at Badli CETP

Treatment Unit	Collected Information
Equalization tank	Hourly influent rate: 200-400 m ³ /hr Volume: 3000 m ³
Tube Settler	Hourly influent rate: 250-350 m ³ /hr Total number of operational hours: 8-12 hr Media depth: 2.5 m
Primary Settling tank	NA
Aeration tank	NA
Secondary settling tank	NA
Dual Media Filter (DMF)	Total units: 9, Diameter: 3.0 m Total no. of operation hours: 8 hr No. of units in use: 3
Activated carbon columns:	Total units: 6, Diameter: 3.0 m Total no. of operation hours: 8 hr. N. of units in use: 3
Sludge thickener	Total no. of operation hours: 8-10 hr
Rotary vacuum filter	Total no. of operation hours: 8-9 hr Diameter: 1.5m and width: 1.3 m Design loading: 28.5 kg/m ² /hr
Chemical dozing	Bleaching powder: 25 kg/day, NaOH: 100 kg/day, Lime: 240 kg/day and Polyelectrolyte: 1 kg/day

Table 5.20 Lab analysis report of CETP at Badli:

Badli	Sample location	Ph	BOD	COD	TSS	TDS	O&G
Design flow rate: 1.5 MLD	Before equal. Tank	6.14	30	187	142	1686	BDL
	After equal. Tank	6.30	13	75	108	1656	
Observed flow: 4.0 MLD	After tube settler	7.59	7	44	21	1738	
	After dual media filter						
	After activated carbon	7.49	3	17	BDL	1604	BDL

* All the parameters are in mg/l except pH

Fact and finding of the study carried out are as follows:

1. The effluent received at CETP during study period was around 4.0 MLD, whereas the designed capacity of CETP is 1.5 MLD, which shows over utilization of the CETP.
2. The overall treatment efficiencies, in respect of BOD, COD, were 90.0 %, and 90.9 %, which indicates proper treatment to the organic load.
3. The solid waste generated from the CETP need scientific disposal. At present it is being stored in open ground which may leads fro ground water contamination and leaching of sludge into adjacent drain during monsoon period.
4. Industrial units are not providing the desired primary treatment to their effluent before sending to CETP and also CETP is not being operated in a scientific manner.
5. All the parameters are well within acceptable limits.
6. All the sludge draying beds were observed filled up with sludge, which shows inadequate capacity. There was no space left over in a sludge drying bed for loading of fresh sludge.
7. Final effluent was being discharge in to the river Yamuna through drain.

5.3.11 NANGLOI CETP

1. Date of Inspection: December 18, 2007
2. Industrial area (s) connected to the CETP: Nangloi Industrial Area - 450 industries
3. Main units of treatment scheme:
 - i. Screens,
 - ii. Grit channels,
 - iii. Equalization tank,
 - iv. Pre-chlorination contact tank,
 - v. Tube settler,

- vi. Dual media filters
- vii. Activated carbon columns
- viii. Sludge thickener and
- ix. Rotary vacuum filter for sludge treatment
- x. Chlorination tank

4. Design flow of CETP: 12 MLD

5. Average flow reaching CETP: 4.0 MLD

Table 5.21: Unit sizes of main treatment units and operational conditions at Nangloi CETP

Treatment Unit	Collected Information
Equalization tank	Hourly influent rate: 350 m ³ /hr Volume: 4000 m ³ No. of aerators: 4
Tube Settler	Hourly influent rate: 150-250 m ³ /hr Total number of operational hours: 8-12 hr Media depth: 2.0 m
Primary Settling tank	NA
Aeration tank	NA
Secondary settling tank	NA
Dual Media Filter (DMF)	Total units: 9, Diameter: 3.0 m Hourly influent rate: 150-250 m ³ /hr Total no. of operation hours: 8 hr No. of units in use: 4
Activated carbon columns:	Total units: 6, Diameter: 3.0 m Hourly influent rate: 150-250 m ³ /hr Total no. of operation hours: 8 hr. N. of units in use: 3
Sludge thickener	Total no. of operation hours: 8 hr
Rotary vacuum filter	Total no. of operation hours: 8-9 hr. Diameter: 1.5 m and width: 1.32 m Design loading: 28.5 kg/m ² /hr
Chemical dozing	Bleaching powder: 25 kg/day, NaOH: 100 kg/day, Lime: 240 kg/day and Polyelectrolyte: 1 kg/day

Table 5.22 Lab analysis report Result of Nangloi CETP:

Nagloi	Sample location	Ph	BOD	COD	TSS	TDS	O&G
Design flow rate: 12 MLD	Before equal. Tank	7.2	305	1438	837	3160	155
	After equal. Tank	7.26	240	1207	1248	3058	
Observed flow: 2.0 MLD	After tube settler	6.55	30	137	62	3798	
	After dual media filter						
	After activated carbon	6.78	22	97	52	4000	BDL

* All the parameters are in mg/l except pH

Fact and finding of the study carried out are as follows:

1. The effluent received at CETP during study period was around 2.0 MLD, whereas the designed capacity of CETP is 12.0 MLD, which shows under utilization of the CETP.
2. The overall treatment efficiencies, in respect of BOD, COD, and TSS were 92.7 %, 93.2%, % and 93.7% respectively, which indicates proper treatment to the organic load.
3. Industrial units are not providing the desired primary treatment to their effluent before sending to CETP.
4. Most of the effluents from the industrial area are discharged onto the drains.
5. The amount to total dissolved solids is extremely high.

TABLE 5.23 Overall Results of CETP Monitoring (December, 2007)

Lawrence Road Design flow rate: 12 MLD Observed flow: 2.0 MLD	Sample location	Ph	BOD	COD	TSS	TDS	O&G
	Before equal. Tank	7.11	247	621	332	4350	122
	After equal. Tank	7.08	339	818	355	4120	
	After tube settler	6.55	190	408	164	4276	
	After dual media filter	6.65	203	414	180	4388	
	After activated carbon	6.50	186	361	158	4176	70
Mangolpuri Design flow rate: 2.4 MLD Observed flow: 1.2-1.3 MLD	Sample location	Ph	BOD	COD	TSS	TDS	O&G
	Before equal. Tank	7.15	75	274	170	7694	89
	After equal. Tank	7.20	150	490	457	8536	
	After tube settler	7.32	44	148	124	8356	
	After dual media filter	7.27	34	114	50	8288	
	After activated carbon	6.69	22	96	36	8316	9
Jhilmil Design flow rate: 16.8 MLD Observed flow: 4.5-5.0 MLD	Sample location	Ph	BOD	COD	TSS	TDS	O&G
	Before equal. Tank	6.75	109	313	136	2598	63
	After equal. Tank	6.34	29	135	78	3698	
	After tube settler	6.49	22	110	72	3714	
	After dual media filter	7.14	9	47	47	3298	
	After activated carbon	6.70	11	71	37	2780	10
Okhla Design flow rate: 24 MLD Observed flow: 3.5 MLD	Sample location	Ph	BOD	COD	TSS	TDS	O&G
	Before equal. Tank	7.29	231	550	222	1756	44
	After equal. Tank	7.52	151	589	422	1798	
	After tube settler	7.25	95	192	33	1818	
	After dual media filter	7.31	90	197	22	1854	
	After activated carbon filter	7.16	76	193	15	1918	15
GTK Road Design flow rate: 6 MLD Observed flow: 1.7 MLD	Sample location	Ph	BOD	COD	TSS	TDS	O&G
	Raw effluent	7.08	190	504	198	1066	
	Before equal. Tank	7.33	157	397	184	1056	17
	After equal. Tank	7.55	51	225	241	1120	
	After tube settler	7.10	15	47	29	1170	
	After dual media filter	7.23	4	15	BDL	1854	
	After activated carbon	7.38	7	31	28	1180	BDL
SMA Design flow rate: 24 MLD Observed flow: 3.5 MLD	Sample location	Ph	BOD	COD	TSS	TDS	O&G
	Before equal. Tank	2.82	58	221	179	5204	52
	After equal. Tank	5.63	10	31	369	3018	
	After tube settler	3.09	42	204	410	5404	
	After dual media filter	6.34	7	48	65	4086	
	After activated carbon	6.03	8	47	260	4054	BDL
Narela Design flow rate: 24 MLD Observed flow: 3.5 MLD	Sample location	Ph	BOD	COD	TSS	TDS	O&G
	Inlet	7.36	82	162	141	794	40
	Before equal. Tank	7.47	59	230	167		
	After equal. Tank	7.43	102	681	634		
	After tube settler	7.55	46	288	273	842	

	After dual media filter	7.35	24	100	65	982	
	After activated carbon	7.50	18	88	327	994	
	After Chlorination	7.47	28	97	75	768	BDL
Mayapuri Design flow rate: 12.0 MLD Observed flow: 4.0 MLD	Sample location	Ph	BOD	COD	TSS	TDS	O&G
	Before equal. Tank	7.11	130	486	412	2308	222
	After equal. Tank	7.88	62	178	134	2412	
	After tube settler	7.85	58	145	82	2520	
	After dual media filter	7.73	50	133	79	2392	
	After activated carbon	7.71	46	144	22	2568	51
Badli Design flow rate: 1.5 MLD Observed flow: 4.0 MLD	Sample location	Ph	BOD	COD	TSS	TDS	O&G
	Before equal. Tank	6.14	30	187	142	1686	BDL
	After equal. Tank	6.30	13	75	108	1656	
	After tube settler	7.59	7	44	21	1738	
	After dual media filter						
	After activated carbon	7.49	3	17	BDL	1604	BDL
Nangloi Design flow rate: 12 MLD Observed flow: 2.0 MLD	Sample location	Ph	BOD	COD	TSS	TDS	O&G
	Before equal. Tank	7.2	305	1438	837	3160	155
	After equal. Tank	7.26	240	1207	1248	3058	
	After tube settler	6.55	30	137	62	3798	
	After dual media filter						
	After activated carbon	6.78	22	97	52	4000	BDL
Standards for discharge in surface waters		5.5-9.0	30	250	100	2100	10

5.4 DISCUSSION

The various chemical parameters, which have been analysed, are discussed below:

5.4.1 pH

The pH of wastewater is observed to be in the range of 6.7 to 7.36 and 2.82 at Wazirpur ETP. The pH of final effluent at all the ETPs lies within the tolerance limit except Wazirpur CETP. The pH value of Wazirpur influent was less than 2. The graphical representation is shown in figure 5.3.

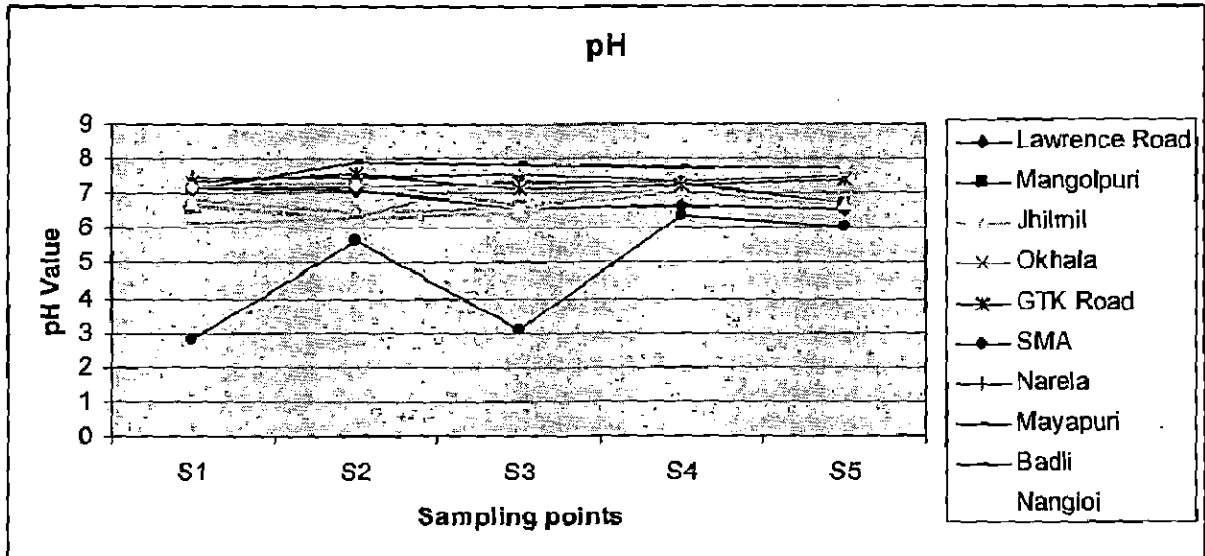


Figure 5.3 Showing pH value at various sampling points of CETPs

5.4.2 BOD

BOD is the measurement of dissolved oxygen used by microbes in the biochemical oxidation of organic matter. It helps in measuring the efficiency and to determine compliance with wastewater discharge permits.

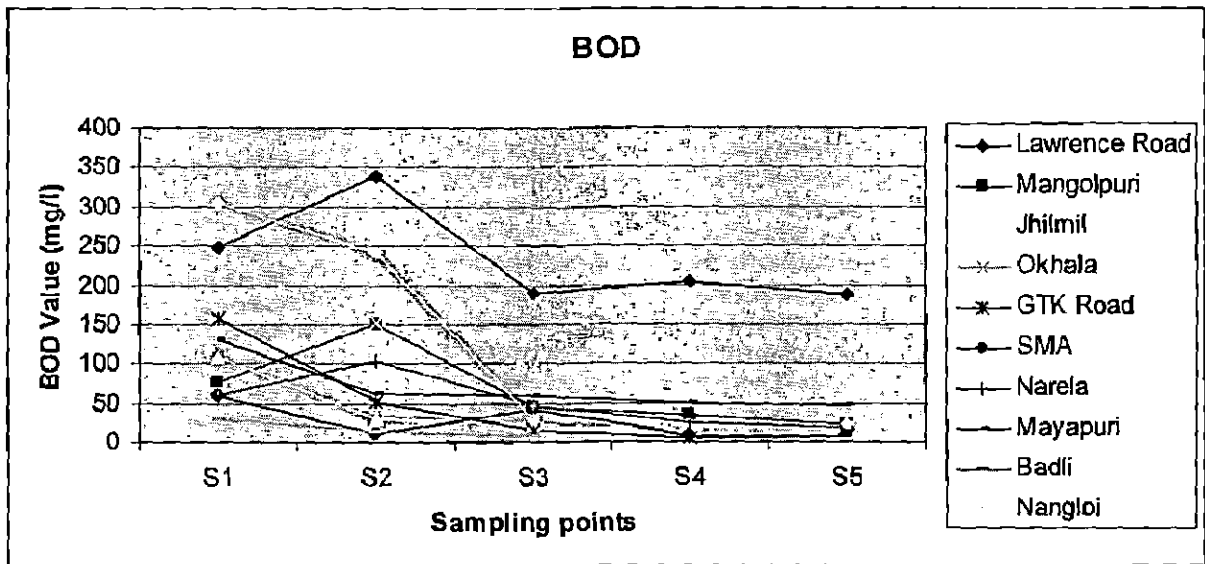


Figure 5.4 Showing BOD at various sampling points of CETPs

The variations in concentration of BOD at different sampling points are shown in the figure 5.4 and the efficiency in the reduction concentration of BOD at different CETPs is represented in Fig 5.8. Three CETPs viz. Lawrence Road, Mayapuri, and Okhala were not complying with the prescribed standards in terms of BOD concentration of final effluent.

5.4.3 COD

Chemical oxygen demand is another means of measuring the pollution strength of wastewater. The COD test is specifically more suitable to measure organic matter present in wastewater that can be oxidized chemically using dichromate in an acid solution.

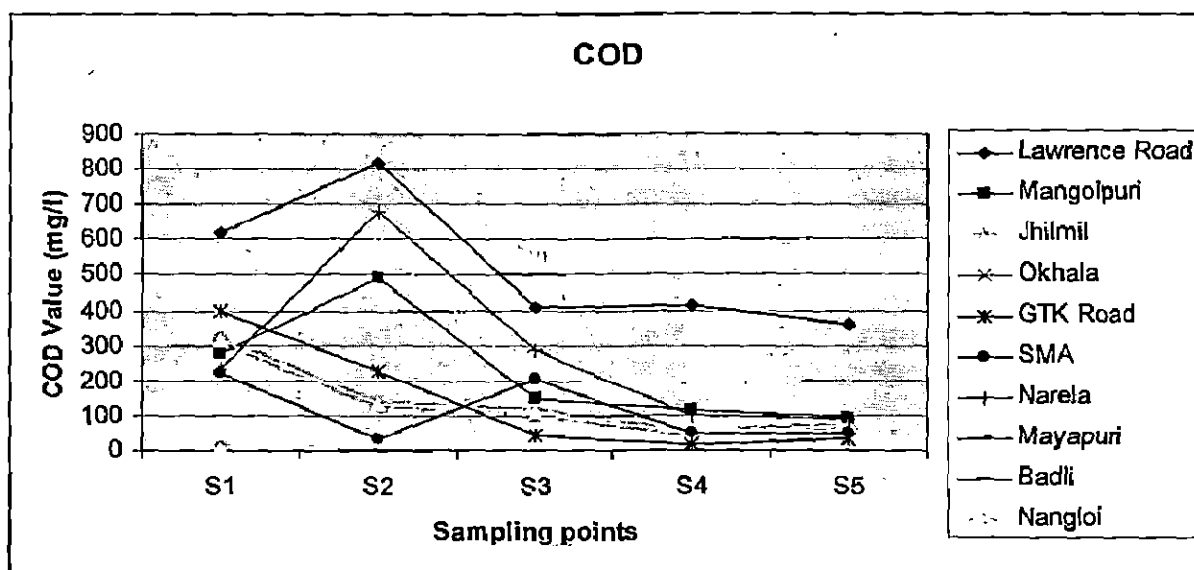


Figure 5.5 Showing COD at various sampling points of CETPs.

COD measurements are preferred when a mixed domestic-industrial is entering a plant or where a more rapid determination of the load is desired. The variations in concentration of COD at different sampling points of different CETPs are shown in the figure 5.5. and the efficiency in the reduction of concentration of COD at different CETPs is represented in figure 5.8. Lawrence road CETP was not complying with the prescribed standards in terms of COD concentration of final effluent.

Figure 5.8 shows the overall efficiency of the treatment plant in the reduction of the parameters (BOD, COD and TSS) at different sampling points.

5.4.4 TSS

A laboratory measurement of the quantity of suspended solids that are filtered from wastewater. It is one of the main indicators of the presence of organic matter and biomass present in the wastewater. This parameter was at one time called non-filterable residue (NFR).

The variations in concentration of TSS at different sampling points of different CETPs are shown in the fig.5.6. and the efficiency in the reduction concentration of COD at different CETPs is represented in fig. 5.8. SMA and, Lawrence road CETP does not meet the prescribed standards.

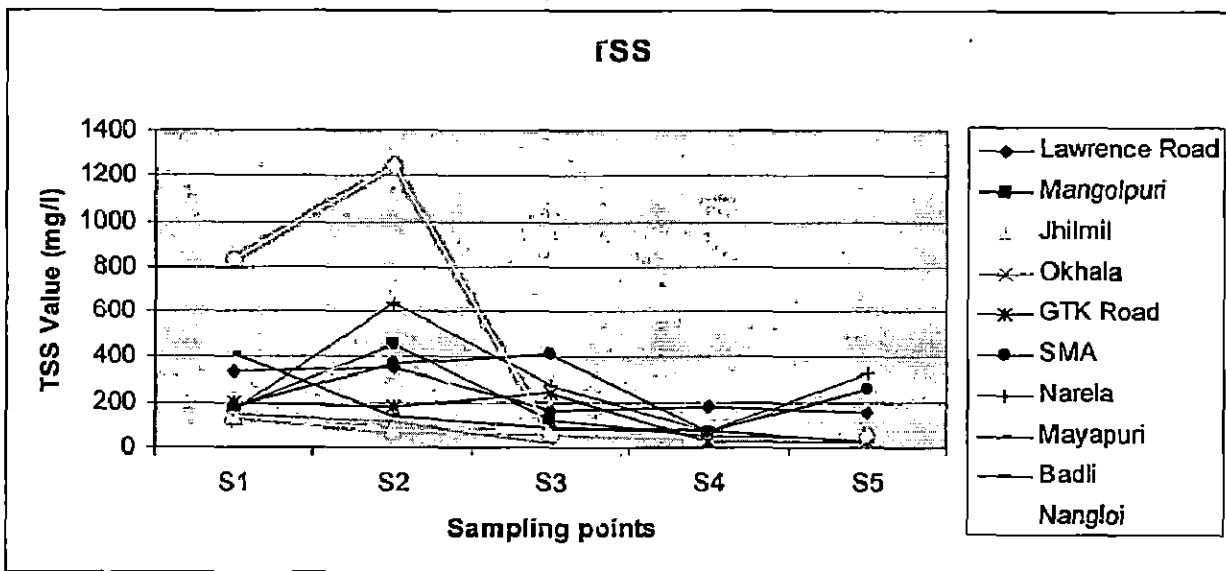


Figure 5.6 Showing TSS at various sampling points of CETPs.

5.4.5 TDS

Also referred to as 'Total Dissolved Solids (TDS)', it is the amount of nonvolatile matter dissolved in a water sample, and is usually expressed in parts-per-million by weight.

The variations in concentration of TDS at different sampling points of different CETPs are shown in the figure 5.7. Lawrence road CETP, Mangolpuri, SMA, and Nagloi CETPs final effluent were not compliant with the prescribed standards.

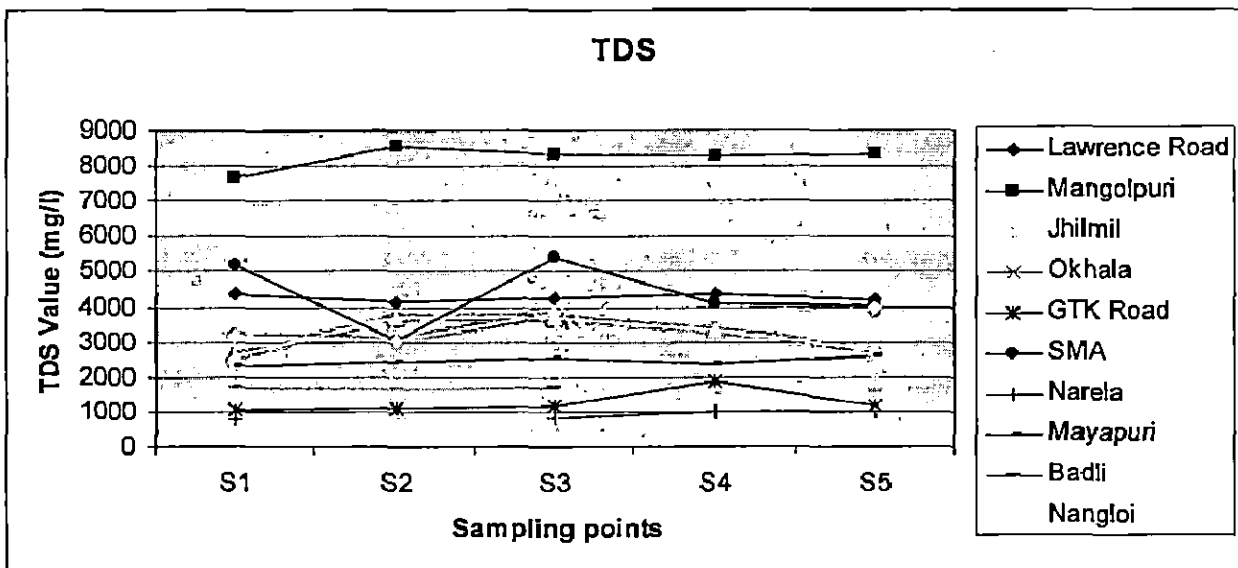


Figure 5.7 Showing TDS at various sampling points of CETPs

5.5 EFFICIENCY of CETPs

To assess the ETP efficiency and performance, effluent samples were collected from each CETP at different sampling points. The samples were analysed as per Standard Methods in the water lab of CPCB, Delhi, and based on the grab samples collected, concentration of important parameters at various stages of treatment.

G.T Karnal Road, Nagloi, and Badli CETP are efficient to get the effluent met the notified standards. The efficiency of Lawrence Road, and Narela CETPs were efficient to get the effluent met the notified standards.

Figure 5.8 shows the overall efficiency of the treatment plant in the reduction of the BOD, COD, and TSS at different sampling points.

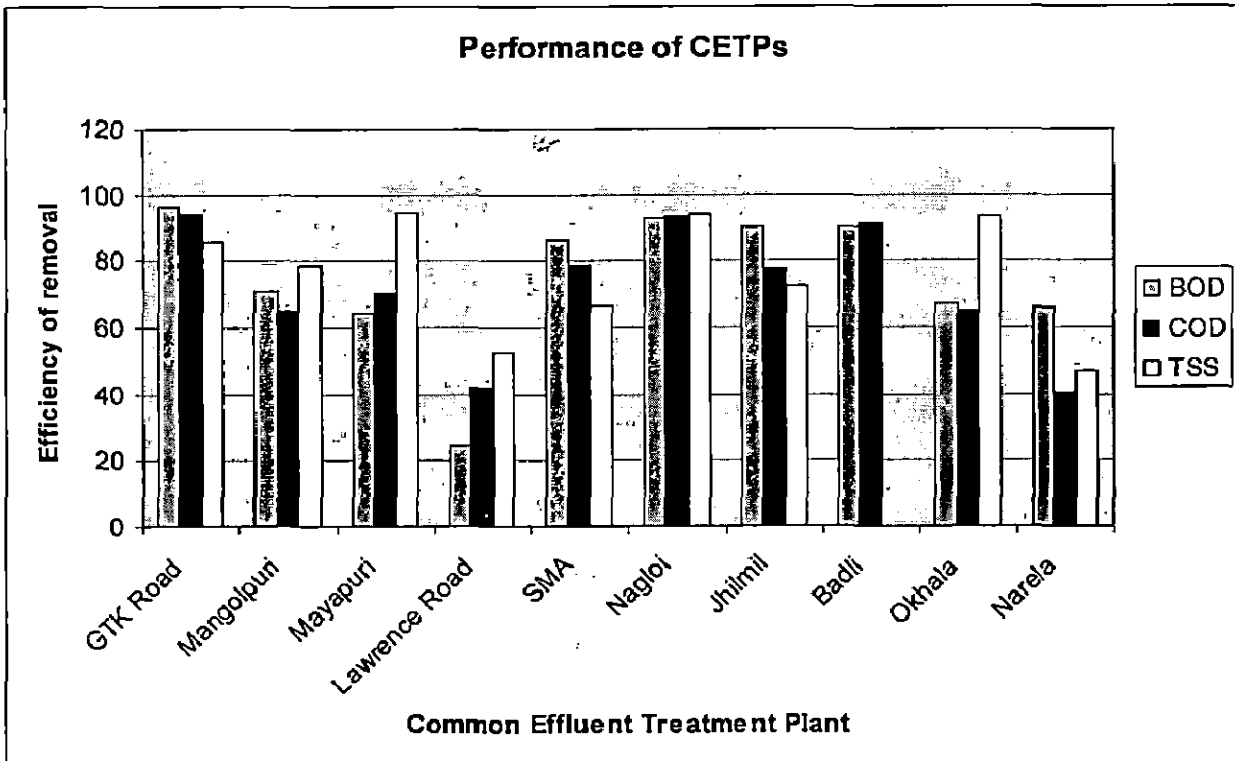


Figure 5.8 Showing removal efficiency of various CETPs of Delhi.

5.6 TDS IN GROUND WATER SAMPLE

The amount of total dissolved solid in ground water samples collected from various industrial areas is given in Table 5.24.

TDS are correlated fairly well to the total mineral content of the water (deposits left after evaporation of a water sample), primarily salts, carbonates, and metals. Organic compounds may also be dissolved solids.

A high concentration of TDS is an indicator of possibly high volume contamination and further investigation may be recommended. From the trends shown in the graph below

one can see that the value of dissolve solids is extremely high in some CETP area like Mangolpuri, Nagloi, Jhilmil, and Lawrence road.

TABLE 5.24 Showing TDS in Ground Water Sample:

TDS in Ground Water (mg/l) of various CETP of Delhi		
GT K Road	GW1	1650
	GW2	1276
	GW3	1660
MANGOLPURI	GW1	2128
	GW2	1740
	GW3	3364
MAYAPURI	GW1	1164
	GW2	774
	GW3	770
LAWRENCE ROAD	GW1	756
	GW2	810
	GW3	2260
SMA	GW1	1720
	GW2	990
NANGLOI	GW1	2514
	GW2	1826
	GW3	1988
JHILMIL	GW1	4680
	GW2	2234
	GW3	826
BADLI	GW1	796
	GW2	732
OKHALA	GW1	1452
	GW2	1754
	GW3	1088
NARELA	GW1	660
	GW2	1528

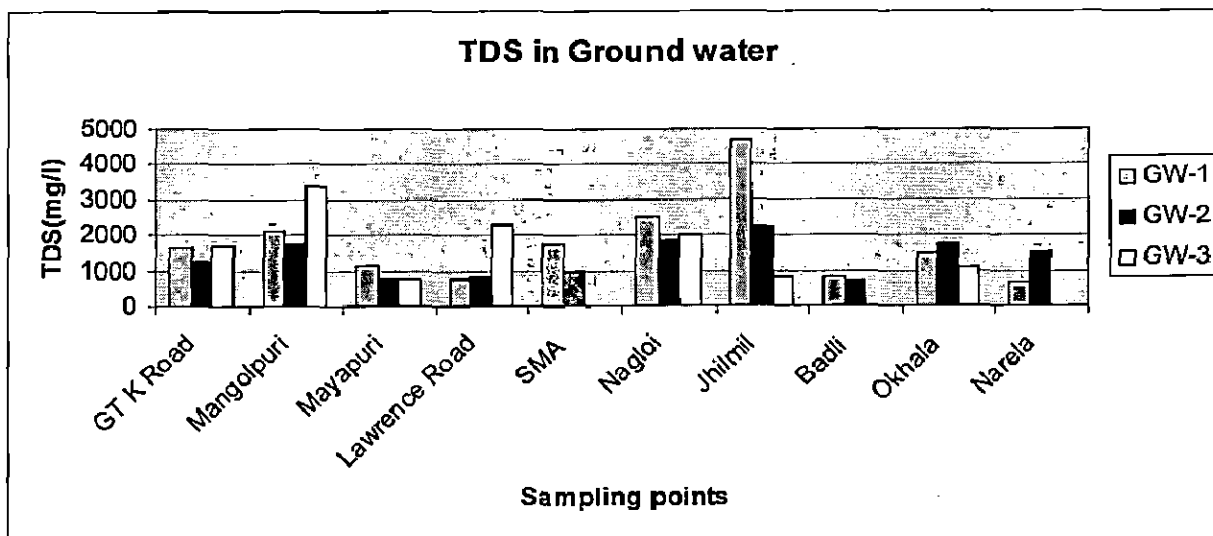


Figure 5.9 Showing TDS in ground water at various sampling points of CETPs.

The regional analysis yields all too familiar trends. Lawrence Road, Jhilmil, Mangolpuri, and Nagloi were not within the prescribed limit. Over all only about 30 % samples lie within tolerable ranges for the parameter.

High concentrations of total dissolved solids can cause water to taste bad. Highly mineralized water also deteriorates plumbing and appliances. Waters containing more than 500 milligrams per liter (mg/l) of dissolved solids should not be used if other less mineralized supplies are available.

This does not mean that any water in excess of 500 mg/l is unusable. People may eventually adjust to drinking water containing high total dissolved solids. But high TDS is not a good sign for water quality of the region.

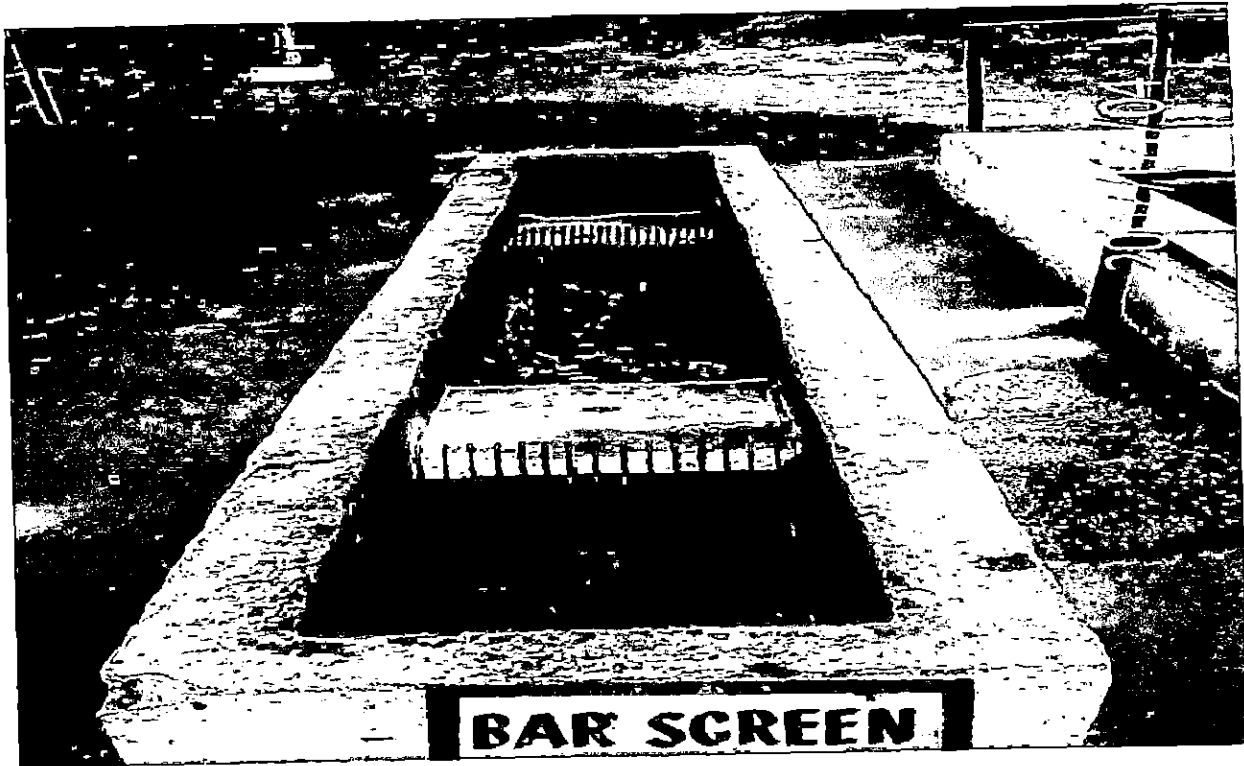


Figure 5.10: BAR SCREEN AT JHILMIL



FIGURE 5.11: EQUALIZATION TANK AT OKHALA

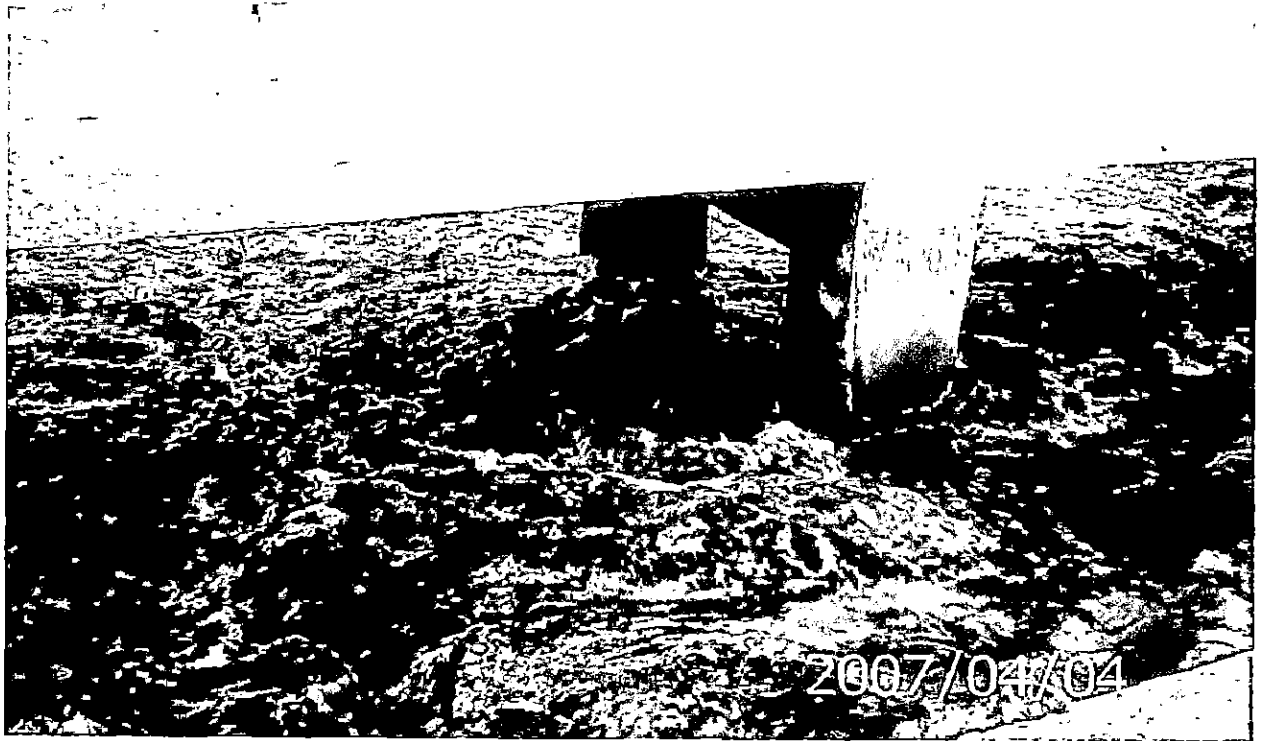


FIGURE 5.12: AERATION TANK AT MANGOLPURI

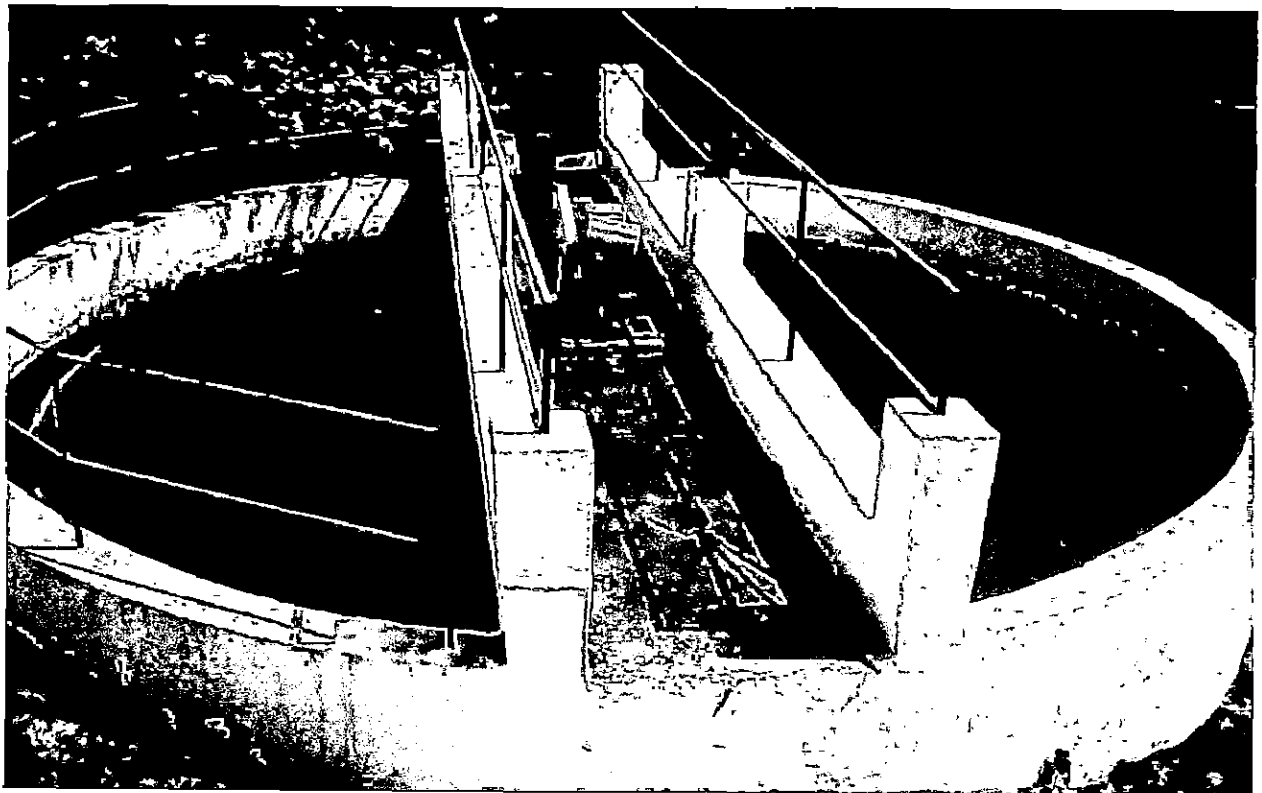


FIGURE 5.13: CLARIFIER AT LAWRENCE ROAD

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSION

Based on the studies carried out, the following conclusions are made:

- The effluent received at CETP during study period was very less than the designed capacity of CETP, which shows under utilization of the CETP. The reason for less flow reaching the CETP sites included silted or choked collection system, untapped industrial discharges and incomplete components of the conveyance system.
- The overall treatment efficiencies, in respect of BOD, COD, TSS, TDS and O&G were not satisfactory, which indicates poor treatment to the organic load. Only Narela, Okhla, Badli and GTK Road were found complying all the parameters.
- Sludge is being dumped in to open dump yard and proper leachate collection.
- Irregular removal of sludge from the clarifiers.
- There was no provision for measurement of sludge withdrawal flow rate and regulating thickened sludge withdrawal.
- Industrial units are not providing the desired primary treatment to their effluent before sending to CETP.
- In most of the CETPs Equalization tank were not clean since the time it was put under operation. This clearly indicates the poor performance of equalization unit,

which leads an adverse impact on overall efficiency of the CETP.

- The sludge generated is removed manually and stored in LDPE bags. The authorities do not have any proper storage and disposal arrangements.
- The treated effluent from the CETP is disposed in the nullah, which finally joins river Yamuna through drain.
- Since power failure is the common phenomenon, stand by arrangement like DG set has not been considered at designed stage in most of the cases.
- Lack of skilled/trained manpower for operation and maintenance of the CETPs.

6.2 RECOMMENDATIONS.

- As the quantity of raw effluent reaching to CETP is very low in as compared to their designed value, so every industrial unit should be checked to find out whether they are discharging their effluents into CETP or in river Yamuna through drain. To save the cost towards treatment of effluent the industries do not send their entire effluent to CETPs and discharge it at unknown places or nullah.
- The solid waste generated from the CETPs needs to be disposed of as soon as possible to avoid any type of contamination of ground water during monsoon period.
- The present practice of accepting the raw effluent as such should be stopped as it may lead to accident hazards due to noxious fumes generation after mixing the effluent into collection tank. The member units may be asked to provide primary treatment at their premises and secondary treatment only will be at CETP.

- Sludge flow rate measurement facility should be installed as in the absence of primary and thickened sludge flow rate measurement facility; control on plant is not possible.
- Training of the manpower and attention on small-small scientific operation & maintenance aspects can itself make lot of improvement in performance and efficiencies of the CETP and reduction in operational costs of CETPs also.
- Equalization tank should be cleaned during regular interval of time. Otherwise it will reduce its capacity due to settling of solids at bottom.
- Monitoring of these CETPs should be done on frequent basis by CPCB and DPCC.

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ANNEXURE-I

Common Effluent Treatment Plants: EFFLUENT STANDARDS (Notified under the Environment (Protection) Rules, 1986)

Primary Treatment

Inlet effluent quality for CETP	Conc. In mg/l
Ph	5.5-9.0
Temperature C	45
Phenolic Compounds(as C ₆ H ₅ OH)	5.0
Ammonical Nitrogen	50
Cynide (as CN)	2.0
Chromium hexavalent (as Cr 6+)	2.0
Chromium (total) (as Cr)	2.0
Copper (as Cu)	3.0
Lead (as Pb)	1.0
Nickel (as Ni)	3.0
Zinc (as Zn)	15
Arsenic (as As)	0.2
Mercury (as Hg)	0.01
Cadmium (as Cd)	1.0
Selenium (as Se)	0.05
Fluoride (as F)	15
Boron (B)	2.0
Radioactive Materials	
Alpha emitters, Hc/ml	10-7
Beta emitters, He/ml	10-8

These standards apply to the small-scale industries, i.e. total discharge up to 25 kld.

For each CETP and its consultant units, the State Board will prescribe standards as per the local needs and conditions; these can be more stringent than those prescribe above. However, in case of clusters of units, the State Board with the concurrence of CPCB in writing may prescribe suitable limits [Gazette of India, 1991].

Nickel(as Ni)	3.0	-	5.0
Boron (as B)	2.0	2.0	-
Percent Sodium	-	60	-
Cynide (as CN)	0.2	0.2	0.2
Chlorine (as Cl)	1000	600	-
Fluoride (as F)	2.0	-	15
Sulphate (as SO4)	1000	1000	-
Sulphide (as S)	2.8	-	5.0
Pesticide	Absent	Absent	Absent
Phenolic compounds (as C6H5OH)	1.0	-	5.0

ANNEXURE-II

Standards for Treatment Effluent Quality of Common Effluent Treatment Plant (Concentration in mg/l except Ph and Temperature)

Parameters	Into inland Surface waters	Onto land for Irrigation	Into Marine Coastal areas
	(a)	(b)	(c)
Ph	5.5-9.0	5.5-9.0	5.5-9.0
BOD ₅ 20 C	30	100	100
Oil & Grease	10	10	20
Temperature	Shall not exceed 40 C in any section of the stream within 15 meters down-stream from the effluent outlet	-	45 C at the point of discharge
Suspended Solids	100	200	(a) For process wastewaters-100 (b) For cooling water effluent 10 % above total suspended matter of effluent cooling water
Dissolved Solids(inorganic)	2100	2100	-
Total residual chlorine	1.0	-	1.0
Ammonical nitrogen(as N)	50	-	50
Total Kjeldahl nitrogen (as N)	100	-	100
Chemical Oxygen Demand	250	-	250
Arsenic(as As)	0.2	0.2	0.2
Mercury (as Hg)	0.01	-	0.01
Lead (as Pb)	0.1	-	0.1
Cadmium (as Cd)	1.0	-	2.0
	(a)	(b)	(c)
Total chromium (as Cr)	2.0	-	2.0
Copper (as Cu)	3.0	-	3.0
Zinc (as Zn)	5.0	-	15
Selenium (as Se)	0.05	-	0.05