A PROJECT REPORT ON

DECENTRALISED WASTE WATER TREATMENT SYSTEM (DEWATS) : A CASE STUDY OF AN EDUCATIONAL INSTITUTION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE AWARD OF DEGREE
OF

MASTER OF TECHNOLOGY
IN
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submitted by

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CERTIFICATE

This is to certify that the dissertation titled **"Decentralized waste Water Treatment System (DEWATS) : A Case Study of an Educational Institution",** which is being submitted by **Bimal Jain,** in partial fulfillment of the requirements for the award of degree of **Master of Technology in Environmental Engineering,** is a bonafide record of his own work carried out by him under my guidance and supervision.

The matter embodied in this project has not been submitted for the award of any other degree.

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CANDIDATE'S DECLARATION

I, Bimal Jain, Roll No. 2K16/ENE/501 student of M.Tech, Environmental Engineering, hereby declare that the dissertation titled **"Decentralized Waste Water Treatment System (DEWATS): A Case study of an Educational Institution"** which is submitted by me to the Department of Environmental Engineering, Delhi Technological University, Delhi in partial fulfillment of the requirements for the award of the degree of Master of Technology, is original and not copied from any source without proper citation.

This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title or recognition.

BIMAL JAIN

Place: Delhi

Date:

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ABBREVIATIONS & ACRONYMS

AS	Activated Sludge
ASP	Activated Sludge Process
BOD	Biochemical Oxygen Demand
BOD_5	5 days Biochemical Oxygen Demand
CBOD	Carbonaceous Biochemical Oxygen Demand
Bs COD	Biodegradable soluble chemical Oxygen Demand
Cl	Chloride
COD	Chemical Oxygen Demand
CO_2	Carbon Dioxide
CPHEEO	Central Public health and Environmental Engineering Organization
H_2O	Water
^{0}C	degrees Centigrade
d	day
dia	diameter
DO	Dissolved Oxygen
DS	Dissolved Solids
F:M	Food to Microorganisms Ratio
FC	Faecal Coliform
h, hr	hour
HMU	Helixor Mixing Unit
hp	horse power
HRT	Hydraulic Retention Time
IS	Indian Standard
kW	kilo Watt
l, L	Litre
m	metre
mm	millimeter
m^2	square metre
m^3	cubic metre
MCRt	Mean Cell Residence Time
mg	Milligrams
MGD, mgd	Miilion Gallons per day
MLD, mld	Million Litres per day
MLSS	Mixed Liquor Suspended Solids
MLVSS	Mixed Liquor Volatile Suspended Solids
mm	millimeter
NH_3	Ammonia
O&M	Operation and Maintenance
OA	Oxygen Absorption
O_2	Oxygen
pH	potential Hydrogen
PO_4	Phosphate
RAS	Return Activated Sludge
RBC	Rotating Biological Contactor
RCC	Reinforced Concrete Pipe
RS	Return Sludge
SCADA	Supervisory Control And Data Acquisition
SRT	Sludge Retention Time
SS	Suspended Solids
SST	Secondary Sedimentation Tank
SSV	Settled Sludge Volume
SSVI	Stirred Sludge Volume Index
STP	Sewage Treatment Plant
SVI	Sludge Volume Index

SWD	Side Water Depth	VA	Voltaic Acid
TA	Total Alkalinity	VOC	Volatile Organic Carbon
TDS	Total Dissolved Nitrogen	VS	Volatile Solids
TS	Total Solids	VSS	Volatile Suspended Solids
TSS	Total Suspended Solids	WAS	Waste Activated Sludge

Contents

Chapter 1 INTRODUCTION

1.1 Introduction

Wastewater or sewage is produced every day by human activities and various industrial processes. The sudden intensification in the residents of the country and the essential need to meet the growing demands of domestic and industrial consumption, irrigation, and the existing water resources in various portions of the country are receiving exhausted, and the water quality get worse. Almost all surface water sources have been polluted to particular extent by organic pollutants, bacterial contamination and make them unfit for human feasting unless disinfected. The contaminated water increases many diseases such as typhoid, cholera, gastroenteritis, bacterial dysentery, hepatitis, poliomycitis, dysentery etc.

The wastewater from every house and organizations, carrying bodily wastes (primarily urine and feces), food preparation and washing water wastes, and other waste harvests of usual existing, are categorized such as domestic or sanitary sewage.

Organic pollutants and nutrients Sewage have been multifarious assortment of chemicals, with numerous distinguishing chemical appearances. These comprise in elevation concentrations of NH_3, NO_3, N_2, phosphorus, high alkalinity, with pH characteristically oscillating between 7 and 8. The organic matter of sewage have been measured by formative its biological oxygen demand (BOD) or the chemical oxygen demand (COD).

1.2 Need of Wastewater treatment

One of the prime objectives of sewage treatment is to safeguard the environment; social economic and public health from the pollutants. This treatment based or depends on the (Primary, Preliminary, Secondary or Tertiary treatment). The aim of public and waste water treatment is to remove pollutants and toxicants, neutralize abrasive particles, and eradicate pathogens so that quality of cleared water is enhanced to extent the allowable level of water to be discharged into water bodies or for agricultural land.

1.3 Waste Water Treatment Process

Treatment of sewage or wastewater protects public health and prevents pollution, disease as well as hazards from sewage contaminants. Hence sewage treatment is required. It includes the following steps:

1.3.1 Preliminary Treatment

This is the first stage of sewage treatment plant process and its main objective is the removal of coarse solids and other large materials often found in raw wastewater. Preliminary treatment operations typically include large filtering screens, grit removal and, in some cases, breaking of large objects. Excess grit cause severe pump blockages thereby affecting a range of subsequent treatment pumps. Flow measurement devices, often standing-wave flumes, are always included at the preliminary treatment stage.

1.3.2 Primary Treatment

The main purpose of this treatment is to reduce any heavy solids (organic & inorganic) that settle to the bottom by sedimentation while oil, grease & lighter solids float to the surface by skimming. The settled and floating materials are removed and the remaining liquid may be discharged or subjected to the next stage i.e. secondary treatment. Primary treatment removes about 60% of suspended solids from wastewater.

1.3.3 Secondary Treatment

The prime objective is the further treatment of the effluent from primary treatment to remove dissolved and suspended biological matter. The biological solids removed during secondary sedimentation, called secondary or biological sludge, are normally combined with primary sludge for sludge processing.

Secondary treatment may require a separation process to remove the micro-organisms from the treated water prior to discharge or tertiary treatment. Secondary treatment removes more than 90% of suspended solids.

1.3.4 Tertiary/Advanced Treatment

Tertiary treatment generally follows secondary treatment and aids the removal of those wastewater constituents which cannot be removed in secondary treatment. Treated wastewater is sometimes disinfected chemically or physically (for example, by lagoons and microfiltration) prior its discharge into the receiving environment (sea, river, lake, wet lands, ground, etc.)

1.4 Bio filtration

Bio filtration systems are typically robust, simple to construct and have low energy requirements. The most common technologies are sand filtration, biological activated carbon (BAC) filtration, riverbank filtration and managed aquifer recharge. Whereas the removal of organic matter and PPCPs from drinking water sources and treated wastewater has been investigated in river bank filtration and managed aquifer recharge systems the treatment of WWTP effluents with engineered BAC filters has not received much attention so far. Recently, observed significant removal of some PPCPs in BAC filters after ozonation.

A BAC filter consists of a fixed bed of granular activated carbon (GAC) supporting the growth of bacteria attached to the GAC surface. This technology has been used for many years for drinking water treatment, usually after ozonation, and has proven to be able to significantly remove natural organic matter, ozonation by-products, DBP precursors as well as odour and taste compounds.

1.5 Scope and objectives of the study

1.5.1 Objectives

The objectives of the study are:

- To study Decentralized Waste Water Treatment System.
- To study the performance of 1MLD Bio-filter STP plant at DTU, New Delhi.
- To evaluate the overall performance of 1MLD Bio-filter STP plant at DTU, New Delhi.

1.5.2 Scope

The broad scope the study is:

- To study the need of waste water treatment.
- To collect the performance parameter such as pH, TSS, Ammoniacal Nitrogen, BOD, COD, Total Nitrogen, Oil & Grease, Total Phosphorus, Nitrates, Fecal Coliforms before and after the treatment process.
- Determine the efficacy of bio filtration as a single step for the advanced treatment of wastewater.
- Compare bio filtration alone to the combination of ozonation and bio-filtration.

Chapter 2 LITERATURE REVIEW

In 1980's bio filters were used to reduce odour from livestock operation in the Netherlands and Sweden Noren, 1985; Scholtens et al., 1987). These bio filters were based on the zeisig design and decreased hydrogen sulfide and ammonia by 50%. Cernuschi and Torretta (1996), reported that the number of installations has significantly increased in Japan, growing from about 40 in the 1980s to 90 in the 1990s in the last two decades. On the contrary, in other European countries, including Italy, Switzerland and Austria, the number of bio filter installations has been quite limited. Cetkauskaite and Jakstaite (1999), reported that bio filters were the first wastewater treatment technologies developed in Western Europe, starting since 1890 as a contact filter process.

They were called percolating beds (in Europe) or trickling filters (in the United States) and further development of high rate trickling filters with recirculation of treated wastewater took place about the1930s. Bio filters were the first biological WWTPs to be built in Lithuania, mostly in 1960-1970.

According to Narmada and Mary Selvam Kavitha (2012), the focal species involved in operational waste water treatment consist of L. casei, Streptoccuslacti, Yeasts -Saccharomyces cerevisiae, Lactic acid bacteria - Lactobacillus plantarum, Actinomycetes – Streptomyces albus, Photosynthetic bacteria -Rhodopseudomonaspalustrus, Rhodobacterspaeroide, Candida utilis, S. griseus and Fermenting fungi – Aspergillus oryzae, Mucor hiemalis. Min jin et al. (2005), studied the role of Bacillus megatherium as external source of organism for bioremediation of sewage. According to Ottengraf (1983), the great advantage of the heterogeneous population present in the bio filter is the excellent ability to survive long periods (up to 2 months) without activity, provided that periodic aeration is ensured. Utmost of the microorganisms growing in bio filters treating organic pollutants are heterotrophic eubacteria, actinomycetes and fungi, which was revealed by plate counting in nutrient agar (Leson and Winer, 1991). More frequently, the bacteria detected in bio filters are soil bacteria, such as Bacillus cereus var. mycoides and several strains and species of actinomycetes belonging to the genus Streptomyces. Helmer (1972), did a microbiological characterization of compost filter population and observed abundant growth of eubacteria (109CFU/g), actinomycetes (2 x 106 CFU/g) and fungi (106 CFU/g) along the whole filter height with higher density of fungi at the bottom. Adamse et al. (1984), stated that the composition of activated sludge treating municipal sewage comprises Pseudomonas, Flavobacterium, Alcaligens, Acinetobacter and Zooglea sp. Other researchers have found Pseudomonas, Acinetobacter sp and Enterobacteriaceae to be the dominant bacteria (Kappesser et al., 1989). Under oxygen restriction conditions, the dominant species are from the genera

According to Wood and Wang (1985), 30 of the 92 elements that comprise the periodic table have been found to be essential to the sum total of microbes.

Members of Bacteroides group are able to degrade various refractory bio macromolecules such as cellulose, chitin, DNAs, lipids and proteins, which are abundant in a biofilm, in which dead organisms are trapped and these species produce exo-polysaccharide slime that has an important role in biofilm formation and development (Kolenbrander et al., 1985). Paracoccussp is a quite biochemical versatile genus able to display wide range of degradative capabilities such as aerobic denitrification and heterotrophic nitrification and some strains of this group grow anaerobically using thiosulfate carbon disulfide, methanol or formate as energy sources and nitrate as final electron acceptor (Baker et al., 1998).

Yang et al. (2004), pronounced that the most important shortcoming in the bioreactor based on anaerobic digestion of soluble substrate is the slow growth rate of methanogens and the desirable organic matter degradation is achieved after along residence time in the reactor. He studied the methods of immobilizing microbial cells on various supports or medium, to maintain high microbial cell densities in the anaerobic bioreactor. Adhesive growth supports high cell density and thus high activity. Akther et al. (2003), developed a new biosorbant, micro algal-luffa sponge, Chlorellesorokinian immobilized disc for the removal of nickel from aqueous solution.

According to Nicolella et al. (2000), wastewater treatment processes are based on the use of three types of microbial aggregates viz., static biofilms (e.g. in trickling filters), particulate biofilms (e.g. biofilm fluidized bed reactors, up flow anaerobic sludge blanket reactors and biofilm airlift suspension reactors) and flocs (in activated sludge processes). According to the studies of Seneviratne et al. (2007), fungal-bacterial biofilm (FBB) are more effective than monocultured or bacterial biofilms or even a mixed culture of bacteria and fungi. Bio filter thicknesses of 1-1.5 feet are usually most economical and the contact time required to remove most of the odorous gases should be between 5-15 seconds (Janni et al., 1999). The major important factor that strongly influences the performance of bio filtration is the composition of the heterogeneous micro flora.

Benedusi et al. (1993), reviewed the distribution of microbial population along biofilters. In their studies, the microbial loads of about 105, 104, 103 colony forming units per gram of support (CFU/g) have been reported for oligoheterotrophic, heterotrophic, and autotrophic metabolic types. The growth and activity of the microorganisms in the bio filter are strongly influenced by the availability of oxygen and nutrients, the degree of moisture, temperature and pH and so on. Stensel et al. (1988), suggested that the clogging of the bio filter with accumulated suspended solids is prevented by backwash procedure. Isaka et al. (2007), reported that the application of cell immobilization techniques to the wastewater treatment process has recently gained much attention. One of the more recent procedures to reduce odour emission is the use of bio filter. Bio filter is not a new technology, but is an adaptation of natural atmosphere cleaning processes. According to Nicolai and Janni (2000), bio filter use microorganisms to convert gaseous contaminants to carbon dioxide, water vapor and organic biomass and thus making bio filter effective to reduce emissions. Bio filters were used in wastewater treatment plants, chemical manufacturing facilities, composting and other industrial air pollution schemes. In 1960s Bio filters were first applied to live stock facilities in Germany to reduce odor emissions from livestock facilities (Seizing and Munched, 1987). Andersson et al. (2008), stated that medium composition has a strong effect on biofilm formation. He observed that strongest biofilm formation was formed when mixtures of 13 bacteria were grown together. Bjerkey and Fiksdal (2009), studied biofilm structure on curved membrane surfaces, such as hollow fiber membranes using Fluorochrome stains, CLSM, and animage analysis program to calculate thickness, volume of biomass, porosity, and roughness of biofilms.

Delatolla et al. (2008), described a simple, rapid and reliable technical procedure that enabled biofilm samples attached to polystyrene beads to be characterized in terms of the biofilm mass and nitrogen content and proposed a protocol that demonstrated 99.9% removal of the biofilm from polystyrene beads. The application of molecular techniques to the study of wastewater treatment systems by

Hozalski and Bouwer (2001a), developed a numerical model called BIOFILT, to simulate the nonsteady state behavior of biologically active filters used for drinking water treatment. The model is capable of simulating substrate (biodegradable organic matter) and biomass (both attached and suspended) profiles in a as a function of time. The model also has capability to simulate the effects of a sudden loss in attached biomass due to filter backwash on substrate removal efficiency (Hozalski and Bouwer, 2001b). For the treatment of aquaculture and other wastewaters with high nitrate concentrations, Saliling et al. (2007), described the use of wood chips and wheat straw as biofilter media. Jignesh et al. (2008), reported that the corn cobs powder can be used in wastewater treatment process for removal of metal ions and is a good absorbent for mercury with grater sorption capacity. Biofilter use a porous solid medium consists of inert substances which ensure large surface areas for attachment and additional nutrient supply to support microorganisms and the media include peat, soil, compost, woodchips, straw or a combination of two or more (Nicolai and Janni, 2001).

Jose et al. (2008), conducted a laboratory-scale submerged attached growth bioreactor using Luffa cylindrica as support material for the immobilization of nitrifying bacteria and observed that the efficiency of nitrification varied within the range of 82 - 95% with a mean of 88%. Pak et al. (2000), used ceramic beads as bio filter media for simultaneous removal of nitrogen and phosphorus. Basiakine (1925), reported that various types of filter materials including cotton, hemp, copper gauze, galvanized iron gauze, brush wood, veneer, sand and wood were tested as media. In an increasing search for low cost adsorbents various substances such as coal-based adsorbents and bituminous coal has been reported.

Basing on the configuration and flow sequence, the bio filters are categorized into open or closed and up flow, down-flow or horizontal flow. According to Devinny et al. (1999), a closed system controls both the bio filter outlet and inlet gas streams whereas an open system discharges treated gas from the bio filter directly to the atmosphere and these systems may be either up or down flow, depending upon the moisture application system. The air passing through the filter must contact the filter media for a given amount of time in order to get maximum odor reduction from a bio filter. This amount of time is known as the residence time or empty bed contact time (EBCT). Devinny et al. (1999), defined it as the empty bed filter volume divided by the rate of airflow.

Chapter 3 DECENTRALIZED WASTE WATER TREATMENT (DEWAT)

3.1 Problems of centralized waste water treatment

Following are the problems associated with Centralised treatment of waste water:

i. Centralized waste water with off site disposal cost two to four times more expensive than waste water treatment alone. Hence the conveyance system is very expensive and few cities in developing countries can afford 100 percent water-borne sewerage system.

ii. About 80-90% of total Capital Cost of treatment relates to collection system.

iii. It is assumed that the whole collection system is to be renewed after every 50-60 years. This is in addition to periodic maintenance and disturbance to the traffic & other public utilities.

iv. Rainwater is to be frequently drained from Residential area by infiltration into the collection system causing lowering of aquifer.

v. Waste water become diluted & repairs more expansive treatment approach.

vi. Heavy rainfall contaminated by Industrial waste water may generate overflow phenomena.

vii. The system strongly depends on electrical energy supply which might not be adequately available due to economic or political crises.

viii. Huge volume of potable water consumed to keep the sewage system clean.

ix. Many plants grow in the water body due to Large Volumes of treated waste water discharged.

x. In centralized system most of the financial cost pertains to construction & maintenance of sewage collection system in comparison with the cost of treatment.

xi. The centralized system is generally publicly owned and collect large volume of waste water and treat for entire community, making use of large size pipes, major excavation and manholes for access.

xii. Centralized system of waste water management is expensive to build & maintain, especially in small town & low-density suburban area.

In centralized system, total sewer length is high. Sewers of longer diameters are required as these proceed downstream.

The sewers are to be laid deeper which sometimes needs pumping. Usually sewerage costs for 80 percent of total capital cost while treatment accounts for approx. 20 percent of the total cost.

The focus should be on sewers when there is a need to reduce overall cost.

Centralized system is wasteful of both water and nutrients (nitrogen and phosphorus) which are carried out to nearby water course, then to the sea and subsequently lost. While in a decentralized system, the water and nutrients are generally put back into the soil and reused.

In a decentralized system, sewer network are short in length and smaller in diameter since there are many disposal points. On site disposal is provided near the source of waste water generation as far as possible (Oldest example is use of septic tank & Soak pit). Thus, the quantity of treated water at the end of each network is small. Natural treatment methods are generally preferred as they are easier to operate and maintain and requires no power.

xiii. Decentralization is characterized by short lengths of sewer lines to serve clusters of houses, the presence of several on-site disposal systems, and treatment generally leading to reuse of the wastewater. Reuse can be in agriculture, horticulture or other form of aqua-culture. Reuse can also be for toilet-flushing, car washing, groundwater recharge and such other purposes. In USA, the use of Membrane Bio-Reactors has been picking up as a form of treatment to give high quality reusable water.

3.1.1 Strategies for Planning New Decentralized Sewerage Projects

The following strategies can be used for planning a new decentralized sewerage project:

i. Examine each property or cluster of properties for treatment and reuse in various ways, or treatment and recharge underground, either on-site or as near to it as possible.
ii. Emphasize reuse, recharge, resource recovery and conservation of water and nutrients while working out a sewerage plan for the area. Assuming that land is available, the following possibilities exist for reuse.
iii. Reuse in landscape and agriculture: This includes commercial nurseries, parks, roadway median strips, greenbelts and crop irrigation.
iv. Recreational/environmental uses: These include development of fisheries, ponds, lakes marshes and wetlands, and lake replenishment.
v. Non-potable urban uses: These are toilet flushing, car washing, fire protection, and make-up water for centrally air-conditioned buildings.
vi. Industrial non-potable uses: These include cooling, boiler feed, and process water.

Following are the advantages of decentralization:

i. It automatically promotes conservation of used water and nutrients.
ii. It makes sanitation cost-effective by reducing the cost of collection.
iii. It often helps in the adoption of a natural treatment system which may, in fact is most appropriate treatment system under the circumstances, keeping in mind the principle of 'affordability, acceptability, and manageability of the treatment system by the community'.

iv. It is best done when a new area is proposed to be developed to ensure proper planning of all aspects, and availability of adequate land for optimizing the advantages of decentralization.

v. Collaboration with urban planners is necessary at all stages to ensure that space is available where needed and that the required population density is maintained.

vi. Decentralization involves a kind of 'public–private partnership'. The municipality is not required to build and maintain big-sized treatment plants and pumping stations. The local authority has to provide lesser capital outlay and maintenance staff and some burden is passed on to the public.

Decentralized systems also have the following disadvantages:

i. Private builders/property owners may provide improperly designed, shoddy systems if the municipal supervision is not strict enough.

ii. Lack of maintenance can lead to mosquito nuisance.

iii. Downstream discharges in rivers may get reduced and the consequent lower flow may have serious consequences for downstream users. Ground water recharge may also affect downstream users. An Environmental Impact Assessment (EIA) may be needed in some cases.

3.2 Decentralized Waste Water Treatment System (DEWATS)

3.2.1 Introduction

Decentralized Wastewater Treatment Systems (DEWATS) is rather a technical approach than merely a technology package. In general, DEWATS are locally organized and people-driven systems that typically comprise a settler, anaerobic baffled tanks, filter beds of gravel and sand, and an open pond (See *figure 3.1)*. The open pond or the polishing tank recreates a living environment for the wastewater to clean itself, naturally.

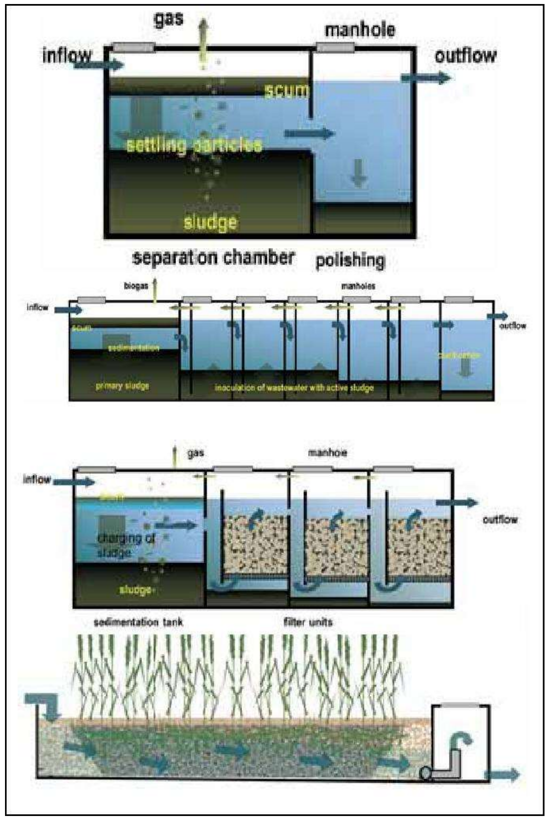


Figure 3.1 Schematic diagram of DEWATS

The system operates without mechanical means and sewage flows by gravity through the different components of the system. Up to 1,000 cubic metre of domestic and non-toxic industrial sewage can be treated by this system *(TencyBaetens, 2004)*. DEWATS applications are based on the principle of low-maintenance since most important parts of the system works without electrical energy inputs and cannot be switched off intentionally (*BORDA*).

DEWATS applications provide state-of-the-art- technology at affordable prices because all of the materials used for construction are locally available. DEWATS approach is an effective, efficient and affordable wastewater treatment solution for not only small and medium sized enterprises (SME) but also for the un-sewered (rural and urban) households in developing countries, especially South Asia. For instance, DEWATS can operate in individual households, at the neighborhood level and even in small and big factories not connected to sewage lines. DEWATS can also treat municipal waste. The recycled water is used for irrigation or for growing plants and is absolutely safe for human use.

3.2.2 The need for decentralized initiatives in wastewater treatment

In India, about 12 million (7.87 %) urban households do not have access to latrines and defecate in the open. About 5 million (8.13 %) urban households use community latrines and 13.4 million households (19.49 %) use shared latrines. About 12 million (18.5 %) households do not have access to a drainage network while about 27 million (39.8 %) households are connected to open drains. The status in respect of the urban poor is even worse. The percentage of notified and non-notified slums without latrines is 17 percent and 51 percent respectively. More than 37% of the total human excreta generated in urban India, is unsafely disposed. This imposes significant public health and environmental costs to urban areas that contribute more than 60% of the country's GDP. Impacts of poor sanitation are especially significant for the urban poor (22% of total urban population), women, children and the elderly.

The Millennium Development Goals (MDGs) enjoin upon the signatory nations to extend access to improved sanitation to at least half of the urban population by 2015, and 100% access by 2025. This implies extending coverage to households to improved sanitation, and providing proper sanitation facilities in public places to make cities open-defecation free.

The quantity of wastewater is increasing in India because of: i) Increase in quantity of wastewater generation per capita due to rapid urbanization and population explosion ii) Inadequate infrastructure for collection and treatment of domestic wastewater which has led to continuously widening of the gap between waste generation and waste treatment; and pollution of surface and groundwater water resources (iii) Inadequate financial resources for upgradation of wastewater treatment plants to meet the input waste requirements at city levels.

In India, domestic wastewater, including sewage that is often not even collected, is a major source of pollution of surface water. This contributes to contamination of groundwater - an important or only source of drinking water for many urban and peri-urban areas. Inadequate discharge of untreated domestic/ municipal wastewater has resulted in contamination of 75 percent of all surface water across India.

Centralized approaches have had limited success to make wastewater management people-centered and effective. For instance, large areas in most cities are not served by formally provided sewerage. Facilities are often overloaded and poorly maintained and the wastewater flow is often re-directed to by-pass them. Even where sewerage systems exist, they often collect only a small proportion of the wastewater produced, and the remainder is discharged to open drains or disposed of locally. In addition, the economies of scale required for using conventional technologies would are not achieved in small settlements for various reasons, including: i) different climatic conditions; ii) topography; iii) geological conditions and water tables; iv) levels of urbanization; and v) population densities and size of settlements. Thus, in India, decentralized and low-cost wastewater treatment and waste management provide more appropriate solutions in several situations.

In India, small-scale decentralized composting plants are also found frequently at community level. Numerous initiatives have developed, in particular, as a result of the unbearable solid waste accumulation in residential areas. Such initiatives have also been taken at city level, e.g. the cities of Pune and Mumbai have adopted promising composting approaches at community level (together with primary waste collection), which are actively promoted by the authorities *(Zurbrugg et al, 2004)*.

3.2.3 Appropriate wastewater treatment technologies in India

A single wastewater treatment technology would be inappropriate for a country like India which has several different geographical and geological regions, varied climatic conditions and levels of urbanization. It is more appropriate to address the potential of identifying appropriate solutions for different regions. In addition, the solutions for wastewater treatment are a response to several factors including: i) the volume of wastewater; ii) type of pollutants; iii) the treatment cost; iv) extent of water scarcity; and v) dilution in the water.

A significant opportunity available in India is to introduce decentralized systems through which the resources generated from the wastewater, including recycled water and manure etc., can be utilized locally at much lower costs.

Five wastewater treatment technologies, namely, i) waste stabilization ponds; ii) wastewater storage and treatment reservoirs; iii) constructed wetlands; iv) chemically enhanced primary treatment; and v) up flow anaerobic sludge blanket reactors are suitable for different situations. Each of these has some advantages and some disadvantages, especially in terms of requirements for land.

All these solutions for wastewater treatment aim at innovations across a broad range of environmental issues including: i) reuse of wastewater; ii) removal of nutrients from effluent; iii) management of storm water; iv) managing solid wastes; v) flood mitigation; and vi) tackling erosion around water bodies, including ponds, lakes and riverbank.

However, from the sustainability aspect, the selection of appropriate solution must be balanced between simple systems that do not require use of chemicals and have high pathogen removal. Motivating the community as a whole to work towards effective functioning of a (local) system is one of the critical prerequisites for DEWATS to succeed.

3.2.4 Innovative approaches applying DEWATS by DTU, Delhi

In an initiative of Decentralized waste water treatment, Delhi Technological University has installed a sewage treatment plant of One million litre per day (1 MLD) capacity in the Campus. The STP is based on Bio- filter and treat waste water discharged from DTU campus. The Campus accommodates 12,000 students, Hostels & Staff flats having a total of 3200 residents. The waste water after treatment is reused for Horticulture and remaining treated water is discharged into a Pond situated in the DTU Campus. A case study of the same project is discussed in detail.

Chapter 4 STP BASED ON BIO-FILTER

4.1 Bio-Filtration:

It is a pollution control technique using a bioreactor containing living material to capture and biologically degrade pollutants. Common uses include processing **waste water**, capturing harmful chemicals or silt from surface runoff, and micro-biotic oxidation of contaminants in air.

Absolute Water Pvt. Ltd. (AWPL) has installed a Sewage Treatment Plant at Delhi Technological University, Delhi and many other such plants at various institutions in the country. The STP based on bio-filter technology ensures maximum sewage treatment at minimum costs and in the shortest time.

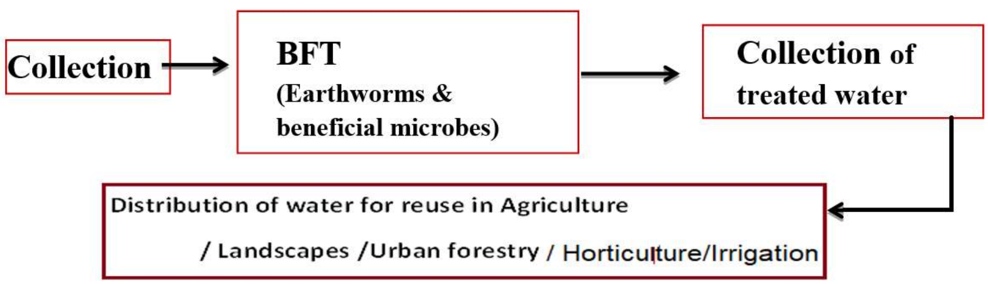


Figure 4.1 Flow diagram of STP based on Bio-filtration

The bio filter consists of a sequential filtration set-up.

- Bio-Filter is a bed of organic material which supports worms (microbes) that break down solid and convert to carbon dioxide, water and nutrients.
- Bio-Filter Technology is a synthesis process, which harnesses the energy, carbon and other elements of the waste and converts them to precious "Bio-nutritional" products like energy rich humus & bio-fertilizer and nutrient rich water.
- It involves removal of organic matter by adsorption & filtration followed by biological degradation and oxy-gen supply by natural aeration to the treatment system.

- And a natural way of recycling nutrients and removal of toxins.

4.2 Bio-Filter Based STP System.

The Process pioneered by Bio-filter is totally different from the conventional processes in existence at present. It is a totally Green process that does not use any Aeration (power), or Chemicals, and most importantly, produces NO Sludge. The process is based on a mix of Vermi-compost and Micro-Organisms that naturally degrade all the pollutants in the raw sewage, converting some into nutrients

An innovative bio-filter based Sewage Treatment system developed for the extraction of clean safe water from raw sewage is totally different among other conventional technologies, a green and natural waste water treatment.

The global scientific community today is searching for a technology which should be “economically viable”, “environmentally sustainable” and “socially acceptable”. Bio-Filter has developed a water recovery system to treat sewage and recover clean, safe, potable or non-potable quality water from it. This is the first such proven project in India which converts directly converts raw sewage into drinking water based on “The Vermi-filtration Technology” (Worms as WASTEWATER ENGINEERS).

The “earthworms” work as a “bio-filter” as they have been found to remove BOD, COD & TSS by over 95%, 85-90% & 90% from wastewater by the mechanism of ‘ingestion’ and bio-degradation of organic wastes and also by their ‘absorption’ body walls. Vermi-filtration has opened new grounds for recovering safe, clean water from wastewater in the world due to its closed loop, low cost engineering, eco-friendly and self-sustaining characteristics. It is a decentralized based solution which can take over the existing conventional technologies and in making possible to recover clean safe water in water scarce countries.

Vermi-filtration offers a cost-effective technology to treat and manage organic effluents, from diverse sources ranging from domestic sewage to industrial refuse, efficiently and conveniently. It could also be setup as economically decentralized treatment options where ever techno economically feasible. Vermi-filtration accompanied with membrane system can ensure a closed-loop waste water treatment solution resulting in the Reclaimed water that can be safely used for drinking purpose even and for many other applications, while the replenished vermin-compost/media obtained as a by-product -i.e. not a sludge in this process technology has an agronomic value and hence can be channelized into the organic fertilizer market chain. Therefore, cost of the system can be hence recovered by feeding of the bio-safe clean water to the nearby community and the nutrient rich vermin-compost as a rich Bio-fertilizer and concentrate stream used as a highly nutritious Liquid Urea for soil fertility and retention. Thereby, this Water Recovery System has a great potential to address wastewater management and water crisis simultaneously which has significant advantages over traditional wastewater treatment processes conceived ever so far.

Bio-filtration is versatile enough to treat odors, toxic compounds, and VOCs. The treatment efficiencies of these constituents are above 90% for low concentrations of contaminants (<1000 ppm). Different media, microbes and operating conditions can be used to tailor a bio-filter system for many emission points.

4.3 Process Description

4.3.1 Raw materials

Raw sewage, Bar-screen, strainer, Rota meter, organic & Inorganic media, Earthworms, Enzyme, pebbles, woodchips, screener, sprinklers, Pipes, Ozonator.

4.3.1.1 Raw sewage: characteristics and the acceptable values

The raw sewage was obtained from the DTU Campus, India. Sewage is the cloudy fluid of human fecal matter and urine, rich in minerals and organic substances. Water is the major component (99%) and solid suspension amounts to only 1%. The biochemical oxygen demand (BOD), chemical oxygen demand (COD), and the oxygen consumption (OC) values are extremely high demanding more oxygen by aerobic microbes for biodegradation of organic matter. Dissolved oxygen (DO) is greatly depleted. The nitrogen (N) and phosphorus (P) contents are very high and there are heavy metals like cadmium (Cd) and significant number of coliform bacteria. The total suspended solids (TSS) are also very high. The average BOD value of the raw sewage ranged between 200 and 400 mg/l, COD ranged between 116 and 285 mg/l, the TSS ranged between 300 and 350 mg/l, and the pH ranged between 6.9 and 7.3. There is great fluctuation in these values depending upon catchment area, flow rate, and season. Sewage from industrial areas can have high COD values, very low or high pH, due to accidental mixing of industrial wastewater. The normal acceptable values for BOD in treated wastewater are in range of 1–15 mg/l, COD is 60–70 mg/l, TSS 20–30 mg/l, and pH around 7.0.

Figure 4.2 Raw Sewage

4.3.1.2 Bar Screen:

A **Bar Screen** is a mechanical filter used to remove large objects from **wastewater**. It is part of the primary filtration flow and it usually is the first level of filtration being installed at the influent to a **wastewater treatment plant.** They typically consist of a series of vertical steel bars spaced between 1 and 3 inches apart.

Figure 4.3 Bar Screen

Screening: include coarse and fine screening, usually mechanically operated, to intercept floating and suspended debris with ancillary equipment to remove the screenings. Flush organic matter hack to the sewage flow and compact the final screenings residue for disposal off site.

4.3.1.3 Pre-filter Strainer:

A **Pre-filter strainer** is a device which provides a means of mechanically removing solids form a flowing fluid by utilizing a perforated, mesh or wedge wire straining element. The range of **strainer** particle retention is 400 microns.

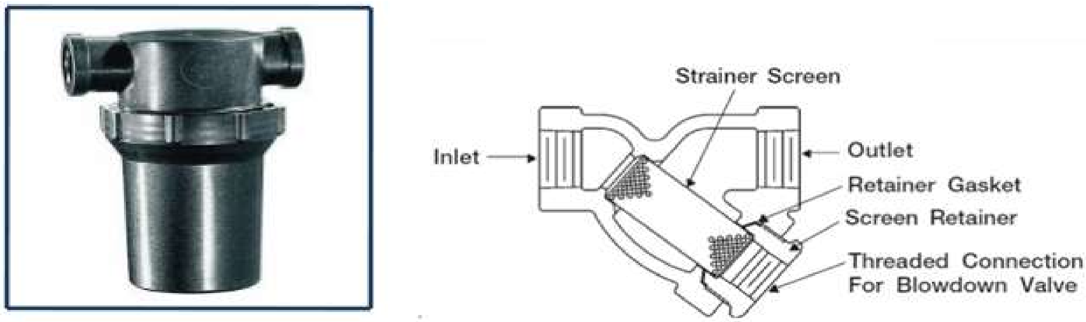


Figure 4.4 Pre-Filter Strainer

Strainers (Figure 2) arrest debris such as scale, rust, jointing compound and weld metal in pipelines, protecting equipment and processes. A strainer is a device which provides a means of mechanically removing solids from a flowing fluid or gas in a pipeline by utilizing a perforated or mesh straining element.

To ensure against untimely shutdown of equipment, strainers should be installed ahead of pumps, loading valves, control valves, meters, steam traps, turbines, compressors, solenoid valves, nozzles, pressure regulators, burners, unit heaters and other sensitive equipment.

Technology:

During the filtration process, the water flows inside the filtration discs, where the particles are retained. The optimized lock system of the thread makes the filter very resistant the sharp changes of pressure and temperature avoiding deformation in the set housing-thread.

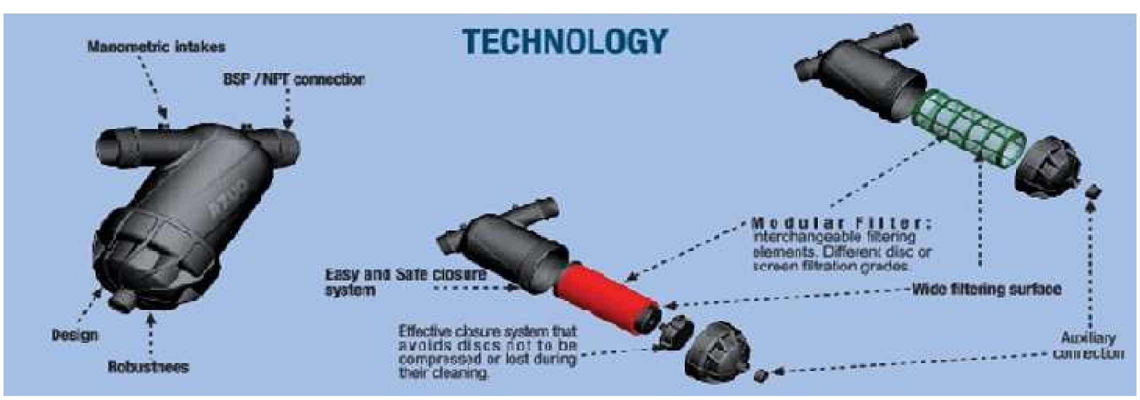


Figure 4.5 Technology inside Pre-Filter Strainer

Advantages:

I. Maximum Quality & Safety in Filtration.
II. Mouth Housing with Different Connection possibilities.
III. The Filter Can be installed in any position.
IV. Water & Energy Saving.

4.3.1.4 Rotameter:

A **rotameter** is a device that measures the volumetric flow rate of fluid in a closed tube. It belongs to a class of meters called variable area meters, which measure flow rate by allowing the cross-sectional area the fluid travels through to vary, causing a measurable effect.

Flanged end connections for better rigidity and strength in field mounted applications (65 NB from 20,000lt/hr. to 50,000lt/hr.).

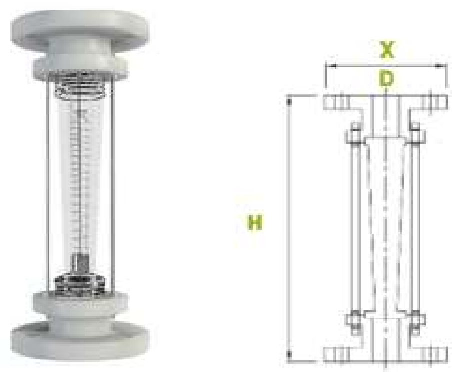


Figure 4.6 Aster flange type rotameter

Key Features

- ❖ FACTORY CALIBRATED each rotameter is with readings traceable to Government body standards. (CWPRS)
- ❖ Temper-Proof & Sunlight-Proof Graduation.

Application

I. FACTORY CALIBRATED each rotameter is with readings traceable to Government body standards.
II. Temper-Proof & Sunlight-Proof Graduation Sticker.
III. Enhanced meter readability using precision textured body.
IV. Each Rotameter is at Pressure Hydro-Tested 8kg/Cm².

4.3.1.5 Earthworms

They are used to **treat** organic pollutants from waste **water** using mechanism of degradation. **Earthworms** enhanced the stabilization of organic matter. They are generally known as environmental engineers. They generally remove average COD 84.4%, BOD 91.8%, TDS 97% & TSS 97.4% respectively.

Figure 4.7 Earthworms

An earthworm is a tube-shaped, segmented worm found in the phylum Annelida. They have a world-wide distribution and are commonly found living in soil, feeding on live and dead organic matter. An earthworm's digestive system runs through the length of its body. It conducts respiration through its skin

Soil Condition: Because **earthworms** breathe through their skin, it must be kept **moist** in order to work. **Dry** skin stops the diffusion process, effectively preventing **earthworms** from getting oxygen. That is why **worms** are so commonly spotted above ground when it is rainy and at night, when air is wetter.

4.3.2 Woodchips

Mesquite **wood chips** (Prosopis) as filter media in a **bio filter** system for municipal **wastewater treatment**. The **bio filtration** system over organic bed (BFOB) uses organic filter material (OFM) to treat municipal wastewater (MWW).

Basically, woodchips are mainly used for oil and grease removal. The mechanisms woodchips used are absorption.

While water is passing through the woodchips it absorbs the oily and greasy dirt from it and the water further goes for treatment.

Figure 4.8 Wood Chips

4.3.2.1 Pebbles:

Different size of pebbles is used for treatment. Pebbles in Various Sizes for **Water Filter** Units. **Pebbles** composed of sub-angular, durable and dense grains of predominately siliceous material. Support gravel acts as a support for the **filter** media and forms the lower levels of the **filter** bed.

Having different sized filtering media particles assist in removing different sized particles while allowing unrestricted flow. If you have several sizes of media, the larger particles that you are filtering out will be trapped there, while the smaller particles pass through to the next layer of presumably smaller particles of media.

Figure 4.9 Different sizes of gravels used in preparation of the vermin-filter bed.

This is of course assuming that the water is flowing progressively from the larger particles to the small particles of filtering media. If for instance you have a filter housing that is tall and the flow is from bottom to top, you would place the pebbles at the bottom and you would place progressively smaller particles of filtering media above that. You might have some fine sand near the top. This not only assists in filtering, but also assists in backwashing the filter. Imagine if you placed the media in the filter in the opposite order with the fine media at the bottom and the larger media at the top. The filter would plug off prematurely and if you attempted to backwash the filter, you would wash out the fine sand at the bottom.

4.3.2.2 Piping

Piping are used for water distribution from inlet to outlet of the complete wastewater treatment plant.

4.3.2.3 Sprinklers

The oscillating sprinkler works on the principle that water provides the power to move the elliptical cam (or heart-shaped cam in some models) which moves the sprinkler arm. Water spins a simple turbine which must be attached to a series of gears stacked up (called a gear train) to slow down the speed of the water.

Figure 4.10 Sprinkler

In a sprinkler system, water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops which fall to the ground. The pump supply system, sprinklers and operating conditions must be designed to enable a uniform application of water.

4.3.2.4 Screen:

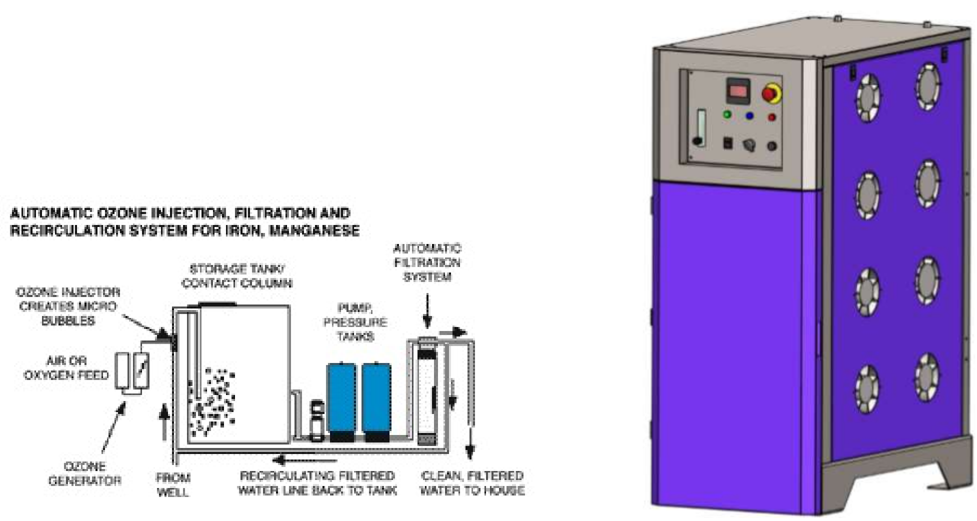
A **Screen Filter** is a type of **filter** using a rigid or flexible **screen** to separate sand and other fine particles out of **water** applications.

Figure 4.11 Screen

4.3.2.5 Ozonator

Ozonation is a water treatment process that destroys microorganisms and degrades organic pollutants through the infusion of ozone, a gas produced by subjecting oxygen molecules to high electrical voltage. Ozonator is a device that is used to clear and purify the air, water and other environmental factors. It gets rid of odors and smells within an area. It is basically a generator that produces ozone which is form of gas that can kill germs and bacteria.

Ozone is a gas. And it's made of just one thing-oxygen. Ozone is one of the most powerful commercially available oxidants & disinfectant for air & water treatment. Any pathogen or contaminant that can be disinfected, altered or removed via an oxidation process will be affected by ozone. Compared to chlorine, the most common water disinfection chemical, ozone is a more than 50% stronger oxidizer and acts over 3,000 times faster. In addition to its capabilities, ozone enables environment friendly method of treatment without creating harmful by products or significant residues.



Oxygen (O_2) ➡ Ozone (O_3) ➡ Oxygen (O_2)

Figure 4.12 Ozonator

Ozone may be **added** as a disinfectant to inhibit the growth of harmful microorganisms. **Ozone** is also effective in removing objectionable odours and flavours because it breaks down into oxygen which improves taste and other qualities. Ozone is effect over a wide pH range and rapidly reacts with bacteria, viruses, and protozoans and has stronger germicidal properties then chlorination. Has a very strong oxidizing power with a short reaction time.

The treatment process does not add chemicals to the water. Ozone can eliminate a wide variety of inorganic, organic and microbiological problems and taste and odor problems. The microbiological agents include bacteria, viruses, and protozoans (such as Giardia and Cryptosporidium). Pathogenic and waterborne disease screening test.

Features:

- High voltage and high frequency corona discharge.
- Variable ozone output setting.
- Durable stainless-steel ozone electrodes. Mild steel powder coated cabinet for safety, ruggedness & durability.
- Easy monitoring using control panel.
- Over current, over temperature Protection.
- Floor-mountable device.
- Zero maintenance

4.3.3 Design Parameters

4.3.3.1 Space Constraints:

Space at a site is the greatest concern during design of a biofiltration system. A biofiltration system designed to treat large water volumes and require space as large as a basketball court.

4.3.3.2 Chemical Constituents and Concentrations:

Analysis of chemical constituents and their concentrations are required to determine if biofiltration is a plausible alternative. Biofilters performed best when treating hydrophilic compounds in low concentrations (<1000 ppm). Some chemicals biologically degrade at low rates, such as chlorinated compounds, which require units to be oversized.

4.3.3.3 Residence Time:

Residence Time represents the amount of time the microbes are in contact with the contaminated water stream, and is defined by (Void Volume/Volumetric Flow Rate). Consequently, longer residence times produce higher efficiencies; however, a design must minimize residence time to allow the biofilter to accommodate larger flow rates.

4.3.3.4 pH-Control:

The by-products of microbial degradation are organic acids. In order to maintain the pH of the vessel around neutral, or a pH of 7, buffering material may be added to the organic media.

4.3.3.5 Biofilter Media:

Generally, the media should be capable of providing nutrients to the microorganisms and minimizing pressure drop. In addition, the moisture content of the biofilter media must be maintained between 30% and 60% in order to support the microbial population. The biofilter that can be controlled to maintain a suitable bed moisture.

4.3.3.6 Pressure Drop:

Pressure drop is directly related to the moisture content in the media and the media pore size. Increased moisture and decreased pore size result in increased pressure drop. Consequently, media filter selection and watering are critical to biofilter performance and energy efficiency. Maintenance:

The operation and maintenance of the bio filtration system would require weekly site visits during initiation of operations. However, after installation and commissioning all system problems are resolved the frequency of site visits could be reduced to the bi-weekly or monthly.

4.3.4 Plant Construction/ Design Calculation

4.3.4.1 Quantity of Waste Water Generated:

Area of Academic Buildings (for existing Construction) =69146.03 sq.m.

Total area	= 69146.03 sq.m.
Applicable norms	= 1P/4 sq.m
Population	= 69146.03/4=17286.51+10% for floating population = 19015.16 say 19015
Water demand	= 45 LPD
Total Water demand	= 19015 x 45 = **855675 LPD**

Area Residential Building (Existing)

Type-I Quarters	= 3212.48 sq.m/ 60 Du's
Type-II Quarters	= 6717.48 sq.m/ 105 Du's
Type-III Quarters	= 3515.12 sq.m/ 45 Du's
Type-IV Quarters	= 6262.24 sq.m/ 60 Du's
Type-V Quarters	= 11938.72 sq.m/ 56 Du's
HVC Bungalow	= 400.00 sq.m/ 1 Du's
Total	= 32044.04 sq.m./327 Du's
Applicable norms	= 5P/1 Du
Population	= 327 X 5 = 1635
Water demand	= 225 LPD
Total Water demand	= 1635 X 225 = **3,67,875 LPD**

Guest House	= 828.06 sq.m
Married Scholar Hostel	= 924.80 sq.m

Transit Hostel Total	= 1719.15 sq.m
Total	= 3472.01 sq.m.
Applicable norms	= 1P/12.5 sq.m
Population	= 3472.01/12.5 = 277.76+10% for floating population= 305.53 say 306
Water demand	= 135 LPD
Total Water demand	= 306 X 135 = **41,310 LPD**
Nursery	= 800sq.m (Provided at 6/c)
Applicable norms	= 1P/4 sq.m
Population	= 800/4 = 200+10% for floating population =220
Water demand	= 45 LPD
Total Water demand	= 220 X 45 = **9900 LPD**
12 Bedded Hospital	= 1564.80 sq.m
Applicable norms	= 1P/80 sq.m
Population	= 1564.80/80=19.56+10% for floating population = 21.52 say 22
Water demand	= 340 LPD
Total Water demand	= 22 X 340 = **7480 LPD**
Boys Hostel	= 38983.40 sq.m
Girls Hostel	= 3107.32 sq.m
PG Hostel	= 8516.68 sq.m
Applicable norms	= 1P/12.5 sq.m
Population	= 50607.40/12.5=4048.59+10% for floating population= 4453.45 say 4454
Water demand	= 135 LPD
Total Water demand	= 4454 X 135 = **6,01,290 LPD**

Water demand for Existing Infrastructure = 18,83,530 LPD

Demand for future expansion @30% of 18,83,530 = 5,65059 LPD

Total Water demand for existing and future development = 24,48,589 LPD

Total daily average sewage discharge

24,48,589 X 80% = 19,58,871 LPD

Total average sewage discharge considered = 9,79,436 LPD

Say 10 lakh litres per day or 1 MLD.

The Plant Design Includes Bar Screen Chamber, Sewage Collection Tank, Bio Filter Bed Tank/Bio-Filter Basin, Treated Sewage Collection Tank Cum Ozone Contact Tank and Treated Water Collection Tank.

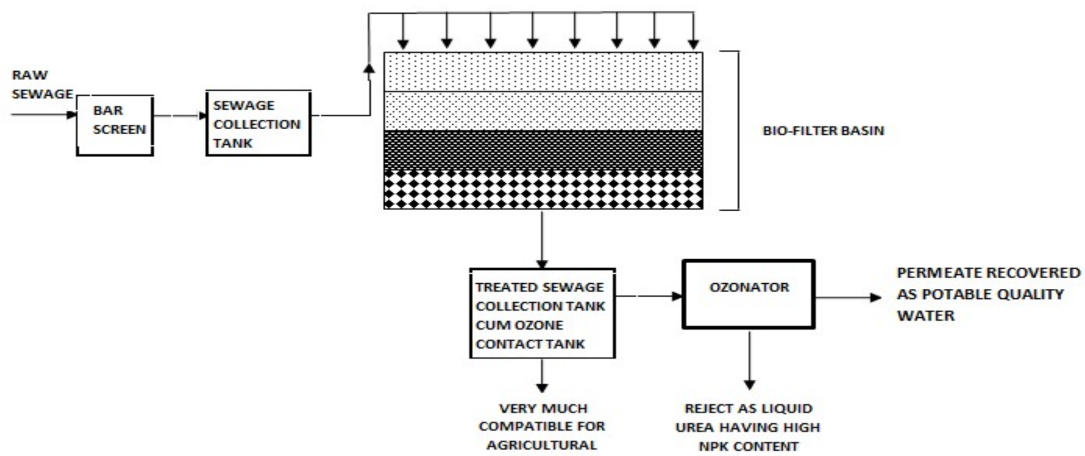


Figure 4.13 Plant construction/ Design

4.3.5 Bar Screen Chamber

Preliminary treatment upon arrival via the sewer system, the wastewater is sent through a bar screen, which removes large solid objects such as sticks and rags. Leaving the bar screen, the wastewater flow is slowed down entering the grit tank, to allow sand, gravel and other heavy material that was small enough not to be caught by the bar screen to settle to the bottom. All the collected debris from the grit tank and bar screen is disposed of at a sanitary landfill.

4.3.6 Sewage Collection Tank

After passing through the bar screen the sewage water is collected in the sewage collection tank which is further goes for step wise wastewater treatment.

4.3.7 Bio Filter Bed Tank/Bio-Filter Basin

- Bio-Filter System is High efficiency and multi filter medium which include worms, specially developed microbes, organic & in-organic media.

- Raw sewage pumped from the collection tank is allowed to pass through screen to remove/separate the macro particles present in the effluent.

- Raw sewage is distributed evenly over the surface of filter medium, by sprinklers. As the waste water slowly percolates down, naturally occurring microbes degrade the solids and organic matter, reduce coli from bacteria, and nitrify ammonium, producing clear and odorless water.

- Earthworm acts as media to host millions of micro-organisms, which help in rapid degradation of the organic matter present in the waste water.

4.3.8 Filtration

- Filtration through sand filter removes the final traces of suspended solids in the water.

4.3.9 Ozonation as Advanced Treatment

- Ozone is injected into the treated water for effective disinfection as coliform, reduction membrane. System for advanced COD, BOD reduction and effective disinfection. This treated water can be reused back in to the process.

- It's been shown that the oxidation of NOM by ozone in source water has the effect of breaking down large molecular weight molecules into smaller less complex ones, with increased hydroxyl, carbonyl and carboxyl groups (Urfer et al. 1997). These resultant molecules are easier to biodegrade, and as such the combined effect of pre-ozonation is an increase in BOM. This culminates in an increase in the risk of biological growth within the distribution system. The removal of this BOM to avoid this condition is a reason that biofiltration and ozonation are commonly coupled.

4.4 Plant Details

Treatment Process :	*Treatment through Bio-filter Based System followed by Ozonation.*
Source of Water :	*Domestic Waste Water*
Operating Hours :	*20 hours*
Feed Flow :	*50 m^3/Hr*

The following are the detailed list of Civil & Structural units envisaged for 50 m3/hr proposed new PLANT

NO.	***ITEMS***		***SPECIFICATIONS***
1.	***BAR SCREEN CHAMBER***		
	Quantity	:	1 No.
	Size	:	1.0m x 1.0m x 1.0m
	Material of construction	:	RCC
2.	***SEWAGE COLLECTION/EQUALIZATION TANK***		
	Quantity	:	1 No.
	MOC	:	RCC
	Volume	:	336 M^3
	Dimensions	:	11.2m x 10m x 3m
	Considered SWD	:	3.0 m
	Retention Time	:	8 Hours
3.	***BIO-FILTER BASIN***		
	Quantity	:	1 No.

NO.	ITEMS		SPECIFICATIONS
	MOC	:	RCC
	Capacity	:	660 m^2
	Dimensions	:	18m x 24.5m x 1.5m
4.	***CLARIFIED CUM OZONE CONTACT TANK***		
	Quantity	:	1 No.
	MOC	:	RCC
	Volume	:	168m^3
	Retention Time	:	4 Hours
	Dimensions	:	10m x 5.6m x 3m
5.	***MCC PANEL/OZONATION ROOM WITH JOINERIES***		
	Quantity	:	1 No.
	MOC	:	Brick work
	Dimensions	:	4m x 3m x 4m

4.5 Process Technology for Bio-Filter based Sewage Treatment system:

The process described here is very simple and unique as it is the first such proven project in India, directly converting raw sewage into drinking water.

Step 1: Sewage Treatment through Bio-Filter (Vermi-filtration)

- Bio-Filter System is High efficiency and multi filter medium which include worms, specially developed microbes, organic & in-organic media.
- Sewage is allowed to pass through bar screen to remove macro particles from the wastewater and collects into the feed tank from where it is pumped to Bio-filter basin.
- Sewage is distributed evenly over the surface of filter medium, by sprinklers. As the waste water slowly percolates down, naturally occurring microbes degrade the solids and organic matter, reduce coli from bacteria, nitrify ammonium, producing clear and odorless water, shown in figure.

- Filtration through In-organic media followed by sand filtration to remove the traces of suspended solids present in the treated water.

Figure 4.14 Wastewater distribution over Bio-filter bed.

Step 2: Recovering clean safe water from Bio-filter treated sewage through Ozonation

Ozone dosing in the final treated water for coliform removal and COD/BOD reduction.

Figure 4.15 Showing Ozonation system as a downstream process for water recovery.

The filtered treated sewage is feed into the Ozonator and permeate from the Ozonator is of Potable/Contact water/Bathing water quality.

4.5.1.1 Scope of Supply

The following are the detailed list of Mechanical Rotating Equipment envisaged for 50 m^3/hr. proposed new Plant project:

NO.	ITEMS		SPECIFICATIONS
1. BAR SCREEN			
	Quantity	:	1 No.
	Size	:	1.0m x 1.0m
	Material of Construction	:	SS-304
2. SEWAGE FEED PUMP			
	Quantity of pumps	:	2 Nos. (1 Working + 1 Standby)
	Type of pumps offered	:	Centrifugal
	Required Capacity	:	42 M^3/hr.
	Discharge Head	:	25 M
	Motor Rating	:	5 KW
	Motor Type	:	Inline TEFC squirrel cage motor, IP-55
	Additional accessories	:	Associated piping, fittings, valves, etc.
	MATERIAL OF CONSTRUCTION		
	Casing	:	CI
	Impeller/Shaft	:	SS
	Seal type	:	Mechanical
	Make	:	KSB/Kirloskar
	Capacity	:	21 Cu.m/Hr.
w	Type of Pumps	:	Centrifugal
3. OZONATION SYSTEM			
	Ozone	:	300gm/hr.
	Power Requirement	:	4.4 KW
	Oxygen Concentrator	:	Included
4. PRESSURE GAUGES			
	Quantity	:	As required.
	Type	:	Diaphragm type.
5. MCC Panel			
	Quantity	:	1No.
6. CABLES			
	Quantity	:	As required.
7. FLOW METER			

NO.	ITEMS		SPECIFICATIONS
	Quantity	:	As required
8. PIPELINES & FITTINGS			
	Quantity	:	As required
	Material	:	UPVC

4.5.1.2 POWER REQUIREMENT

Power Consumption of proposed PLANT of 50 M^3/Hr.:

SL. NO.	***DESCRIPTION***	***MOTOR RATING (KW)***	***UNITS***		***OPERATING HOURS***	***POWER CONS./DAY IN KWH***
			WORKING	***INSTALLED***		
1	Sewage Feed Pump	5	1	2	24	120
2	Ozonation System	4.4	1	2	24	105.6
	TOTAL					**225.6**

4.5.1.3 ORGANIC MEDIA REQUIREMENT

The following media is envisaged for regular consumption at various stages of treatment system required at certain interval.

Sl.Nos.	***DESCRIPTION OF CHEMICALS***	***PURPOSE***	***DURATION***
1.	Organic Media for Bio-Filter	Substrate for Vermi-filtration	Once in 6-8 Months

4.5.1.4 ELECTRICALS

The Electricals will be complete with installation of Electrical System comprising the following:

The offered electrical systems include:

a) MCC Panel
b) Cable Glands, Lugs, Termination kits and accessories.
c) Earthing system

All power / control cables for use on medium voltage systems shall be heavy duty type, with aluminium / copper conductor, PVC insulated, inner sheathed, & armoured. All other electrical equipment for Entire PLANT region is safe hence all electrical equipment shall be non-flame proof.

4.5.1.5 AN INNOVATIVE AND CREATIVE FEATURES OF BIO-FILTER BASED STP.

Vermi-filtration of wastewater using earthworms that digest waste is a newly conceived novel technology.

Earthworms have proved to be master bio-processing agents for the management of organic effluents from diverse sources ranging from domestic sewage to industrial refuse. Earthworms and Micro-organisms co-operate to ingest and degrade organic matter present in wastewater in a natural and very simple way, shown in figure below.

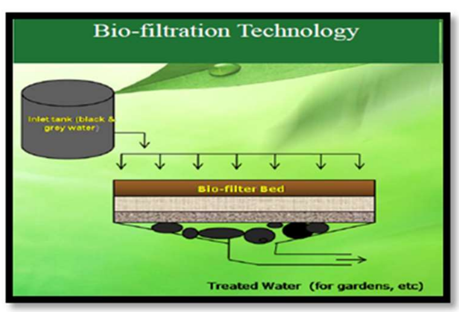


Figure 4.16 Showing Bio-filter Principle.

There are number of salient features, which makes Bio-filter based WRS a creative and an innovative approach leading to its sustainability, which are as follows:

- India’s first totally green, sustainable and eco-friendly
- **The 1st ever STP cum WRS of India** recovering >85% potable water from city’s wastewater and catering the freshwater needs of nearby areas where water supply is in adequate.
- **Zero Discharge of wastewater**, as all the streams coming out of WRS system is highly nutrient efficient to re-use and is totally safe for its disposal to environment.
- **Small footprint**
- **No sludge generation** (cuts sludge disposal cost) and no chemicals needed.
- **Noise free system** and **odour free** system surroundings.
- **Plug and play system** (portable/ mobile).

4.5.1.6 BIO-FILTER SMART ADAPTABILITY TO SITE CONDITION AVAILABILITY

A glowing feature of AW technology in comparison to conventional technologies is its smart arrangement adaptability to the available site conditions.

Many developing nations cannot afford to construct and maintain costly centralized STPs as they are disposal based. They need more options for sewage treatment at a low cost. In both developed and developing world, at least for new developments, centralized sewage treatment system may not fulfill sustainable wastewater management requirement in future due to ever-increasing demand. Cluster of homes/ societies/residential complexes/villages should treat their domestic wastewater at source in a de-centralized manner so as to reduce the burden (BOD & COD loads) on the sewage treatment plants (STPs) down the sewer system.

Bio-filter based STP cum WRS is a smart solution for a wastewater treatment which can be replaced with the existing conveying wastewater conventional treatment system by installing the system at a point of wastewater generation itself treat that wastewater rapidly and can re-use for number of applications depending on the requirement.

If we talk about the arrangement and engineering of the system in reference to the area availability for the installation, WRS can be easily installed at a site on brick work arrangement in civil based arrangement for bigger capacities (50KLD-5MLD), shown in figure 16 where adequate space availability is there.

Figure 4.17 Showing civil based Bio-filter (for larger capacity)

Wherever these systems have been installed, there are no issues of Odour, Noise or mosquitoes/ insects breeding due to its green hygienic arrangement and safe system operation without affecting to natural habitat. A common man/unskilled labor can easily operate the system safely without any special training and safety measurements as it is totally eco-friendly and very easy to operate and monitor.

Chapter 5 PERFORMANCE ANALYSIS OF STP

The performance analysis is done on the basis of water quality testing parameters and the amount of water achieved as a yield after the treatment of wastewater.

Table 5.1 Waste water quality before treatment and after treatment.

Parameters	**Before Treatment**	**After Bio-filter Treatment**	**Standard Norms for Land Irrigation**
pH	7.0-7.8	7.5-8.0	5.5-9.0
TSS (ppm)	Up to 400	Up to 20	>30
Turbidity (NTU)	40-100	<2.0	
COD (ppm)	200-400	50 - 80	100
BOD (ppm)	100-200	10 - 20	30
DO (ppm)	Nil	3-4	
Colour	Dark Grey	Pale Yellow	
Odour	Strong	Odourless	
Fecal Coliforms (MPN/100ml)	$> 10^6$	$<10^3$	$<10^3$

Testing of these parameters decided the quality of water received after treating the water with desired TECHNOLOGY.

5.1 pH

pH is a scale of acidity from 0 to 14. It tells how acidic or alkaline a substance is. More acidic solutions have lower pH. More alkaline solutions have higher pH. Substances that aren't acidic or alkaline (that is, neutral solutions) usually have a pH of 7.

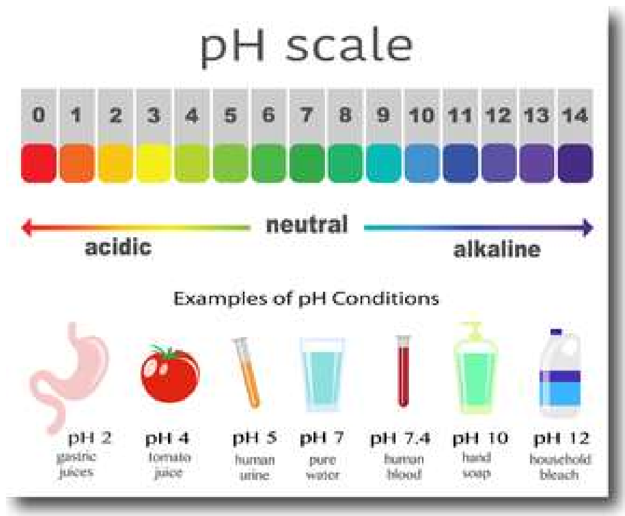


Figure 5.1 pH Scale

pH is a measure of how acidic/basic water is. The range goes from 0 to 14, with 7 being neutral. pH of less than 7 indicate acidity, whereas a pH of greater than 7 indicates a base. pH is really a measure of the relative amount of free hydrogen and hydroxyl ions in the water. Water that has more free hydrogen ions is acidic, whereas water that has more free hydroxyl ions is basic. Since pH can be affected by chemicals in the water, pH is an important indicator of water that is changing chemically. pH is reported in "logarithmic units". Each number represents a 10-fold change in the acidity/basicness of the water. Water with a pH of five is ten times more acidic than water having a pH of six.

5.1.1 Importance of pH

The pH of water determines the solubility (amount that can be dissolved in the water) and biological availability (amount that can be utilized by aquatic life) of chemical constituents such as nutrients (phosphorus, nitrogen, and carbon) and heavy metals (lead, copper, cadmium, etc.). For example, in addition to affecting how much and what form of phosphorus is most abundant in the water, pH also determines whether aquatic life can use it. In the case of heavy metals, the degree to which they are soluble determines their toxicity. Metals tend to be more toxic at lower pH because they are more soluble. (Source: A Citizen's Guide to Understanding and Monitoring Lakes and Streams).

5.1.2 Measurement of pH.

The pH value can be measured using electrochemical measuring systems, litmus paper, or indicators and colorimeters. The easiest way to take a pH measurement is to use litmus paper or a colorimeter. The advantage of this type of pH measurement is that the pH range is well known and they are easy to apply. Unfortunately, in many cases litmus paper and colorimeters are not accurate enough to make high quality pH measurements, because the pH value transition point depends on the user.

Another pH value measurement possibility is amperometry. The advantage of amperometry as a pH measurement method is that it is simple to use. In amperometric pH measurements hydrogen generation occurs on a noble metal. When combined with a less noble metal a power distributing galvanic cell is formed. Because hydrogen ions are generated the cell's current depends on the pH value. The disadvantages of this method are that differences in the sample composition create very large errors in pH measurements and the method cannot deliver dependable results in extremely concentrated acids and bases due to effects related to the pH glass membrane.

In special cases the pH value measurement can be made using conductometry (conductivity measurement). With this pH measurement method any membrane effects are minimized because of the measurement technique. The advantage of this pH measurement method is that it is relatively easy to use. The disadvantage is that a conductivity measurement measures all ion activity not just hydrogen ion activity. Additionally, this pH measurement is only reproducible and safe at low ion concentrations.

A relatively new method for pH value measurement is the use of an ion selective field effect transistor (ISFET). Briefly the ISFET is a transistor with power source and drain, divided by an isolator. This isolator (gate) is made of a metal oxide where hydrogen ions accumulate in the same way as an electrode. The positive charge that accumulates outside the gate is 'mirrored' inside the gate by an equal negative charge generates. Once this happens the gate begins to conduct electricity. The lower the pH value the more hydrogen ions accumulate and the more power can flow between source and drain. The ISFET sensors, similar to glass pH electrodes, act according to the Nernst equation. The advantage of an ISFET is that they are very small. The actual field effect transistor is only 0.2 mm2. The disadvantage of using an ISFET for pH measurements is that they have comparatively short durability and low long-term stability with a typical use life cycle being in range of weeks.

The most common method of pH value measurement is the use of pH measurement electrodes, like the IoLine series from SI Analytics. These pH measurement devices are electrochemical sensors which consist of a measuring electrode and a reference electrode. The pH measurement electrode is made of special glass which, due to its surface properties, is particularly sensitive to hydrogen ions. The pH measurement electrode is filled with a buffer solution which has a pH value of 7. When placing the pH measurement electrode into a test solution, the change in voltage is measured by the pH electrode by comparing the measured voltage to the stable reference electrode. This change is recorded by the pH meter, such as the pH3110 Field pH Meter, Lab 850 Benchtop pH Meter, or ProLab 1000 Professional Bench Top pH Meter, and converted into the pH measurement value displayed.

Of these pH value measurement methods, at this time, the best one is the use of pH electrodes. There is no other pH measurement system that provides as good reliability, accuracy, and speed of pH measurement across the complete pH range. The minimal disadvantage of using glass pH electrodes for pH measurement method is the fact that glass electrodes are delicate and should be handled with care. This disadvantage is overcome by using gel filled pH electrodes in applications where the electrodes must be more robust.

Figure 5.2 pH Meter

Relating $[H^+]$ and pH

The pH for an aqueous solution is calculated from $[H^+]$ using the following equation:

$$\mathrm{pH} = -\log[\mathrm{H}^+]$$

The lowercase p indicates "$-\log_{10}$". You will often see people leave off the base 10 part as an abbreviation.

$$\mathrm{pH} = -\log(1 \times 10^{-5}) = 5.0$$

Given the pH of a solution, we can also find $[H^+]$:

$$[\mathrm{H}^+] = 10^{-\mathrm{pH}}$$

5.2 Total Suspended Solids

Total Solids include both total suspended solids, the portion of total solids retained by a filter and total dissolved solids, the portion that passes through a filter.

Total solids can be measured by evaporating a water sample in a weighed dish, and then drying the residue in an oven at 103 to 105°C.To measure total suspended solids (TSS), the water sample is filtered through a pre-weighed filter. The residue retained on the filter is dried in an oven at 103 to 105°C.TSS can also be measured by analyzing for total solids and subtracting total dissolved solids.

High TSS in a **water** body can often mean higher concentrations of bacteria, nutrients, pesticides, and metals in the **water**. These pollutants may attach to sediment particles on the land and be carried into **water** bodies with storm **water**. The increase in weight of the filter represents the **total suspended solids**.

TSS removal/membrane filtration. Many wastewater streams contain suspended solids that need to be disposed of or cause problems in 'downstream' wastewater treatment systems. Effective TSS removal is an important step to purify water sufficiently for reuse, thereby lowering the requirement for fresh water.

Total Dissolved Solids (TDS) are solids in water that can pass through a filter (usually with a pore size of 0.45 micrometers). TDS is a measure of the amount of material dissolved in water. This material can include carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions. A certain level of these ions in water is necessary for aquatic life. Similar to TSS, high concentrations of TDS may also reduce water clarity, contribute to a decrease in photosynthesis, combine with toxic compounds and heavy metals, and lead to an increase in water temperature.

TDS is used to estimate the quality of drinking water, because it represents the number of ions in the water. Water with high TDS often has a bad taste and/or high-water hardness, and could result in a laxative effect. The U.S. Environmental Protection Agency sets a secondary standard of 500 mg/L TDS in drinking water. Secondary standards are unenforceable, but recommended, guidelines for contaminants that may cause cosmetic or aesthetic effects in drinking water. High TDS concentrations can produce laxative effects and can give an unpleasant mineral taste to water.

Figure 5.3 TSS Meter

Total Suspended Solids (TSS) is the portion of fine particulate matter that remains in suspension in water. It measures a similar property to turbidity, but provides an actual weight of particulate matter for a given volume of sample (usually mg/l).

TSS are particles that are larger than 2 microns found in the water column. Anything smaller than this is called a dissolved solid. The majority of suspended solids are made up of inorganic materials, although bacteria and algae can contribute to total solid levels. These solids include anything floating through the water such as gravel, silt, sand or clay. Another contributor to TSS is the decomposing of plants and animals meaning small particles break away from the organism becoming a suspended solid in the water. TSS is significant in regards to the aesthetics of the water, as the more suspended solids that are present the less clear the water will become.

Some suspended solids can settle to the bottom of the body of water over time along with heavier particles such as sand and gravel. This is usually present in areas of water that are shallower due to slow water flow. This settling improves water clarity however the increased silt can smother eggs and benthic organism.

TSS is the most visible indicator of water quality. It is considered that clear water is usually considered healthy water. It is especially cause for concern if the water becomes murky in a previously clear body of water. Excessive suspended solids can be cause for concern for aquatic and human life as well as impede navigation and increase flooding risks.

5.3 Biochemical Oxygen Demand

Biochemical Oxygen Demand (BOD, also called Biological Oxygen Demand) is an amount of dissolved oxygen needed (i.e. demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period.

BOD Level in mg/liter	Water Quality
1 - 2	**Very Good:** There will not be much organic matter present in the water supply.
3 - 5	**Fair:** Moderately Clean
6 - 9	**Poor:** Somewhat Polluted - Usually indicates that organic matter present and microorganisms are decomposing that waste.
100 or more	**Very Poor:** Very Polluted - Contains organic matter.

Table 5.2 Water Quality w.r.t. BOD Level

It is a measure of the oxygen required to decompose the organic matter in a body of water over a five-day period at 20°C.In carrying out the test, two ml

bottles are filled with water whose BOD is to be determined. The oxygen content of one is determined immediately by the Winkler method and in the other at the end of five days incubation at 20°C. The difference between the two is the BOD.
Biochemical Oxygen Demand or Biological Oxygen Demand is a measurement of the amount of dissolved oxygen (DO) that is used by aerobic microorganisms when decomposing organic matter in water.

BOD indicates the amount of putrescible organic matter present in water. Therefore, a low BOD is an indicator of good quality water, while a high BOD indicates polluted water. Dissolved oxygen (DO) is consumed by bacteria when large amounts of organic matter from sewage or other discharges are present in the water.

5.3.1 Measurement of BOD

A. Collect the water sample from a pond.
B. Carefully fill a BOD bottle with sample water without making air bubbles.
C. Add 2ml of manganese sulfate to the BOD bottle carefully by inserting the pipette just below the surface of water. So that you can avoid the formation of air bubbles.
D. Add 2 mL of alkali-iodide-azide reagent in the same manner.
E. Close the bottle and mix the sample by inverting many times. A brownish cloud will appear in the solution as an indicator of the presence of Oxygen.
F. Allow the brown precipitate to settle out to the bottom.
G. Add 2ml of Conc.H_2SO_4 carefully without forming air bubbles.
H. Close the bottle and mix the solution well to dissolve the precipitate.
I. Keep the bottle in BOD incubator for 5days of incubation.
J. After incubation, titrate 50 ml of sample water with 0.025N Sodium thiosulphate to a pale-yellow color.

K. Then add 2ml of starch solution. So, the sample turns blue in color.
L. Continue the titration till the sample gets clear and note the readings.
M. The concentration of dissolved oxygen in the sample is equivalent to the number of milliliters of titrant used.

5.3.2 Another way of measurement of BOD

We combine the data rich measurements from our advanced real-time UV-VIS sensors with our custom AI algorithms to develop site specific calibrations for our clients. These custom calibrations enable us to provide real-time detection of parameters, such as BOD, that would traditionally be left to the laboratory.

Our Liquid Ai data analytics services provide ongoing calibration health monitoring to ensure the real-time BOD results are as accurate and predictive of the lab as possible. The service enables continuous calibration improvements to be made as water quality composition changes or new contaminants are introduced. We ensure reliability and trust in the results, so our clients can make confident, informed decisions to improve their plants processes. The longer our systems are installed, the smarter and more insightful they become with our Liquid Ai service.

Figure 5.4 BOD Analyzers

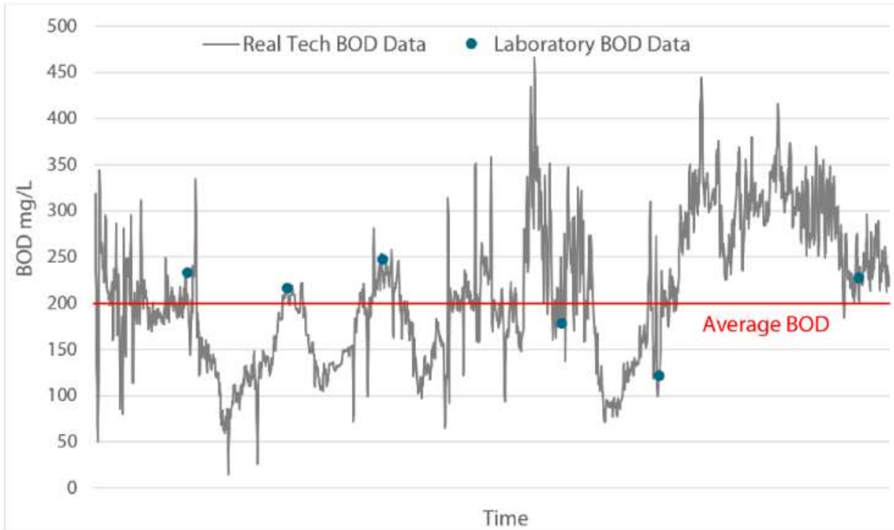


Figure 5.5 Variation of BOD wrt time

If the **BOD** value is **higher than** the solubility of oxygen then this cannot occur and the water remains polluted. This test method oxidizes more organic material **than** the **BOD** test and therefore the **COD** value is always **higher than** the **BOD** value.

5.3.3 **Importance of BOD**

Biochemical Oxygen Demand is an important water quality parameter because it provides an index to assess the effect discharged wastewater will have on the receiving environment. The higher the BOD value, the greater the amount of organic matter or "food" available for oxygen consuming bacteria. If the rate of DO consumption by bacteria exceeds the supply of DO from aquatic plants, algae photosynthesis or diffusing from air, un-favorable conditions occur. Depletion of DO causes stress on aquatic organisms, making the environment unsuitable for life. Further, dramatic depletion can lead to hypoxia or anoxic environments. BOD is also used extensively for wastewater treatment, as decomposition of organic waste by microorganisms is commonly used for treatment.

Regulations for BOD will vary by country and region. In general, maximum allowable concentration for direct environmental wastewater discharge fall around 10 mg/L BOD and maximum allowable concentrations for discharge to sewer systems around 300 mg/L BOD.

5.4 COD - Chemical Oxygen Demand

The total oxygen consumed by the chemical oxidation of that portion of organic materials in water which can be oxidized by a strong chemical oxidant.

It is a more rapid test than BOD, the method can be used for a wider variety of wastes.

Furthermore, when materials toxic to bacteria are present it is perhaps the best method available. Its major disadvantage is that bulky equipment and hot concentrated sulfuric acid are used.

The COD value indicates the amount of oxygen which is needed for the **oxidation of all organic substances** in water in mg/l or g/m^3.

The COD (Chemical Oxygen Demand) is closely related to the laboratory standard method named Dichromate-Method. With this method the chemical oxygen demand is determined during chromic acid digestion of organic loads in waste water. Based on this method the COD became a commonly used sum parameter in waste water analysis. It is used for **planning** of waste water treatment plants, for **controlling** the cleaning efficiency and for the **calculation** of waste water taxes.

The COD test involves a blank, which is a sample made by adding the reagents of acid and an oxidizing agent to distilled water. There is a formula for calculating COD. Consider the formula for COD calculation: (a - b) X C X 8,000 / volume of the sample in ml.

Chemical Oxygen Demand or COD is a measurement of the oxygen required to oxidize soluble and particulate organic matter in water.

5.4.1 How we measure COD in Real-Time

We combine the data rich measurements from our advanced real-time UV-VIS sensors with our custom AI algorithms to develop site specific calibrations for our clients. These custom calibrations enable us to provide real-time detection of parameters, such as COD, that would traditionally be left to the laboratory.

Figure 5.6 Online COD Analyzers

Our Liquid Ai data analytics services provide ongoing calibration health monitoring to ensure the real-time COD results are as accurate and predictive of the lab as possible. The service enables continuous calibration improvements to be made as water quality composition changes or new contaminants are introduced. We ensure reliability and trust in the results, so our clients can make confident, informed decisions to improve their plants processes. The longer our systems are installed, the smarter and more insightful they become with our Liquid Ai service.

5.4.2 Liquid in Action

Our real-time COD data fills the gap between grab samples, so you will never miss an unexpected event again.

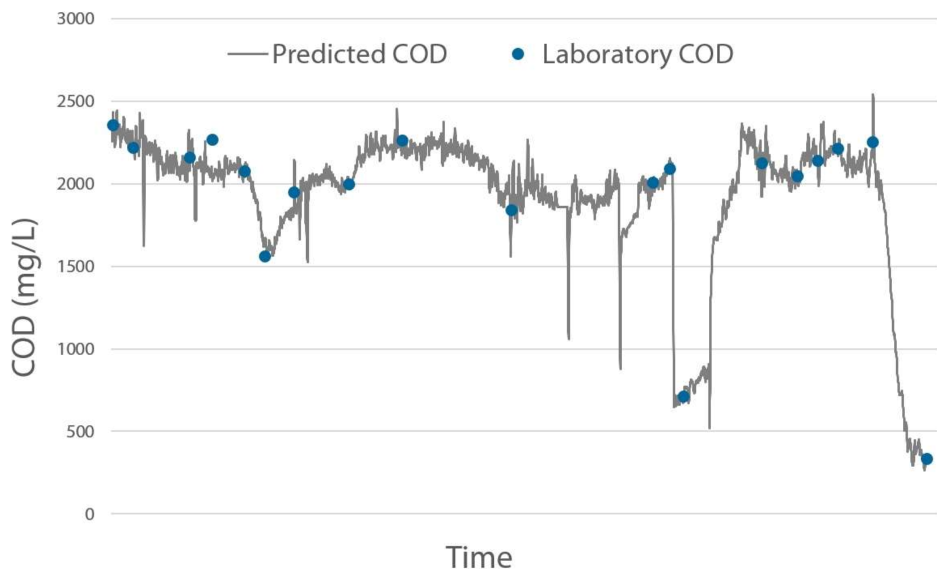


Figure 5.7 Variation of COD w.r.t. time

5.4.3 Importance of COD

Chemical Oxygen Demand is an important water quality parameter because, similar to BOD, it provides an index to assess the effect discharged wastewater will have on the receiving environment. Higher COD levels mean a greater amount of oxidizable organic material in the sample, which will reduce dissolved oxygen (DO) levels. A reduction in DO can lead to anaerobic conditions, which is deleterious to higher aquatic life forms. The COD test is often used as an alternate to BOD due to shorter length of testing time.

5.5 Total Nitrogen

Total Nitrogen (TN) is the sum of nitrate-nitrogen (NO3-N), nitrite-nitrogen (NO2-N), ammonia-nitrogen (NH3-N) and organically bonded nitrogen. Total Nitrogen (TN) should not be confused with TKN (Total Kjeldahl Nitrogen) which is the sum of ammonia-nitrogen plus organically bound nitrogen but does not include nitrate-nitrogen or nitrite-nitrogen.

TN is sometimes regulated as an effluent parameter for municipal and industrial wastewater treatment plants, but it is more common for limits to be placed on an individual nitrogen form, such as ammonia. Treatment plants that have a TN limit will usually need to nitrify and denitrify in order to achieve the TN limit.

Because nitrogen in wastewater can be found in four major forms (excluding trace amounts of nitrogen gas), each major form is generally analyzed as a separate component, with Total Nitrogen calculated from the sum of the four forms.

Nitrogen in freshly polluted water is originally present in the form of organic nitrogen and ammonia. Natural biochemical processes slowly convert the organic nitrogen into ammonia, which is the form of nitrogen best able to be utilized as a nutrient by microorganisms in the treatment process. (Some waste waters may be nitrogen deficient and require supplemental ammonia for adequate reproduction. See Application Summary #95 “Nutrient Balancing”.) Under aerobic conditions the conversion of organic nitrogen into ammonia reaches a peak and, under the appropriate biological conditions, is biochemically oxidized first into nitrite, then into nitrate. When nitrite and ammonia nitrogen are at minimum concentration (at or near zero) and nitrate is at a maximum value, the wastewater has been fully nitrified. A fully nitrified wastewater will have little or no organic nitrogen

5.6 Laboratory Analysis Methods

Measurement of organic nitrogen is difficult due to the need to digest the sample prior to analysis in order to convert the organic nitrogen into a form that is more amenable to analysis. A Kjeldahl digestion converts the organic nitrogen to ammonia but requires collection of a distillate, which is not easily accomplished by an on-line analyzer in the field. The persulfate digestion method oxidizes all nitrogenous compounds into nitrate, but requires heating the sample with a digestion reagent for 30 minutes at 110oc, then cooling to room temperatures before analysis. This is also difficult to automate under field conditions.

5.7 ChemScan Analysis Methods

Because organic nitrogen is a very small component of Total Nitrogen in fully nitrified wastewater effluent, the standard ChemScan method will use the sum of the individual analysis results for ammonia-nitrogen (See Method #4l), nitrate-nitrogen and nitrite-nitrogen. Organic nitrogen can be estimated mainly from the nitrite and ammonia concentration. High nitrite-nitrogen is indicative of incomplete nitrification or denitrification.

Samples should be obtained from intermediate points within the nutrient removal process for control applications. The individual values and trends for ammonia, nitrate and nitrite at intermediate and effluent sample points are far more instructive about the state of the process than the TN value.

Measurement of TN in raw influent wastewater will require analysis of the organic fraction. A rapid UV-persulfate oxidation method could be used for this application, but requires additional cycle time and reagent expense. Raw wastewater samples (especially prior to screens, grit removal, FOG removal and primary clarification) are difficult to analyze and are of questionable value. The Total Nitrogen load on the process is the sum of the soluble organic nitrogen and ammonia contributed by the incoming wastewater plus any nitrogen contributed by the Return Activated Sludge plus the nitrogen from any recirculation flow back from the nitrification stages of the treatment process. The ideal initial sample point for process load estimation is after RAS and recirculation addition to the primary effluent. If denitrification is performed in an initial anaerobic zone, separate measurement of nitrate and nitrite in the influent and effluent to the denitrification zone may be a valuable parameter for process control.

The ChemScan Process Analyzer can accommodate samples with up to 150 mg/l of total suspended solids and turbidity of up to 60 NTU. Samples extracted from points in the treatment process ahead of secondary clarification will typically exceed these solids or turbidity specifications. These samples will require filtration or settling prior to analysis to produce a sample meeting ChemScan solids and turbidity requirements. ChemScan has cross flow membrane filters and porous plastic cyclic filters available for use with on-line analyzer systems. Sample points should be selected to assure that fat, oil and grease (FOG) will be low enough not to interfere with the sample filtration method selected for the analyzer system.

5.8 Oil & Grease

Oil and grease include fats, **oils**, waxes, and other related constituents found in water, generally **wastewater**. If these compounds are not removed before discharge of treated **wastewater**, **oil and grease** can interfere with biological life in surface waters and create unsightly films.

Removal requires chemical addition to lower the pH followed by addition of dissolved oxygen or nitrogen to remove the emulsified oils as they break free from the wastewater. Dissolved Oil is a true molecular solution within the water and can only be removed with biological treatment.

5.9 Ammoniacal nitrogen

Ammoniacal nitrogen (NH3-N), is a measure for the amount of ammonia, a toxic pollutant often found in landfill leachate and in waste products, such as sewage, liquid manure and other liquid organic waste products. The term is used widely in waste treatment and water purification systems.

Nitrification is the most common way to biologically remove ammonia in wastewater lagoons. In this process, ammonia treatment occurs via bacteria already present in the water. These bacteria break down the ammonia and eventually promote the release of nitrogen gas into the atmosphere

5.10 Faecal Coliforms

A fecal coliform (British: faecal coliform) is a facultatively anaerobic, rod-shaped, gram-negative, non-sporulating bacterium. Coliform bacteria generally originate in the intestines of warm-blooded animals. Fecal coliforms are capable of growth in the presence of bile salts or similar surface agents, are oxidase negative, and produce acid and gas from lactose within 48 hours at 44 ± 0.5°C.1 The term "thermotolerant coliform" is more correct and is gaining acceptance over "fecal coliform".

5.11 Importance of Fecal Coliform Testing of Drinking Water.

Total coliform bacteria are a collection of relatively harmless microorganisms that live in large numbers in the intestines of man and warm- and cold-blooded animals. They aid in the digestion of food. A specific subgroup of this collection is the fecal coliform bacteria, the most common member being Escherichia coli. These organisms may be separated from the total coliform group by their ability to grow at elevated temperatures and are associated only with the fecal material of warm-blooded animals.

The fecal coliform group includes all of the rod-shaped bacteria that are non-spore forming, Gram-Negative, lactose-fermenting in 24 hours at 44.5 ° C, and which can grow with or without oxygen.

Fecal coliform by themselves are usually not pathogenic; they are indicator organisms, which means they may indicate the presence of other pathogenic bacteria. Pathogens are typically present in such small amounts it is impractical monitor them directly.

5.12 Environmental Impact:

The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals. At the time this occurred, the source water may have been contaminated by pathogens or disease producing bacteria or viruses which can also exist in fecal material. Some waterborne pathogenic diseases include typhoid fever, viral and bacterial gastroenteritis and hepatitis A. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to this water. Fecal coliform bacteria may occur in ambient water as a result of the overflow of domestic sewage or nonpoint sources of human and animal waste.

5.13 Total Phosphorus

In most lakes, phosphorus is the limiting nutrient, which means that everything that plants and algae need to grow is available in excess (sunlight, warmth, water, nitrogen, etc.) except phosphorus. Ortho-phosphate is the chemically active dissolved form of phosphorus that is taken up directly by plants.

Phosphorus is an essential element for plant life, but when there is too much of it in water, it can speed up eutrophication (a reduction in dissolved oxygen in water bodies caused by an increase of mineral and organic nutrients) of rivers and lakes. A sign of this is excess algae in the lake.

5.14 Safe level of phosphate

The natural background levels of total phosphorus are generally less than 0.03 mg/L. The natural levels of phosphate usually range from 0.005 to 0.05 mg/L. Many bodies of freshwater are currently experiencing increases of phosphorus and nitrogen from outside sources.

The removal of phosphorous from wastewater involves the incorporation of phosphate into TSS and the subsequent removal from these solids. Chemical precipitation is used to remove the inorganic forms of phosphate by the addition of a coagulant and a mixing of wastewater and coagulant.

Chapter 6 RESULTS AND DISCUSSION

Performance Study of 1 MLD Plant has been done. The results given below shows that the water quality we get after the treatment comes in the range of standard parameter set by the government of India and other Organisation like WHO, BIS, ISO etc.

As per the result analysis of treated water, it is observed that the water we are getting could be used for Agriculture/Horticulture or also for Irrigation. Further treatment of this water can also be done, to use this water for human & animal consumption.

Bio filter Conversion (also known as trickling filter technology) effectively treats domestic sewage that's high in organic matter, BOD, COD and other pollutants. This technology is ideal for both small-scale package plants and full-scale wastewater treatment plants and offers highly-efficient solutions that benefit both the environment and communities.

Various types of pollutants can be eliminated by using the bio filtration system. In addition to the filtration effects of quartz sand matrix, bacteria in the bio filter (biofilm) also oxidized the organic materials into simpler compounds, such as water and carbon dioxide 12.The start-up of bio filtration to allow biofilm development was carried out with a relatively high hydraulic retention time and excessive dissolved oxygen at 5-6 mg/L. The retention time was maintained at 8 h (day 0-22) and was reduced to 6 h (day 23-27). the COD removal efficiency during the start-up. The relatively low flow rate enabled the raw water to have a long contact time with the media and an adequate supply of oxygen, and thus speeding up the formation of biofilm on the media. During the first 3 day of operation, the COD elimination rate was relatively low at approximately 30%. After 7 days, the removal efficiency of organic matter increased to 80-90%. The bacterial layers were visually observed on the media, indicating biofilm formation and development. After 18 days of operation, the organic removal efficiency was relatively stable at approximately 90% at this point, a steady-steady condition had been achieved.

TABLE 6.1: Treated Water Quality

Sl. No	PARAMETERS	UNITS	VALUES
1.	pH	s.u.	6.5
2.	TSS	mg/l	20
3.	Ammoniacal Nitrogen	mg/l	5
4.	BOD	mg/l	10
5.	COD	mg/l	50
6.	Total Nitrogen	mg/l	10
7.	Oil & Grease	mg/l	1
8.	Total Phosphorus	mg/l	2
9.	Nitrates	mg/l	10
10.	Faecal Coliforms	MPN/100ml	100

The above result of treated water is noticed in a day which showing the water quality level is up to the acceptable limit. And the water parameter changes as no. of days exceeding.

The below parameter is measured after an interval of **six days**

TABLE 6.2: Treated Water Quality after 6 days

Sl. No	PARAMETERS	UNITS	VALUES
1.	pH	s.u.	7.0
2.	TSS	mg/l	18
3.	Ammoniacal Nitrogen	mg/l	4
4.	BOD	mg/l	8

5.	COD	mg/l	35
6.	Total Nitrogen	mg/l	10
7.	Oil & Grease	mg/l	2
8.	Total Phosphorus	mg/l	3
9.	Nitrates	mg/l	9
10.	Faecal Coliforms	MPN/100ml	98

The below parameter is measured after an interval of **15 days.**

TABLE 6.3: Treated Water Quality after 15 days of Commissioning

Sl. No	PARAMETERS	UNITS	VALUES
1.	pH	s.u.	7.35
2.	TSS	mg/l	15
3.	Ammoniacal Nitrogen	mg/l	5
4.	BOD	mg/l	10
5.	COD	mg/l	30
6.	Total Nitrogen	mg/l	8
7.	Oil & Grease	mg/l	1
8.	Total Phosphorus	mg/l	2
9.	Nitrates	mg/l	7
10.	Faecal Coliforms	MPN/100ml	90

The below parameter is measured after an interval of **20 days.**

TABLE 6.4: Treated Water Quality after 20 days

Sl. No	PARAMETERS	UNITS	VALUES
1.	pH	s.u.	7.25
2.	TSS	mg/l	10
3.	Ammoniacal Nitrogen	mg/l	3
4.	BOD	mg/l	5
5.	COD	mg/l	25
6.	Total Nitrogen	mg/l	5
7.	Oil & Grease	mg/l	3
8.	Total Phosphorus	mg/l	2
9.	Nitrates	mg/l	5
10.	Faecal Coliforms	MPN/100ml	93

The below parameter is measured after an interval of **25 days.**

TABLE 6.5: Treated Water Quality after 25 days

Sl. No	PARAMETERS	UNITS	VALUES
1.	pH	s.u.	7.6
2.	TSS	mg/l	8
3.	Ammoniacal Nitrogen	mg/l	4
4.	BOD	mg/l	10
5.	COD	mg/l	15
6.	Total Nitrogen	mg/l	6
7.	Oil & Grease	mg/l	1

8.	Total Phosphorus	mg/l	2
9.	Nitrates	mg/l	4
10.	Faecal Coliforms	MPN/100ml	85

The below parameter is measured after an interval of **30 days.**

TABLE 6.6: Treated Water Quality after 30 days

Sl. No	PARAMETERS	UNITS	VALUES
1.	pH	s.u.	7.5
2.	TSS	mg/l	10
3.	Ammoniacal Nitrogen	mg/l	5
4.	BOD	mg/l	8
5.	COD	mg/l	15
6.	Total Nitrogen	mg/l	8
7.	Oil & Grease	mg/l	1
8.	Total Phosphorus	mg/l	1
9.	Nitrates	mg/l	3
10.	Faecal Coliforms	MPN/100ml	90

The result analyses of water testing parameters are shown below with the help of tables and graphs.

interval of days	pH value
1	6.5
6	7
15	7.35
20	7.3
25	7.6
30	7.5

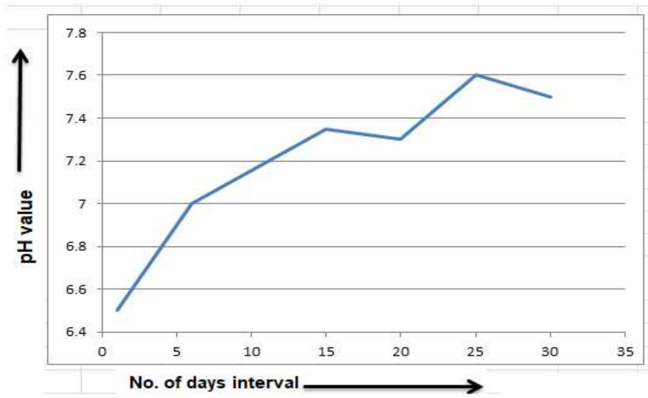


Figure 6.1: pH Value Variation

interval of days	TSS value
1	20
6	18
15	15
20	10
25	8
30	10

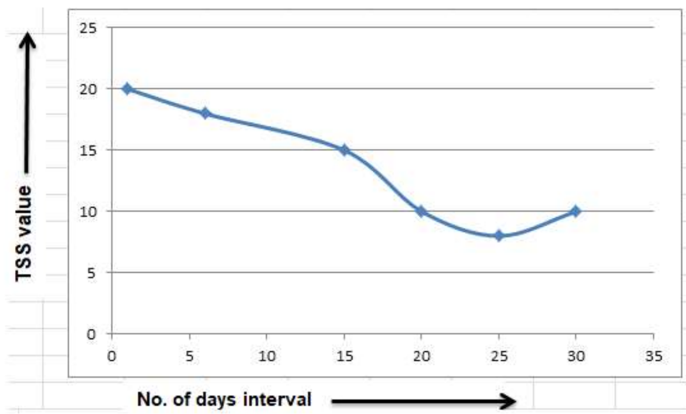


Figure 6.2: TSS Variation

interval of days	Ammonical nitrogen value
1	5
6	4
15	5
20	3
25	4
30	5

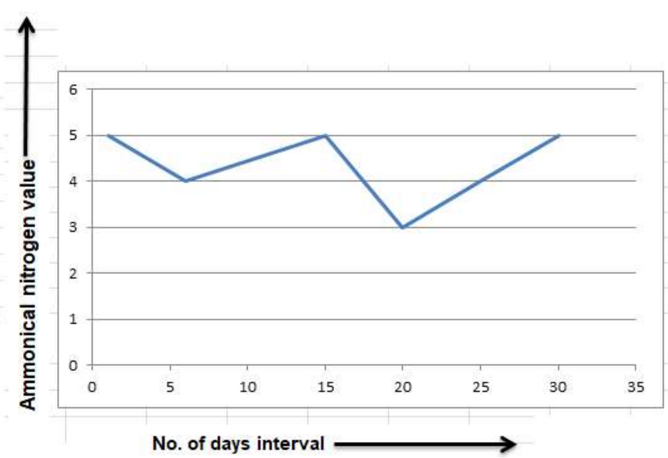


Figure 6.3: Ammoniacal Nitrogen Variation

interval of days	BOD value
1	10
6	8
15	10
20	5
25	10
30	8

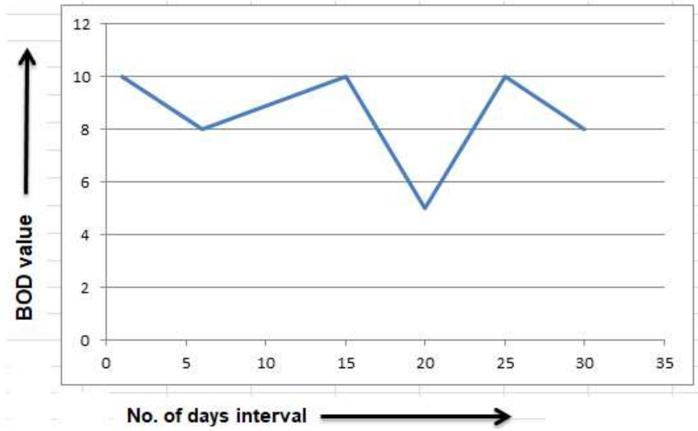


Figure 6.4: BOD Value Variation

interval of days	COD value
1	50
6	35
15	30
20	25
25	15
30	15

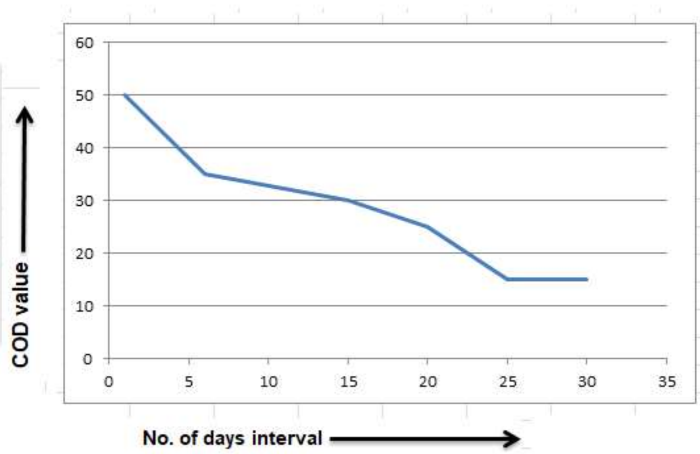


Figure 6.5: COD Value Variation

interval of days	Total Nitrogen value
1	10
6	10
15	8
20	5
25	6
30	8

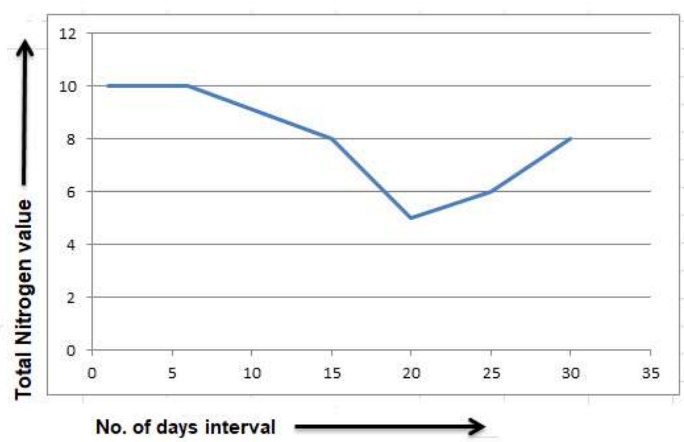


Figure 6.6: Total Nitrogen Value Variation

interval of days	Oil & Grease value
1	1
6	2
15	1
20	3
25	1
30	1

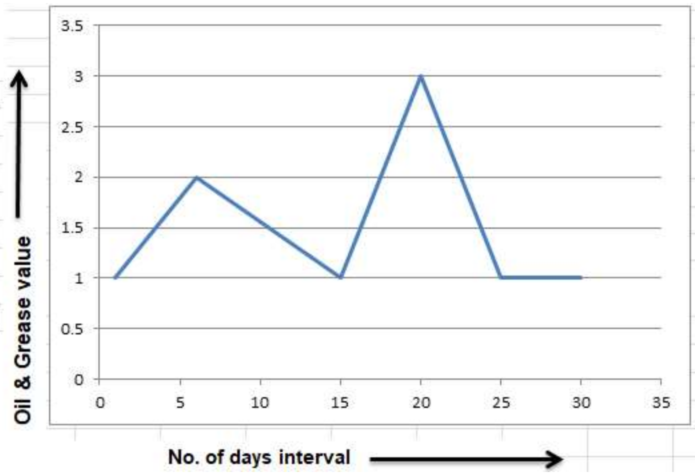


Figure 6.7: Oil & Grease Value Variation

interval of days	Total Phosphorus value
1	2
6	3
15	2
20	2
25	2
30	1

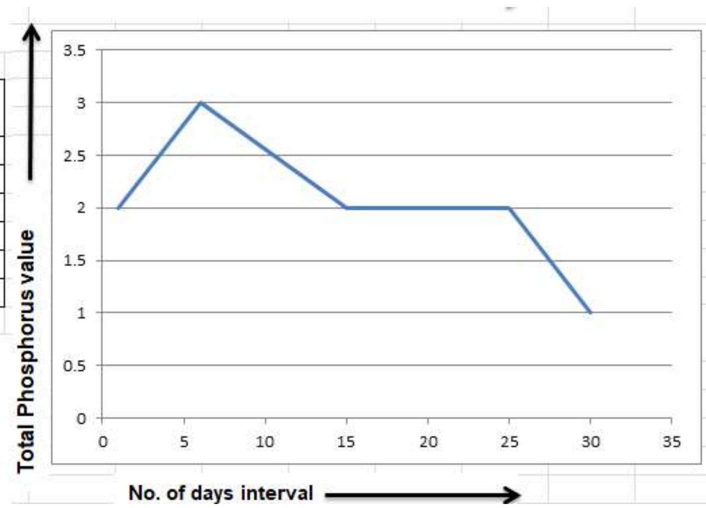


Figure 6.8: Total Phosphorus Value Variation

interval of days	Nitrates value
1	10
6	9
15	7
20	5
25	4
30	6

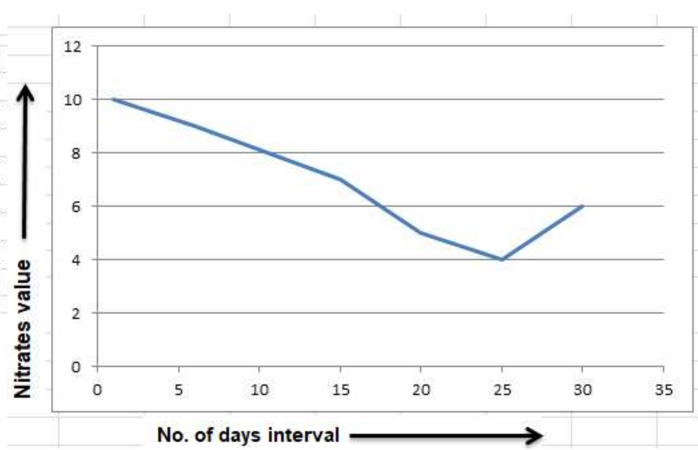


Figure 6.9: Nitrates Value Variation

interval of days	Faecal Coliforms value
1	100
6	98
15	90
20	93
25	85
30	90

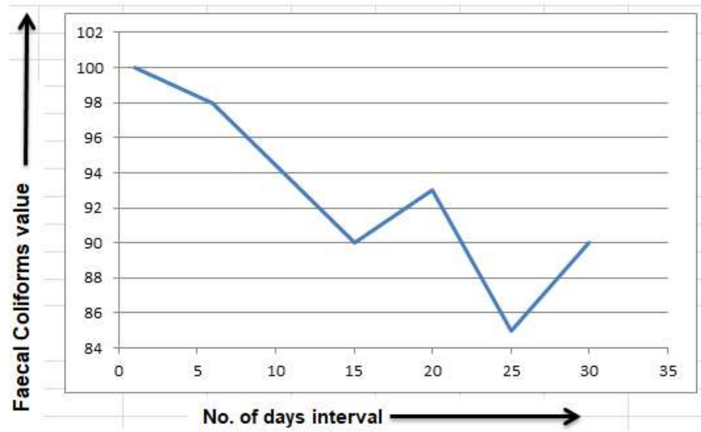


Figure 6.10: Faecal Coliforms Value Variation

Chapter 7 CONCLUSION AND RECOMMENDATION

7.1 Conclusion

Following conclusions are drawn from the study:

i. The centralized approaches to wastewater treatment have had limited success as there is problem in collecting the sewage and transporting to centralized STP and then discharging the treated sewage.

ii. There is a need to make wastewater treatment people-centric and effective through the use of decentralized systems such as DEWATS (Decentralized Wastewater Treatment Systems).

iii. There is a need for capacity building of community institutions and participation by urban local bodies in order to scale up and replicate such innovative approaches in the future.

iv. Decentralized Sewage treatment can be established in an educational institution.

v. Performance of 1 MLD STP based on bio-filter is working efficiently and all parameters are within prescribed limit. Treated sewage BOD is 7 mg/l which is even below 20 mg/l prescribed in standard by DPCC. And again, treated sewage may be reused for horticultural and flushing purposes in the campus.

vi. Treated effluent from 1 MLD, STP is being used for horticulture and recharge of pond in the campus.

7.2 Recommendation

The following recommendations are made from the study:

i. Decentralized STPs may be used for treating the sewage which saves energy for transportation and reuse of treated sewage is easier which reduces the water requirement/ demand.

ii. Further research and development of the bio-filter process for treatment of polluted water as raw water for the drinking water supply is still required to optimize these advantages, including testing the stability of the system against shock load, process optimization, and a comprehensive techno-economic analysis.

iii. The recommendations were suggested for future studies that many selective media with low density, high internal porosity and based chemical composition must be tested to investigate the hydraulic behaviour of bio-filtration wastewater systems.

iv. STP based on biofiltration can be used for academic Institution as Decentralised waste water treatment system.

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Annexure-I

Test Lab Report of STP (DPCC)

WATER LABORATORY

DELHI POLLUTION CONTROL COMMITEE
4TH FLOOR, ISBT BUILDING, KASHMERE GATE, DELHI-110006
visit us at http://dpccocmms.nic.in

Result No- DPCC/Comm/W/2216/ 656 14/08/2019 **Date:13/08/2019**

LAB REPORT

1.	Name & Address of Unit	:	M/s.Delhi Technological University Shahbad Daulatpur Bawana Road New Delhi Delhi-110042
2.	Sampling Location	:	STP Outlet
3.	Date of sampling	:	30/07/2019
4.	Sample collected by	:	DPCC Lab
5.	Control Measure (if any)	:	STP
6.	Nature of sample	:	Grab
7.	Nature of Industry	:	Shopping Malls, Housing / Commercial/ Office Complexes having built up area 20,000 sqm and above

8. Parameter analyzed and result

S. No.	Parameters	STP Outlet	Prescribed Standard
1	pH	7.2	5.5-9.0
2	Total Suspended Solids (TSS)	8	30.0
3	Oil and Grease	0.8	10.0
4	Dissolved Phosphate (as P)	0.6	5.0
5	Chemical Oxygen Demand(COD)	24	250.0
6	Nitrate Nitrogen	1.1	10.0
7	Bio-Chemical Oxygen Demand(BOD)[3 days at 27°C]	7	20.0
8	Ammonical Nitrogen	2.1	50.0

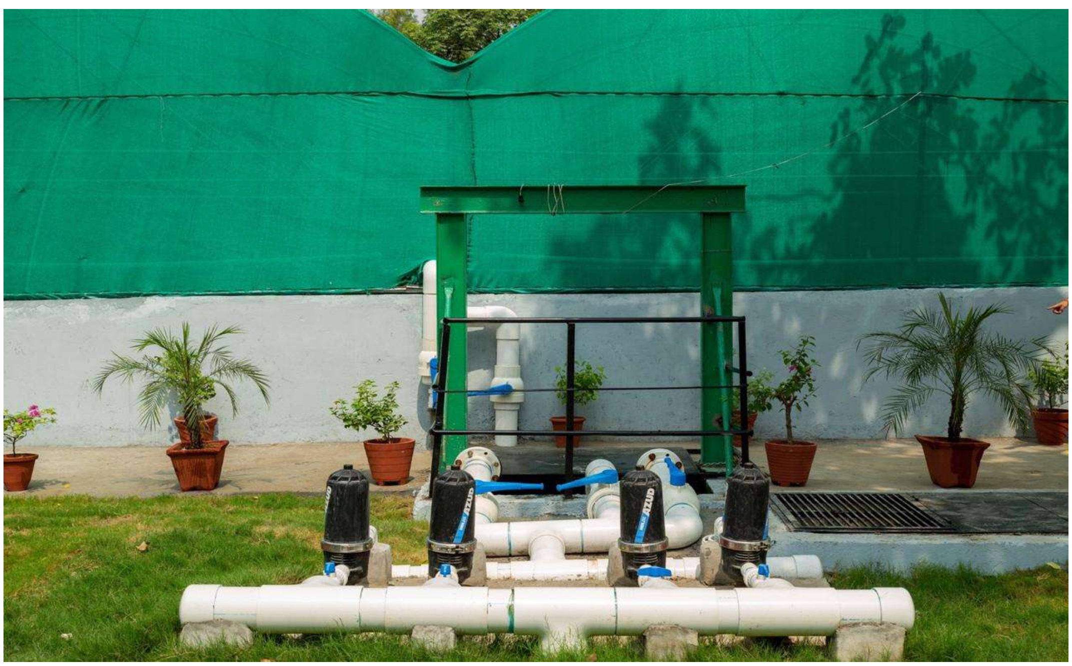
***All parameters are in mg/l except pH**

Dr Nandita Moitra
I/C Water Laboratory
Dr. NANDITA MOITRA
Scientist 'C'

Scientific Assistant

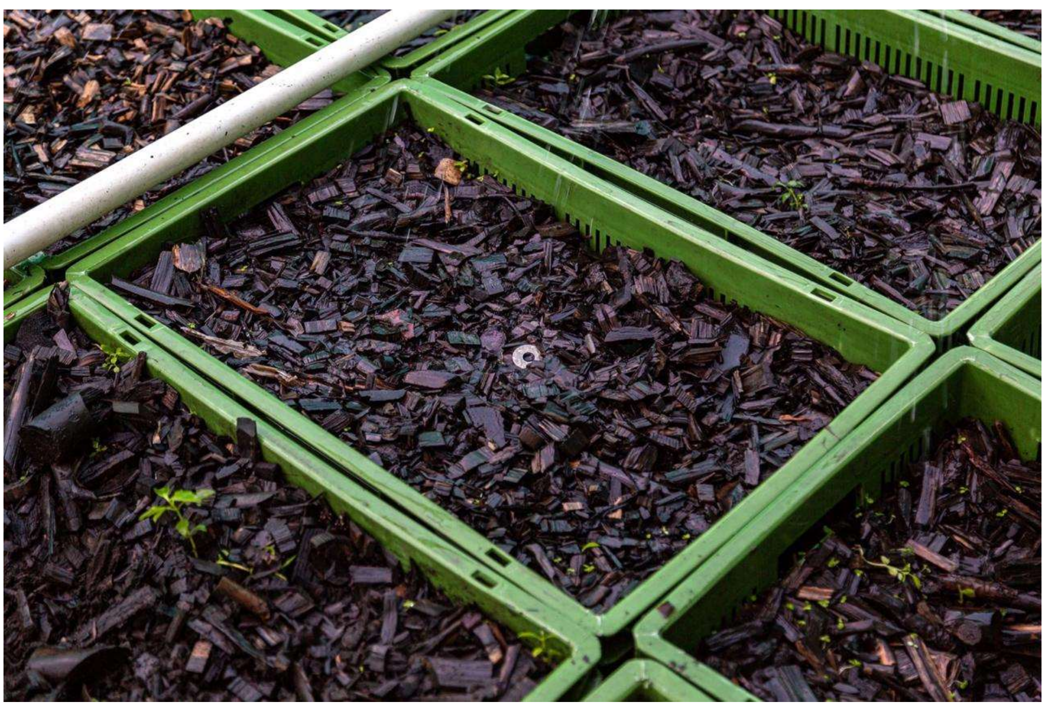
PICTURES

Picture-1 Sewage Treatment Plant at DTU



Picture-2 Strainer

Picture-3 Sprinklers

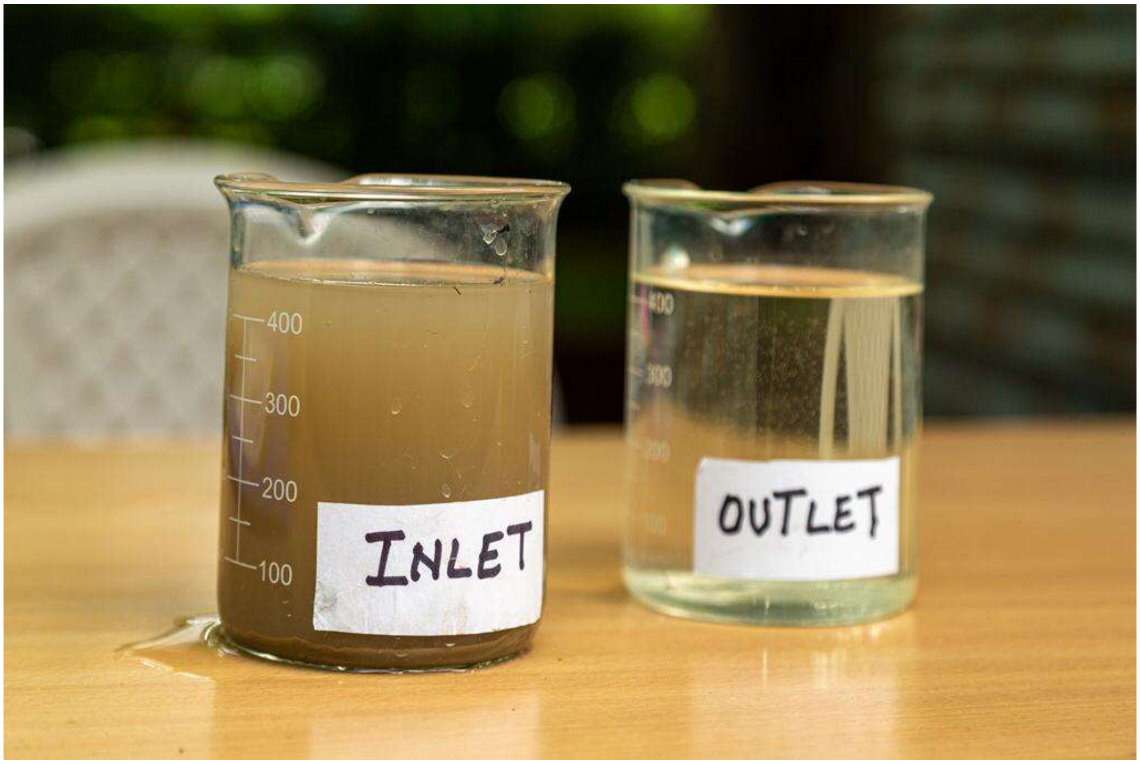


Picture-4 Organic Media- Popular Wood Chips

Picture-5 Earthworms

Picture-6 Ozonator System for Effective Disinfection

Picture-7 Testing pH on portable pH meter



Picture-8 Inlet and Outlet Sample

Picture-9 Inauguration of STP by Hon'ble Deputy Chief Minister & Education Minister, Delhi

Vitae

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