Performance Evaluation & Strategic Analysis of Water Quality for Wastewater Treatment Plant: A Sustainable Study of Cadbury Gwalior

ABSTRACT

The chocolate company is one of the most polluting food companies regarding its large water consumption. Due to the increased demand of chocolate, the chocolate companies in India are expected to grow rapidly and have waste generation & some relevant environmental problems are also assumed increased. Improper treated wastewater with the very increased level of pollutants can be caused by some improper design, process and operation or treatment systems create main environmental hurdles when these are discharged to the surface land or water. Considering the above included implications a good try has been done in this project to evaluate one of the Effluent Treatment Plant for chocolate wastes. The samples are collected from the various points to evaluate the performance of Waste Water Treatment Plant. Main parameters analysed for evaluation of performance of Effluent Treatment Plant are pH, TDS, TSS, Chloride, Oil & Grease, COD, and BOD. The pH, TDS, TSS, Chloride, Oil & Grease, COD and BOD removal efficiency of Effluent Treatment Plant were 33.47 %, 33.88 %, 90.09 %, 70.37 %, 97.39 %, 97.28% and 99.23% respectively.

Keywords: Performance evaluation, Effluent treatment, Wastewater characteristics, Removal efficiency.

INTRODUCTION

Fast growth of the companies has not only increased the productivity but also resulted in production and release of various toxic matters into the environment, creating the health problems and effected normal operations, plants & animals. These matters are potential pollutants when they result harmful effects on the environment and generally released in the form of liquid effluent, solids and slurries, containing a spectrum of organic & inorganic chemicals. So now the pollution is a necessary evil of all development. To deal with the plethora of environmental problems of present era society, efficient & environmentally safe organic waste treatment technologies are needed.

Like other companies that have serious waste removal hurdles, the chocolate based food company is faced with the prospect of having to erect a large number of relatively small treatment plants. Liquid effluent from chocolate based food company consists environmental hurdles like air, water & soil pollution. Oil & grease in wastewater generated from chocolate based food company consists a main threat to the environment considering the project demand by 2020 A.D., the chocolate based food company in India is expected to grow very fast and have the wastewater generation & some relevant environmental hurdles are also assumed increased. Improper treated wastewater with increased levels of the pollutants caused by some improper design, process, operation or treatment systems creates main environmental problems when discharge to the surface water or land.
Such main problems are as following:

- Contamination & deoxygenating of the streams & waterways by the direct run off of the improper treated wastewater.
- Some excessive concentration of the nutrients such as N & P in surface and subsurface of the water bodies. This contributes to the excessive growth of the plants and blooms, which makes downstream water unhealthy for the field, domestic, agriculture and industrial use.
- Land degradation & damage to the pastures & some crops. Long term damaging of soil may arise from
- Excessive nutrient
- Increased salinity
- Low / High pH
- Extra application of the wastewater to the land results in polluted water
- Soil structure declines due to the waste water with increased Na Adsorption Ratio
- Clogging of the soil by fats or solids from irrigated waste water.

In this study a try has been made to evaluate the WWTP provided for the treatment of the wastewater produced by the chocolate based food company. This study was limited to performance evaluation & strategic water quality analysis of the WWTP of chocolate based food company.
Characterization of the wastewater from various units of processing plant and different management strategies are not studied.

Cadbury is expanding its Gwalior plant capacity to cope up the additional requirement from the market. This additional requirement of water & waste water facility is being achieved by the proposed WTP & ETP respectively.

Industrial wastes from chocolate production contain chocolate solids in more or less dilute in condition, but in some varying concentration. These solids enter the wastes from almost all of the operations.
The wastes generated from the chocolate based food company are as following-
1. The washing & cleaning of product which remain in the tank, trucks, cans, piping & other equipment is performed routinely after each production cycle.
2. Spillage is also produced by the leaks, overflow, boiling, equipment malfunction or few manual careless handling.
3. Processing involves:
   - Sludge discharge from the clarifiers
   - Product wasted during the pasteurized start-up, shut-down & product change
   - Evaporator entrainment
   - Discharge from bottles & washers
   - Splashing & container breakage in the packaging equipment
   - Product change-over in the filling machines.
4. Spoiled products, returned products or by-products.
5. Detergents and some compounds are also used in the washing & sanitizing solutions whcih are discharged as waste.
6. Use of lubricants from conveyors, stackers & other equipment appear in the wastewater from the cleaning processes.
7. Normal routine operation of utilities like toilets, washrooms and canteens facilities at the plant contribute waste.
8. Waste constituents may contain the raw water which ultimately goes to waste.
9. Non-Choco ingredients (like sugar, flavor, nuts & fruit juice) used in certain processed products.

   Uncontaminated water from the coolers & refrigeration systems, which does not come in direct contact with the product, is not considered as process wastewater. Such water is recycled in different plants. Sanitary sewage from the plant employees and domestic sewage from the washrooms and canteens is usually disposed of separately from process wastes and represent a load of the plant.

REVIEW OF LITERATURE

1. Wastewater from the Chocolate based Food Company and Treatment

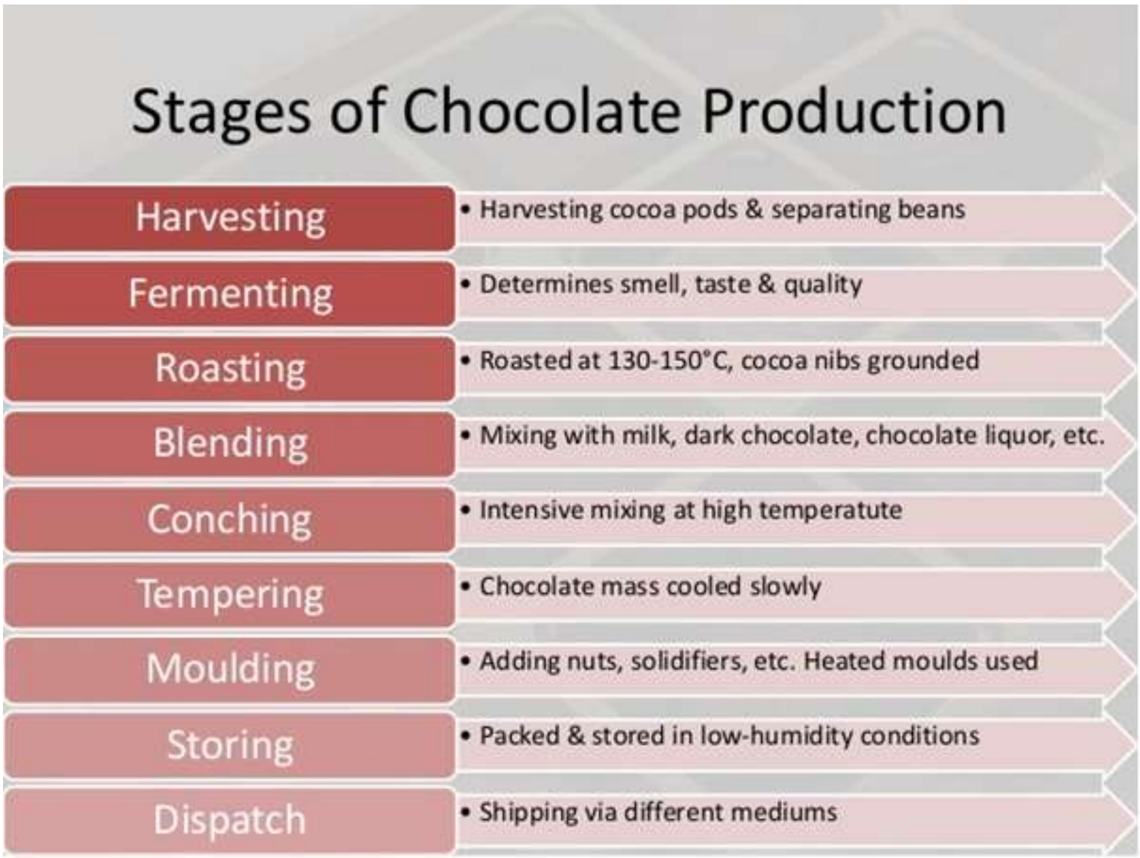
1.1. Operation of Chocolate based food company-

Chocolate production is a highly technical and computerized process, with much of the new specialist machines being produced to the design with speciality.

Production starts from the cocoa factories where the high quality cocoa beans are processed to make the cocoa mass - which consists 54% cocoa & cocoa butter - the basis for all products of chocolate. When the chocolate is produced, that 'mass' goes to the factories.
Fresh & full cream milk is first collected and then condensed and transported to those factories. After that sugar is added to the condensed milk with cocoa mass, makes a rich creamy chocolate fluid, which is evaporated to make the milk chocolate crumb. As the ingredients are cooked, a special rich and creamy taste of the Cadbury chocolate is produced.

At chocolate factory, that crumb is passed through a pin mill and then mixed with the cocoa & cocoa butter, also with special chocolate flavour. Amount of the emulsifiers added actually depends on consistency of the chocolate needed. Thick chocolate is needed for the moulded blocks, while thinner consistency is needed for assortments & covering bar.
Milk & dark chocolate undergo same final & special production stages, like - refining, conching & tempering - which produce the famous smoothness, gloss & snap of the Cadbury chocolate.
Conching includes the mixing and beating the semi-liquid mixture of chocolate to develop a flavour, removing the unwanted volatile flavour and reducing its viscosity & size.

Another stage tempering is a final crucial and very complex stage which includes mixing & cooling the liquid chocolate in controlled conditions to ensure that the fat in the chocolate crystallises in its most stable form. Very complex machinery has been developed for this important process. Tempered chocolate is then used in so many ways to produce the famous brand.
Blocks of the solid chocolate, including the bars with some added ingredients such as nuts & raisins, are very well known in company as 'moulded' products. Tempered chocolate is then poured into bar-shaped moulds, shaken & cooled. After that the moulded blocks continue to high speed wrapping plants.
Figure 1 is showing the main operations for processing of the famous chocolate products.



Stages of Chocolate Production

Harvesting	• Harvesting cocoa pods & separating beans
Fermenting	• Determines smell, taste & quality
Roasting	• Roasted at 130-150°C, cocoa nibs grounded
Blending	• Mixing with milk, dark chocolate, chocolate liquor, etc.
Conching	• Intensive mixing at high temperatute
Tempering	• Chocolate mass cooled slowly
Moulding	• Adding nuts, solidifiers, etc. Heated moulds used
Storing	• Packed & stored in low-humidity conditions
Dispatch	• Shipping via different mediums

Figure 1: A composite flow diagram of the major operations for processing of the common chocolate products.

Characterization of Wastewater generated from chocolate based food company

The major pollutants in the wastewater discharges form Chocolate based food company are: Organic matter (BOD, COD), Suspended Solids (TSS, TDS), pH, Oil & grease, Chloride etc.

The organic matters in chocolate waste waters are contributed mainly by the chocolate and chocolate products wasted and to a much lesser degree, by cleaning some products, sanitizing the compounds, lubricants & domestic sewage which are discharged to the stream.

The inorganic substances of the chocolate wastewaters have been much less attention as sources of pollution than the organic wastes because the product manufactured is edible matter which do not contains hazardous quantities of inorganic substances. However, the non-edible materials used in process, do contain the inorganic matters which by themselves, or added to the chocolate products & the raw water, potential pose a pollution hurdle. Such inorganic matters include phosphates (which are used as deflocculates & emulsifiers in some cleaning compounds), chlorine (which are used in detergents & some sanitizing products) and nitrogen (which are contained in wetting agents & some sanitizers). Table 1 show the characterization of design feed water and Table 2 show the characterization of treated water.

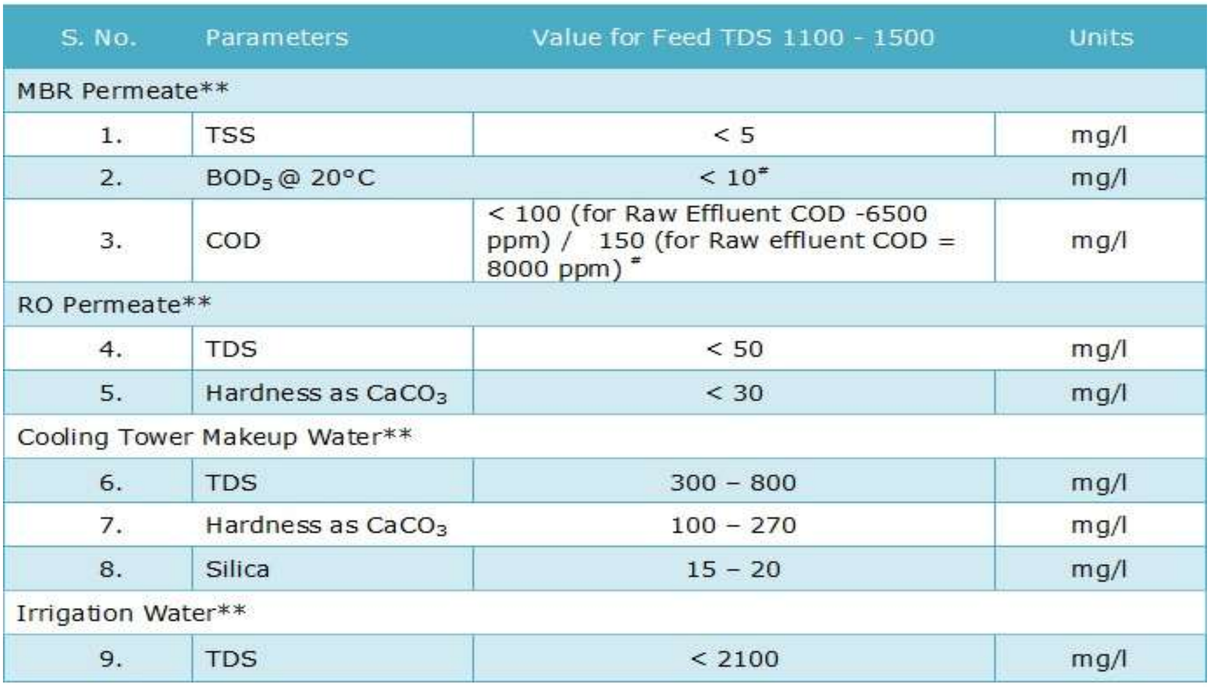
1.2 Design Feed Water- The plant is designed for following water analysis.

Table 1: characterization of design feed water

S.No.	Parameters	ETP Feed Value	units
1.	pH	4.0 – 11.0	mg/l
2.	Temperature	25	° C
3.	Free Oil	< 50	mg/l
4.	Emulsified Oil	< 150	mg/l
5.	TSS	< 1100	mg/l
6.	COD	6500 ± 20% *	mg/l
7.	BOD	3000	mg/l
8.	Ca as CaCO3	< 375	mg/l
9.	Mg as CaCO3	< 125	mg/l
10.	Na	< 265	mg/l
11.	So4	< 375	mg/l
12.	Cl	< 600	mg/l
13.	Iron	< 0.5	mg/l
14.	Reactive Silica (as SiO2)	< 25	mg/l
15.	Bicarbonate	< 30	mg/l
16.	TDS	< 1500	mg/l

1.3 Treated Water Quality- The following is the treated water quality desired from the plant with above feed water quality mentioned.

Table 2: characterization of treated water



S. No.	Parameters	Value for Feed TDS 1100 - 1500	Units
MBR Permeate**			
1.	TSS	< 5	mg/l
2.	BOD$_5$ @ 20°C	< 10$^{\#}$	mg/l
3.	COD	< 100 (for Raw Effluent COD -6500 ppm) / 150 (for Raw effluent COD = 8000 ppm) $^{\#}$	mg/l
RO Permeate**			
4.	TDS	< 50	mg/l
5.	Hardness as CaCO$_3$	< 30	mg/l
Cooling Tower Makeup Water**			
6.	TDS	300 – 800	mg/l
7.	Hardness as CaCO$_3$	100 – 270	mg/l
8.	Silica	15 – 20	mg/l
Irrigation Water**			
9.	TDS	< 2100	mg/l

1.4 Wastewater treatment technologies for Chocolate based Food Company

Wastewater of Chocolate based food company includes following options

- Treatment to a suitable standards for its reuse or recycling
- Discharge to local sewers under the trade waste agreement
- Proper treatment and its land discharge wherever environmentally beneficial

Best process for wastewater systems is shown in Figure 2.

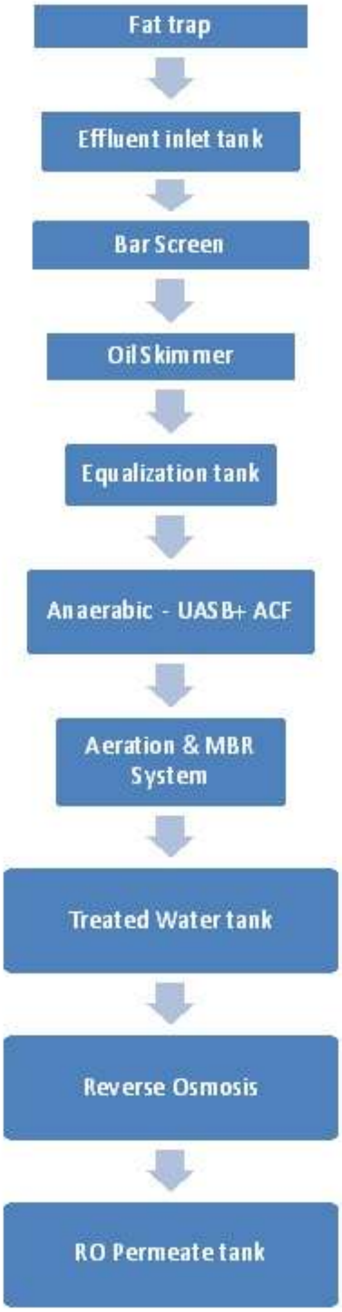


Figure 2: Process Flow Diagram

DESIGN SUMMARY

1.4.1 Plant Capacity

The plant is basically designed to treat 900 m3/day of influent Waste water from the plant. The tertiary plant is designed to handle 600-650 m3/day of effluent range. Capacity of different units offered for the plant is as per the listed details:

1.4.2 Anaerobic Contact Filter (ACF): The Equalized effluent of 450 KLD is properly treated in the Existing ACF system.

1.4.3 Up flow Anaerobic Sludge Blanket (UASB) system: The Remaining 450 KLD equalized effluent is treated in a new UASB system

1.4.4 MBR System: The Aeration system is designed mainly for the total 900 KLD effluent. In addition to the existing aeration tanks, one aeration tank is proposed for the additional capacity. The MBR system is designed for two numbers of 50% capacities each.

1.4.5 RO System: The RO system is designed for (partial feed from total MBR permeate produced) of 330 m3/day for 20 hours operation.

PROCESS DESCRIPTION

Primary treatment: The effluent is first collected in the inlet chamber and fed with the pumps to the bar screen chamber & oil skimming tanks for the suspended particle and oil reduction is collected in the buffer tank and transferred to Equalization tank for further process of homogenization & treatment of effluent.

In some more recent schemes, employing activated sludge treatment and bio filters, initial settlement has been eliminated to get surety that aerobic conditions are maintained all times. (Metcalf and Eddy, 2003)

Equalization tank: The collected effluent is mixed and pH correction is done using the Caustic / Acid dosing. The Equalized and Neutralized effluent is pumped to the existing anaerobic contact filters & Proposed UASB units respectively.

Secondary Treatment or Biological treatment

There are mainly 2 types of biological wastewater treatment systems; aerobic and anaerobic systems. In view of high BOD load in the wastewater from chocolate based food company, aerobic processes (for low organic load) and anaerobic processes (for high organic loads) are adopted for the treatment of wastewater from chocolate based food company.
The selection of processes for any particular plant depends upon the size of the problem, location of the plant and the necessary degree of treatment.

Anaerobic Treatment (Existing ACF and UASB):

ACF - The ACF system is designed with anaerobic contact filter (ACF), which is having anaerobic Media to facilitate the attached growth of the anaerobic micro-organisms. The existing system is designed to handle 450 KLD flow and it will perform at minimum of 75% COD & 80% BOD reduction at all times to facilitate the further aerobic treatment without affecting the outlet guarantees for individual downstream units.

UASB - Up flow Anaerobic Sludge Blanket system (UASB) the anaerobic micro-organism form a sludge blanket to degrade the organic content. UASB system not requires any media. The supernatant is transferred to the aeration tank by gravity.

The Anaerobic treatment in the form of UASB using for the Better reduction of high BOD and COD levels for Influent. In the up flow anaerobic sludge blanket (UASB) reactor wastewater is directed to the bottom of the reactor where it rises upward, a combination of inoculated media and adequate retention time initiates the organic degradation, this results in generation of sludge and formation of sludge blanket that floats on the top level of the reactor.

The wastewater flows upward through a blanket of biologically formed granules, which consume the waste as it passes through the blanket. Methane and carbon dioxide gas are generated and the bubbles rise and are captured in the gas dome at the top. The gas collected from the hoods flow and transferring to the Gas Holding Tank. The upward velocity and the flow maintaining as per the requirements of the system. Because of the low synthesis rate of anaerobic microorganisms, the excess sludge that must be disposed of is minimal.

The UASB system comprise the following

- Bottom distribution system
- GLSS Device
- Gas collection system

- UASB Reactor:
- Up-flow Anaerobic Sludge Blanket reactor is provided for anaerobic treatment of dairy effluent. The UASB reactor constructed in RCC. The reactor consists of three zones viz. Influent distribution zone, Reaction zone, Gas solid liquid separation zone.
- Influent Distribution zone: The raw wastewater enters from the bottom through influent distribution zone. A sophisticatedly designed piping network is provided for uniform distribution of the effluent in the tank. The effluent then travels upward in the reactor.
- Reaction Zone: In the reaction zone the anaerobic bacteria are maintained in the form of sludge blanket. The organic matter in the wastewater comes in contact with the bacterial population and is degraded anaerobically to methane rich biogas, the end product of anaerobic digestion. The process of conversion of organic matter in to the biogas is a two-stage process. In the first stage the organic matter in the raw effluent is converted in to the volatile acids by acid forming bacteria. In the second stage the acid produced in the first stage are converted in to methane by another group of bacteria i.e. methane formers. In UASB process both the stages are completed in single reactor. The biogas so produced is

bubbled through the effluent and is separated out in the third section i.e. Gas-Solid-Liquid separation zone. The suspended solids are also separated to prevent escape of solids from the reactor.

- Gas-Solid – Liquid Separation: In gas solid liquid separation a hood fabricated in M S and duly painted with corrosion resistant paint is provided. The hood separates the solid from the overflowing reactor content. Gas collectors are provided for collection and conveyance of gas. The treated effluent overflows through a launder and will take to a secondary treatment.

- Biogas Holder
- Biogas collecting at the top of the reactor and keeping store in a gasholder separately constructed. Biogas holder is fabricated in MS plated as floating type. RCC Wet well provided to accommodate the MS dome. Biogas from biogas holder will be compressed and sent to boiler for burning or to the Flare stack to flare the excess biogas.
- Aeration Tank The anaerobically treated effluent feeding to the fine screen chamber for screening before entering into the aeration tank for the further degradation of organic matter with help of aeration. The total combined outlet of ACFs & UASB unit out let water feed to three Aeration tanks by gravity. Diffused aeration system with fine bubble diffusers is using for the biological oxidation of effluent instead of conventional surface aeration from energy conservation point of view.

MBR: Membrane bioreactor (MBR) is a basically new wastewater treatment technology which focuses on exceptional treatment efficiency and a reduced footprint when compared to the conventional treatment processes.

- MBR is an activated sludge process by a membrane separation process. The MBR system operating without any primary clarification, before MBR the fine screening (3 mm or smaller) generally to protect the membranes from the waste components. Due to the presence of various absolute barriers for the suspended solids, MBR is able to maintain a high solid concentrations (7000-10000 mg/L) and solid retention times which allow for smaller aeration basins & high BOD removals.
- Because MBR effluent is micro- or ultra- filtration permeates, the effluent suspended solids are generally near the detection limit & turbidity are generally less than 1 NTU.
- So MBR is typical process of suspended growth biomass with micro or ultra-filtration system which rejects particles. We recirculate major portion of the sludge from the MBR to the aeration tank to mainly maintain the MLSS levels and some amount of biomass will be wasted as Waste Activated Sludge.
- Sludge Dewatering System: The sludge then generated from Aeration Process collected in a Sludge Holding Tank. This sludge treading with the sludge conditioning & feeding process to the Filter Press for Solid –Liquid separation. The filtrate water recycling back into the system. The dried sludge cake which is obtained from Filter Press disposes as per PCB norms.

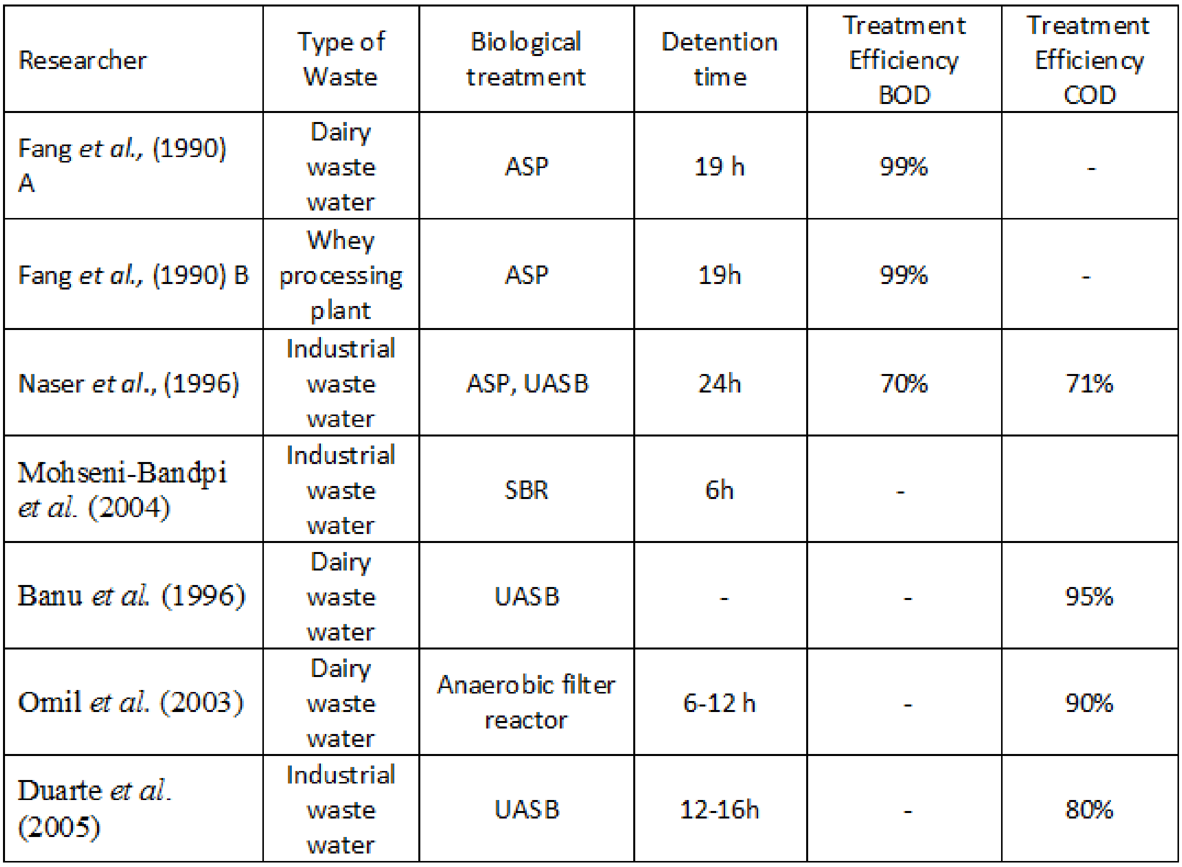
Reverse Osmosis System (RO system): The total dissolved solids can be reduced by Ion Exchange or Membrane process. Membrane based system known as more specifically as RO system because of its compatibility, purity, durability, rigidness for different water quality & environmentally friendly.

- Osmosis is a natural process, which takes place when 2 solutions of different concentrations are separated by semi permeates membrane. Under such condition, the pressure is generated which forces the solvent through the membrane from dilute to concentrate. This movement of pure solvent is known as osmosis and the pressure at which it happens is called osmotic pressure. When the pressure is applied gradually to concentrated solution a stage is reached when there is no flow of solvent through the membrane and as we apply excess pressure the pure solvent starts flowing through the membrane from concentrate solution to the dilute solution. This movement of solvent separation from the concentration solution is known as reverse osmosis.
- RO technology includes a high pressure pump to force a portion of the feed water through semi-permeable membrane. The amount of permeate product water produced varies with the feed water pressure and the temperature. Since the bulk of the product water contaminants are left on the feed water upstream side of the membrane and would over time, foul or scale the membrane, a portion of the feed water is directed to drain or other use. This stream is called concentrate, and the amount of the concentrate needed varies with the amount and type of the contaminants in the water. Each specific feed water source will have a max recovery rate or conversion which is determined by on-site and lab analysis, for such application the conversion rate will be 78% with 20% of the feed water being rejected to drain.

Figure 3: RO System

The performance of RO membrane system is continuously controlled online by different instruments such as Pressure gauge, Flow Indicators, pH analyser & Conductivity Indicators. These parameters will help to trend the RO performance against the Inlet water quality and result the health of RO system.

Table 3: Biological treatment of wastewater from food company (Source- Rao & Datta, 2012)



Researcher	Type of Waste	Biological treatment	Detention time	Treatment Efficiency BOD	Treatment Efficiency COD
Fang *et al.,* (1990) A	Dairy waste water	ASP	19 h	99%	-
Fang *et al.,* (1990) B	Whey processing plant	ASP	19h	99%	-
Naser *et al.*, (1996)	Industrial waste water	ASP, UASB	24h	70%	71%
Mohseni-Bandpi *et al.* (2004)	Industrial waste water	SBR	6h	-	
Banu *et al.* (1996)	Dairy waste water	UASB	-	-	95%
Omil *et al.* (2003)	Dairy waste water	Anaerobic filter reactor	6-12 h	-	90%
Duarte *et al.* (2005)	Industrial waste water	UASB	12-16h	-	80%

Both aerobic & anaerobic processes have been used by different researchers for the treatment of wastewater from Food Company. These are showed in Table 3. Lab scale aerobic treatment of waste water by three stages of ASP, investigated by Fang and Herbert (1990). The average BOD5 of 1060 mg/L and an average TKN of 109 mg/L within overall retention time of 19.8 h, the final effluent contained 9mg/L of BOD5 and 10 mg/L of TKN, corresponding to respective reduction of 99% and 91%. Treatment of the wastewater from whey processing plant using the ASP and anaerobic process was investigated by Fang and Herbert (1990). He found ASP was more efficient in removing BOD5. ASP removes 99% of BOD5 as compared to 87% by anaerobic reactor. The chemical–biological treatment was carried out on food wastewater using ASP, TF and UASB by Nasr *et al.* (1996). ASP removed 64% of VOM, 71% COD and 70% BOD5. 90% of VOM was removed by TF. Removal of COD and BOD by UASB was found to be 97% & 96% respectively.

A bench scale aerobic SBR was investigated by Mohseni-Bandpi *et al.* (2004) to treat food wastewater. Easy operation low cost and minimal sludge bulking condition make the SBR system an interesting option for the biological medium strength industrial wastewater treatment. The study demonstrated the capability of aerobic SBR for the COD removal from company wastewater. The reactor was feed with factory and synthetic wastewater under the different operating conditions. The highest COD removal efficiency was more than 90% and the sludge settling properties for factory wastewater were obtained at high sludge (20 days) and aerated period 6 hrs. (Sushil Kumar, 2007)

The study done by Banu *et al.* (1996) targeted to treat the wastewater by using the anaerobic photocatalytic oxidation treatment. The optimum pH and catalyst loading for solar photochemical oxidation was found to be 5 and 300 mg/L, respectively. The secondary solar photocatalytic oxidation using TiO2 removed 62% of the COD from primary anaerobic treatment. Integration of the anaerobic & solar photocatalytic treatment resulted in 95% removal of COD from the dairy wastewater. The findings suggest that anaerobic treatment followed by the solar photocatalytic oxidation would be a promising alternative for treatment of dairy wastewater and solar photocatalytic oxidation methods. The anaerobic treatment was carried out in a laboratory scale hybrid up flow anaerobic sludge blanket reactor (HUASB) with a working volume of 5.9 L. It was operated at the organic loading rate (OLR) varying from 8 to 20 kg COD/m3 day for a period of 110 days. The maximum loading rate of anaerobic reactor was found to be 19.2 kg COD/m3 day and corresponding chemical oxygen demand (COD) removal at this OLR was 84%. The anaerobically treated wastewater at an OLR of 19.2 kg COD/m3 day was subjected to the secondary solar. (Arceivala *et al.*, 1980)

Omil *et al.* (2003) found anaerobic filter (AF) reactor, the performance for the treatment of complex food wastewater. A full scale up plant which comprising of 12m3 anaerobic filter (AF) reactor and a 28 m3 sequential batch reactor (SBR) was used. The organic loading rates maintain in the AF reactor were 5-6 kg COD/ m3.d, with the COD removal being higher than 90%. The effluent of the AF reactor was successfully treated in the SBR reactor, and final effluent with COD content below 200 mg/L and the total Nitrogen below 100mgN/L was obtained.

Duarte *et al*. (2005) concluded the possibility of using the flocculated sludge in UASB reactors for the treatment of wastewater and studies effect of HRT (6, 8, 12, 16 h) on performance of the reactor. UASB reactors were used with a height of 1170 m and a working volume of 31.71. The reactors were kept at the temperature of 35ºC in a climate room. Initially the reactors were feed with the wastewater from an company (COD 700-1200 mg/L; fats 75-150 mg/L; pH 9.5-11) supplemented with alkalinity and nutrients. It was seen by raising the HRT from 6-12 h the performance of the system improved concerning maximum applicable load, COD removal efficiency and the methane production, but by raising the HRT from 12-16 h the differences is not meaningful to attain soluble COD removals, VFA removals and protein mineralization near 80% and fat removal above 60%.

2. Land Disposal of Secondary Effluent

Land application of the municipal, domestic & industrial wastewater is gaining momentum owing to the fact that the land applications provides primary, secondary and tertiary treatment to waste, all in a single operation with the recycling and reuse benefits of the wastewater and nutrients, besides preventing the pollution of streams & lakes, as shown in Figure 3.

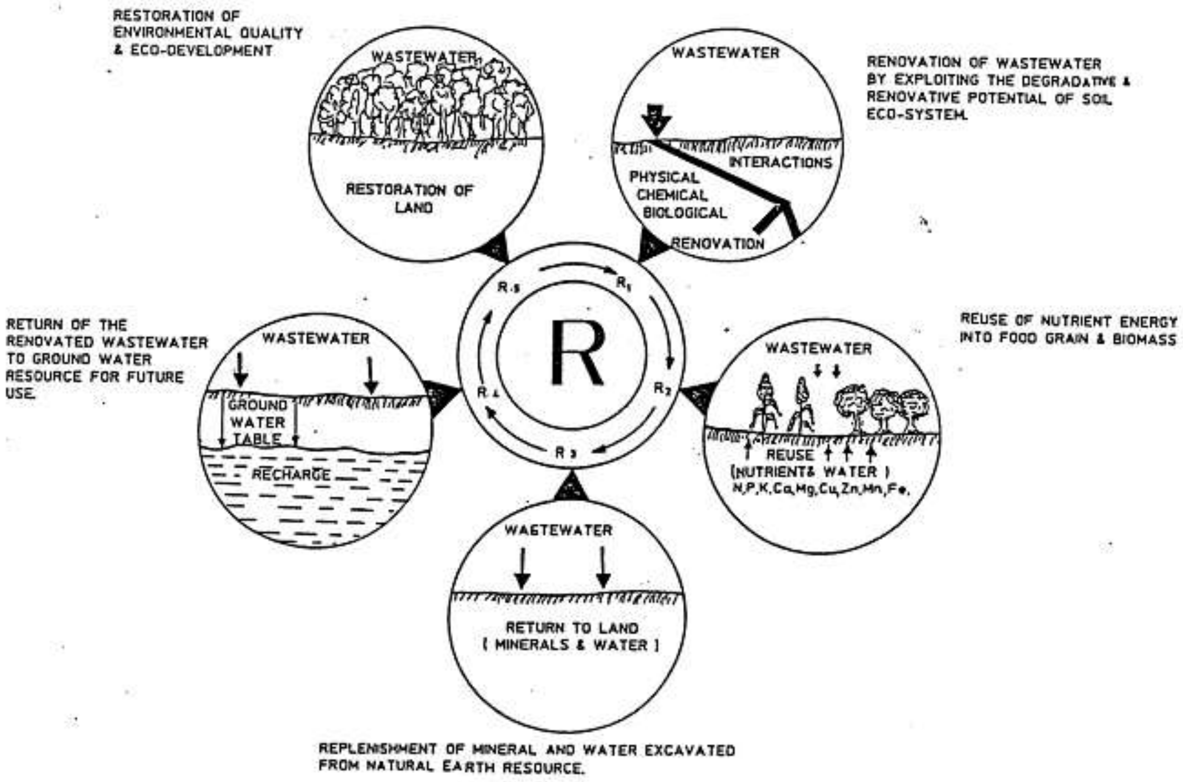


Fig. 4: Concept of wastewater management and recycling, reuse & Eco-development. (Eaton *et al.*, 1995)

In the disposal of waste water through the crop irrigation, the soil works as a living treatment system. The soil & its associated ecosystem component acts as the physico-bio-chemical reactors capable of treating and stabilizing the pollutants of solid and liquid origin through the degradation, adsorption, precipitation and utilization by the crops. The wastewater, while passing through the soil matrix, provides filtration on soil surface leading to removal of the coarse particles. Degradation of the soluble organic pollutants in soil profile by the microbial action, and mixing & aeration extended by macro soil habitant (earthworms & macro fauna) represent waste treatment process occurring in aeration tank. The wastewater from soil reactor is subjected to the final polishing/renovation for removal of the metals through adsorption and ion exchange (Mishra *et al.*, 2006). The suspended solids and bacterial biomass removal through the adsorption, ion exchange and precipitation with hydroxides & carbonate indicate reaction processes occurring in secondary clarifier. Removal of the assimilable macro and micronutrients through plant utilization resembles the tertiary waste treatment. All the renovative processes are the nature's own treatment processes and thus the land application is in fact an eco-friendly treatment and disposal system. (Rico *et al.*, 1991)

Thawale *et al*. (2006) carried out the investigation to ascertain efficiency of the high rates transpiration system (HRTS) in renovation of the primary treated wastewater using *D. strictus* and *C. equisitifolia* species of plants. The result indicated that the removal efficiency of N was greater in case of *C. equisitifolia* and ranged between 60 – 76%. Removal of phosphate was comparatively less and the ranged between 17.7- 70.3%. Levin *et al*. (1980) also reported nitrogen removal to the extent of 30-65% and the phosphorous removal 40-80%

in a soil aquifer treatment system. Lance *et al*. (1972) formed that nitrogen removal was increased by 10-48.5% when vegetation was used.

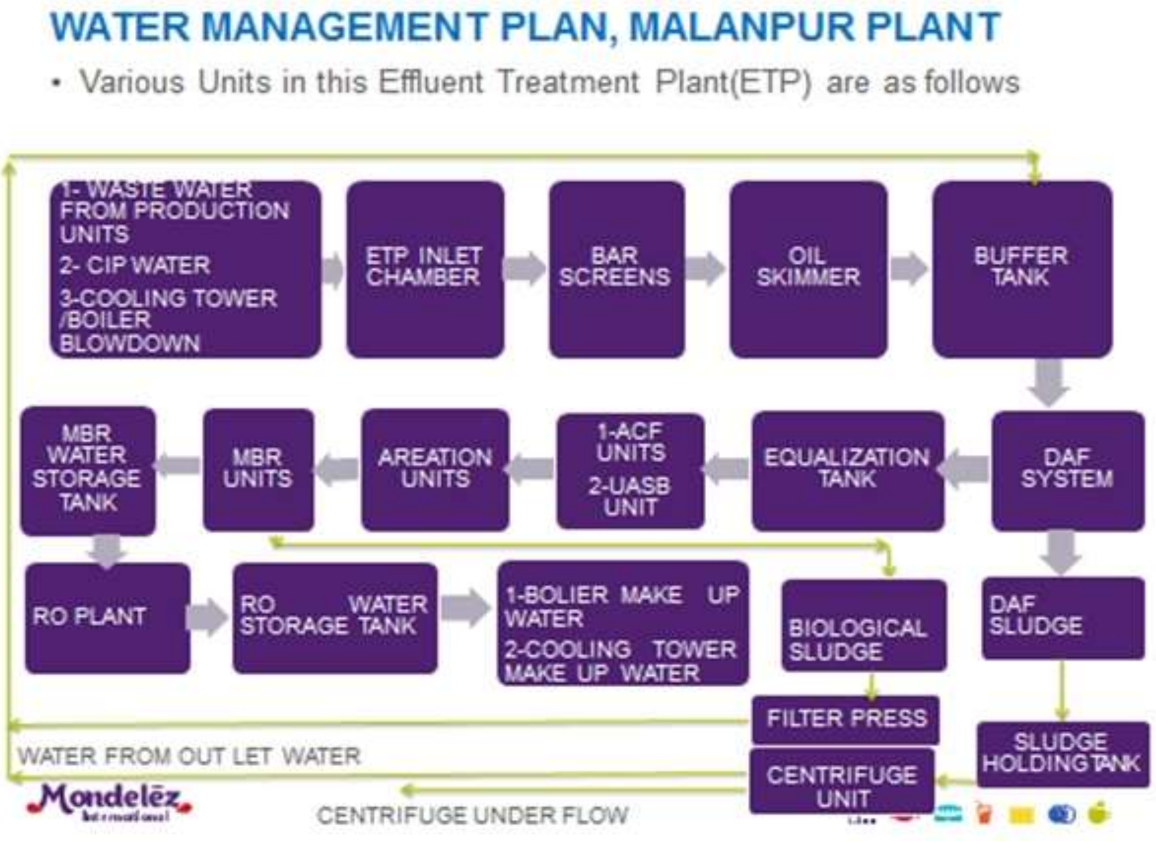
Emongor *et al.* (2005) evaluated the suitability of the treated sewage effluent for irrigation of the horticulture crops. Based on the EC, SAR, Cl, NaCl, fecal Coliforms available plant nutrients and low concentration of the heavy metals they concluded that effluent can be used for irrigation of horticulture crops.

METHODOLOGY

The objective of this work is to Evaluation of pollution parameters of wastewater from milk based food company and check whether the treatment units are working with designed efficiency or not. Within this view, the experimental work has been designed and is presented here with.

- Overview of WWTP.
- Monitoring of waste water treatment plant /ETP-
  Samples were collected from WWTP at different sampling points of WWTP and Characterize for parameters BOD, COD, TS, SS, TDS, Nitrogen, Phosphorus, Nitrogen, Oil & grease, pH, Acidity, Alkalinity etc.
- Sampling Schedule and frequency.
- Performance evaluation.

1. Wastewater Treatment Plant: An overview



WATER MANAGEMENT PLAN, MALANPUR PLANT

- Various Units in this Effluent Treatment Plant(ETP) are as follows

Fig. 5: Waste water management plan at Cadbury, Malanpur.

Fig. 6: Arial View of ETP Plant.Capacity-900 KLD

Fig. 7: Nos. of Aeration Tanks of rectangular type . Capacity of Tank352 KLD

Fig. 8: RO unit of ETP Plant. No. of RO Streams 1. RO Permeate Flowrate / Stream-13.13 m3/hr

Fig. 9: Treated Water Tank. Capacity of Tank-550 m3

Fig. 10: Effluent Storage Tank

2. Monitoring of waste water treatment plant (ETP)

Samples were collected from WWTP at different sampling points of WWTP and Characterize for parameters BOD, COD, TS, SS, TDS, Nitrogen, Phosphorus, Nitrogen, Oil & grease, pH, Acidity, Alkalinity etc.

2.1 pH Value

pH – 4 buffer solutions-

Dissolve 1.012 g anhydrous Potassium Hydrogen Phthalate in distilled water and make upto 100 ml in a volumetric flask.

pH – 7 Buffer Solution-

Dissolve 1.361 g anhydrous Potassium Dy-Hydrogen Phosphate (KH2PO4) and 1.420 g anhydrous disodium hydrogen phosphate Na_2HPO_4 (Both of which have been fried at 110 °C to 130 °C for 2 hours) in distilled water and make up to 1000 ml in a volumetric flask.

pH – 9 Buffer Solution-

Dissolve 3.81 g of Sodium Borate dehydrates (borax) $Na_2B_4O_7$ $10H_2O$ in distilled water and make up to 1000 ml.

Standardization of pH Meter:

1. Wash the electrodes thoroughly with distilled water.
2. Dip the electrodes in pH 7 Buffer and set the reading at 7.
3. Dip the electrode in pH 9 Buffer Solution and set the reading at 9.
4. Again dip the electrode in pH 7 Buffer Solution and set the reading at 7.
5. Dip the electrode in pH 4 Buffer Solution and set the reading at 4.

Before changing the solutions, rinse the electrodes with distilled water.

Now the pH Meter is standardized for taking pH of any sample.

2.2 Total Suspended Solids

Reagents: Gooch Crucible (G3), Filteration Flank, Rotary Vacuum Pump, Asbestos Powder.

Procedure

- Prepare gooch crucible with G3 sintered disc by forming a layer of asbestos on it.
  For this, prepare asbestos solution by dissolving asbestos powder in distilled – water and mixing it thoroughly and then allowing asbestos to settle down Then take the supernatant and pour into gooch crucible and apply vacuum on the other side through filtration flask, a layer of asbestos will be formed on the sintered disc. Dry the gooch crucible in an oven at 105 °C and then cool it in a desiccator and weigh it (W1).
- Fit this gooch crucible on a filtration flask and connect filtration flask to vacuum pump. Take 25 ml sample and diluted to 200 ml and pour it in the gooch crucible slowly and apply vacuum.

- When the sample has passed the gooch crucible then fill gooch crucible with 20 – 25 ml distilled water and apply vacuum, so that all the distilled water passes through gooch crucible and no moisture if left in it and only TSS is retained.
- Dry gooch crucible with TSS in an oven at 105 °C for half to one hour and then cool it in a dessicator and weigh it (W2).
- After completion of gooch test, clean gooch crucible by keeping 20 ml of chromic acid in it overnight and in the morning clean it and prepare again with asbestos solution.

Calculations:

$$\text{TSS mg/l} = \frac{\text{W2} - \text{W1} \times 1000}{\text{Sample Volume}}$$

Where,

W1 = Initial Weight (mg)

W2 = Final Weight (mg)

2.3 Total Dissolved Solids

Reagents:

a) Evaporating dishes: Dishes of 100 ml capacity made of one of the following materials.
- Porcelain 90 mm dia.
- Platinum – Generally satisfactory for all purposes.
- High Silica Glass.

b) Desiccator provided with a desiccant containing a color indicator of moisture concentration.
c) Glass fibers filter disks without organic binder.
d) Filtration Apparatus: One of the following, suitable for filter disks selected
- Membrane filter funnel.
- Gooch crucible 25 ml to 40 ml capacity, with gooch crucible adapter.
- Filtration Apparatus with reservoir and coarse (40 to 65 µm) fritted disk as filter support.

e) Suction flask of sufficient capacity for sample size selected.
f) Drying oven for operation at 180 °C.
g) Steam Bath.
h) Muffle Furnace for operation at 550 °C.

Procedure:

a) Preparation of glass fibre filter disk: Insert disk with wrinkled side up into filtration Apparatus. Apply vacuum and wash disk with three successive 20 ml volume of distilled water. Continue suction to remove all traces of water. Discard washings.

b) Preparation of evaporating disk: Heat clean dish to 180 °C for one hour in an oven. Store in desiccator until needed. Weigh immediately before use.

c) Selection of filter and sample sizes: Choose sample volume to yield between 2.5 and 200 mg dried residue. If more than 10 minutes are required to complete filtration increase filter size or decrease sample volume but do not produce less than 2.5 mg residue.

d) Sample analysis: Filter measured volume of well mixed sample to glass fiber filter, wash with three successive 10 ml volume of distilled water, allowing complete drainage between washing, and continue suction for about 3 minutes after filtration is complete. Transfer filtrate to a weighted evaporating dish and evaporate to dryness on a steam bath. If filtrate volume exceeds dish capacity add successive portions to the same dish after evaporation. Dry for at least one hour in an oven at 180 ºC, cool in desiccator to balance temperature, weigh. Repeat drying cycle of drying, cooling, desiccating and weighing until a constant weight is obtained or unless weight loss is less than 4% of previous weight.

Calculation:

$$\text{Total Dissolved Solids (mg/l)} = \frac{(\mathrm{A}-\mathrm{B})\times 1000}{\text{Sample Volume (ml)}}$$

Where,

A = Weight of dried residue + Dish (mg)

B = Weight of dish (mg)

2.4 Oil & Grease

Reagent:

- Magnesium Sulphate Solution – Dissolve 1 g of magnesium Sulphate hepta-hydrate in 100 ml of water.
- Milk of lime – Mix 2 g of Calcium Oxide with water into a paste and dilute the suspension to 100 ml.
- Light Petroleum (Petroleum Ether) – Boiling range 40 °C to 60 °C
- Dilute Hydrochloric Acid
- Anhydrous Sodium Sulphate

Procedure: Take 250 ml, or an aliquot containing 50 to 150 mg, of extractable matter of the well-mixed sample in a beaker. If a noticeable layer of floating mater is present in it,, carefully transfer as much of it as possible by decantation into a separating funnel. Draw into the beaker containing the residual portion of the sample any liquid that separates out in the funnel. To the sample in the beaker, add 5 ml magnesium sulphate solution. Stir in a rotatory direction with a glass rod and add continuously small amounts of milk of lime until flocculation occurs. Continue stirring for 2 minutes, withdraw the glass rod and wash it down in the separating funnel with a small quantity of light petroleum. Allow the precipitates in the beaker to settle for 5 minutes. When it has settled completely,, siphon off the clear supernatant liquid to within about 1 cm of the top of the sediment. Allow any remaining floating oil to be in the beaker itself. Dissolve the precipitate in the beaker with dilute hydrochloric acid and transfer the contents to a separating funnel, taking care not to transfer any large adventitious solids like twigs, leaves, etc. Rinse the beaker with about 50 ml of light petroleum and add this to the liquid in the funnel. Shake the funnel continuously, but not vigorously, for one minute. Allow the liquid layers to separate. Draw the aqueous layer into another separating funnel and extract again with a fresh 50 ml portion of light petroleum. Reject the aqueous layer and combine the petroleum extracts.

Add to the combined petroleum extracts 2 gm of powdered anhydrous sodium sulphate and shake intermittently over a period of about 30 minutes. Filter through a small size filter paper (Whatman No.30) collecting the filtrate in a dry weighted wide-neck glass of 250 ml capacity. Wash the paper with two successive 20 ml portions of light petroleum and collect the filtrate in the flask distil off most of the light petroleum from the filtrate in the flask and finally evaporate the last traces in a current of warm air. Keep on a water-bath for 10 minutes wipe the outside dry with a filter paper, cool in a desiccator and weight. The difference in weight is the weight of the residue. (If after the solvent has evaporated the residue contains water, add 2 ml of acetone and evaporate on a water-bath. Repeat the acetone addition and evaporation until the contents are free of water)

Note: Some effluents do not readily flocculate with lime. In such cases, determine the suitable flocculating agent by preliminary trial and add them. The following flocculating agents are suggested.

- Aluminum Sulphate – 1 percent solution with pH adjustment of the sample
- Ferric Chloride – 1 percent solution and ammonium hydroxide
- Zinc Acetate – 10 percent solution and sodium carbonate 5 percent solution.

Calculation:

$$\text{Oil \& Grease, mg/l} = \frac{1000W}{V}$$

Where,

W = Weight in mg of the residue.

V = Volume in ml of the sample taken for test.

2.6 Chemical Oxygen Demand (COD)

Reagents:

a) Potassium Dichromate : 0.25 N
   Dissolve 12.258 g Potassium Dichromate in distilled water and make up to 1000 ml in a volumetric flask.

b) Ferrion Indicator
   Ferrous Ammonium Sulphate (FAS)
   98 g of Ferrous Ammonium Sulphate dissolved in little water and added 20 ml conc. H_2SO_4 and make it upto 1000 ml.
c) Silver Sulphate
d) Mercuric Sulphate

Standardization of FAS: Pipet 10 ml 0.25 N Potassium Dichromate in a volumetric flask, make it upto 100 ml transfer in a conical flask. Add 30 ml conc. Sulphuric Acid and cool it to room temperature. Add 3 drops of ferrion indicator and titrate with Ferrous Ammonium Sulphate.

Ml of Ferrous Ammonium Sulphate required to produce green to wine red colour is volume of FAS.

$$N_1V_1 = N_2V_2$$

Where,

N_1 = Normality of Potassium Dichromate. ie. 0.25 N

V_1 = Volume of Potassium Dichromate ie. 10 ml

N_2 = Normality of FAS

V_2 = Volume of FAS required for titration.

Procedure: Shake the sample well. Make dilutions, for inlet, 1: 250 i.e., 1 ml sample in 250 ml volumetric flask and make upto the mark. For outlet ie., treated 1: 100 dilution means 1 ml sample in 100 ml volumetric flask and make upto the mark.

Place 10 ml Potassium Dichromate in flask, Add 20 ml diluted sample and 30 ml (approx.) conc. H_2SO_4. One pinch Mercuric Sulphate and one pinch Silver Sulphate is added and kept for refluxing for 2 hours.

After 2 hours remove the samples and cool it to room temperature, add 80 ml distilled water 3 – 4 drops of ferrion indicator and titrate it with Standard Ferrous Ammonium Sulphate. End point is green to wine red colour.

ml of FAS required for titration – ‘A’: Conduct a blank using distilled water in place of sample (the quantity of other Reagents added are the same as that added for the sample)

ml of FAS required for titration = ‘B’ for blank

Calculation:

$$\text{mg/l COD} = \frac{(\text{Blank titre value} - \text{sample titre Value}) \times \text{Normality of FAS} \times 8000 \times \text{dilution}}{\text{ml of sample taken}}$$

2.7 Biological Oxygen Demand (BOD)

Reagents:

a) Manga nous Sulphate Solution
   Dissolve 91 g Mangnous Sulphate Mono Hydrate, $MnSO_4 \cdot H_2O$ in distilled water and dilute it to 250 ml.

b) Alkali iodide azide Reagent
   a. Dissolve 175 g Potassium Hydroxide (or 125 g Sodium Hydroxide) and 37.5 g Potassium Iodide (or 33.7 g Sodium Iodide) in distilled water and make it to 250 ml.
   b. Dissolve 2.5 g Sodium Azide in 10 ml distilled water.
   c. Pour the azide solution to the alkali-iodide solution and mix well.

c) Conc. Sulphuric Acid

d) Sodium thio Sulphate 0.1 N:
   Dissolve 24.82 g sodium Thio- Sulphate $Na_2S_2O_3 \cdot 5H_2O$ in boiled and cooled distilled water and to make it upto 1000 ml
   0.025 N: Dilute 250 ml of the above solution to 1000 ml with distilled water.

e) Starch Solution

   Dissolve 1 g starch in a little water. Stir it with a glass rod to make it as a thin paste. Pour this paste in about 100 ml boiling water and boil for 2 minutes and cool.

Reagents for Dilution Water

a) Calcium Chloride Solution: Dissolve 27.5 g anhydrous calcium chloride $CaCl_2$ in distilled water and dilute to 1000 ml.

b) Magnesium Sulphate Solution: Dissolve 25 g magnesium Sulphate hepta hydrate $MgSO_4 \cdot 7H_2O$ in distilled water and dilute it to 1000 ml.

c) Ferric Chloride Solution: Dissolve 0.25 g ferric chloride hexa hydrate $FeCl_3 \bullet 6H_2O$ in distilled water and dilute to 1000 ml.

d) Phosphates Buffer Solution: Dissolve 8.5 g Potassium Dihydrogen Phosphate KH_2PO_4, 21.75 g Di-potassium Hydrogen Phosphates, 33.4 g, disodium hydrogen phosphate –hepta hydrate Na2HPO4•7H2O, and 1.7 g Ammonium Chloride in 500 ml distilled water and make upto 1000 ml. The pH of this buffer solution should be 7.2 and keep it in refrigerator.

BOD Dilutions

1:1000 - 3 ml of 1:10 in 300 ml BOD bottle

1:2000 - 1.5 ml of 1:10 in 300 ml BOD bottle

1:3000 - 1 ml of 1:10 in 300 ml BOD bottle

1:4000 - 0.75 ml of 1:10 in 300 ml BOD bottle

1:10000- 3 ml of 1:100 in 300 ml BOD bottle

Preparation of Dilution Water:

Take 1 ml of each Calcium Chloride, Magnesium Sulphate, Ferric Chloride, Phosphate Buffer Solution and add 1000 ml water. Before addition of these Chemicals aerate water for 3 – 4 hrs. and store it at 27 °C in BOD Incubator and its temperature should always be maintained at 27 °C. This is standard dilution water prepare it first before use.

Sample Volume and Dilution Techniques

On the basis of Chemical Oxygen Demand (COD) determine expected BOD. Use the following formula for calculating sample volume

$$\text{Sample Volume in ml., per Ltr. of dilution} = \frac{X}{\text{Expected BOD}} \times 1000$$

For keeping 2 dilutions take X = 2.5 and 4.0.

For single dilution take X = 3.0 or 3.5.

Round off to nearest convenient volume fraction.

In case of high BOD samples, prepare primary dilutions with distilled water and then make the final dilution.

Procedure:

a) Collect the sample in BOD bottle fills it with dilution water upto the mouth.
b) Add 2 ml Mangnous Sulphate and 2 ml alkali-iodide azide solution. Stopper the bottle and mix it by inverting the bottle 10 times. The tip of the pipet should be below the surface of liquid.
c) Allow the precipitate to settle completely leaving a clear supernatant liquid.
d) Carefully remove the stopper and add 2 ml conc. Sulphuric Acid by sides of the bottle.
e) Stopper the bottle and mix thoroughly until dissolution is complete.
f) Measure 203 ml of the solution from the bottle in to a conical flask of 500 ml capacity.
g) Titrate it immediately with 0.025 N Sodium Thiosulphate solution using starch as the indicator.
h) For all the samples take 2 sets one titrate immediately and second keep in incubator for 3 days at 27 °C and titrate it's DO.
i) Carry out Blank with each set using water instead of sample.

Calculation:

$$\text{mg / l BOD}_5 = [(\text{Do} - \text{D5}) - (\text{Bo} - \text{B5})] \times \text{Dilution}$$

Where,

Do – Initial DO

D5 – After 5 days DO

Bo – Initial DO for Blank

B5 – After 5 days DO for Blank

3. Suggested Tests and Frequency

The following table lists the tests and their frequency for control of anaerobic reactor. This table is indicative only and should be modified on the basis of reactor performance and guidelines provided by process supplier. The frequency may be suitably reduced after achieving steady state condition. On other hand parameters like VA and Alkalinity may be required to analyse more frequently during initial stages of commissioning.

Table 4: Frequency of various tests of parameters

Sr	Parameter	Influent	Reactor Content	Treated Effluent	Biogas
1	Temperature	8 h	12 h	-	-
2	pH	8 h	8 h	-	-
3	Alkalinity	-	12 h	-	-
4	Volatile Acids	-	12 h	-	-
5	COD	24 h	24 h	2 days	-
6	BOD	1 week		1 week	-
7	Total suspended Solids	2 days	2 days	4 days	-
8	Nitrogen / Phosphorus	1 week	1 week	-	-
9	Internal Pressure	-	1 h	-	-
10	Flow measurement	12 h	-	-	12 h

RESULTS AND DISCUSSION

The company should have comprehensive treatment system consisting of the primary, secondary and tertiary treatment as is warranted with the reference to influent quality, operate and maintained the same continuously so as to achieve quality of the treated effluent to the standard Norms of the Pollution Control Board.

Samples were collected from WWTP at different sampling points of WWTP and Characterize for parameters BOD, COD, TS, SS, TDS, Nitrogen, Phosphorus, Nitrogen, Oil & grease, pH, Acidity, Alkalinity etc. Results have been summarized and discussed in the following sections:

- Characterization & water quality analysis-
  Monthly variations in the various parameters & their evaluation through Tables & Graphs.
- WWTP Performance Evaluation & efficiency of treatment.

1. Characterization & water quality analysis

The physico-chemical & biological characterization of the inlet water in WWTP is given in Table 5. The key pollutants in the wastewater from chocolate based food company are organic compounds, oil & grease, suspended solids etc.

Characterization of Inlet waste water into WWTP of chocolate based food Company:

pH: pH of the each sample was measured immediately after its collection by the pH meter. Table 6 represents the pH of different samples. The pH of the effluent varied from 5.17 to 10.93 before the treatment, whereas the value of average pH after physical & biological treatment was found 8.37. The use of acids, alkali, cleansers and sanitizers in the chocolate company typically results in highly variable wastewater pH values. The percentage reduction of -33.47 % was achieved. The findings of the present study are in agreement with PCB standards (pH range = 7.5-9.0).

Total Suspended Solids (TSS): Suspended solids do not mean that they are floating matters and remain on the top of water layer. They are under suspension and remain in the water sample. Total suspended solids play an important role in the water and waste water treatment. The presence of TSS in water sample causes depletion of oxygen level. The TSS content in the effluent varied from 498 to 1320 mg/l before treatment whereas after physical & biological treatment the average value was obtained 88.46 mg/l. The percentage reduction of 90.09% was achieved. The TSS values in our study were in accordance with the PCB standards. TSS is an important parameter for the designing wastewater treatment plant and length of the time for which wastewater should be retained for primary treatment.

Total Dissolved Solids (TDS): The total solid concentration in the waste effluent represents the colloidal form & dissolved species. The main reason for fluctuation of the value of total solid and subsequent the value of dissolved solids due to content collision of these colloidal particles. The rate of collision of aggregated process is also influenced by the pH of these effluents. The TDS content in the effluent varied from 1520 to 1780 mg/l before the treatment whereas after physical & biological treatment the average value obtained was 1102.86 mg/l. The percentage reduction of 33.88% was achieved. The TSS values in our study were in accordance with the PCB standards.

Chemical Oxygen Demand (COD): The chemical oxygen demand (COD) determines, the oxygen required for chemical oxidation of the organic matter with help of strong chemical oxidant. The COD is a test which is used to measure the pollution of domestic and industrial waste. The waste is measure in terms of the equality of oxygen required for oxidation of organic matter to produce the CO2 and water. It is a fact that all the organic compounds with a few exceptions can be oxidizing agents under the acidic condition. COD test is useful in pinpointing toxic condition and presence of the biological resistant substances. For COD determination samples were preserved using H2SO4 and processed for the COD determination after the entire sampling operation was complete. The COD of effluent varied from 4791 to 8988 mg/l before treatment whereas after physical & biological treatment the average value obtained was 132.22 mg/l. The percentage reduction of 97.28 % was achieved. The value of COD after treatment was under PCB standards.

Chlorides:

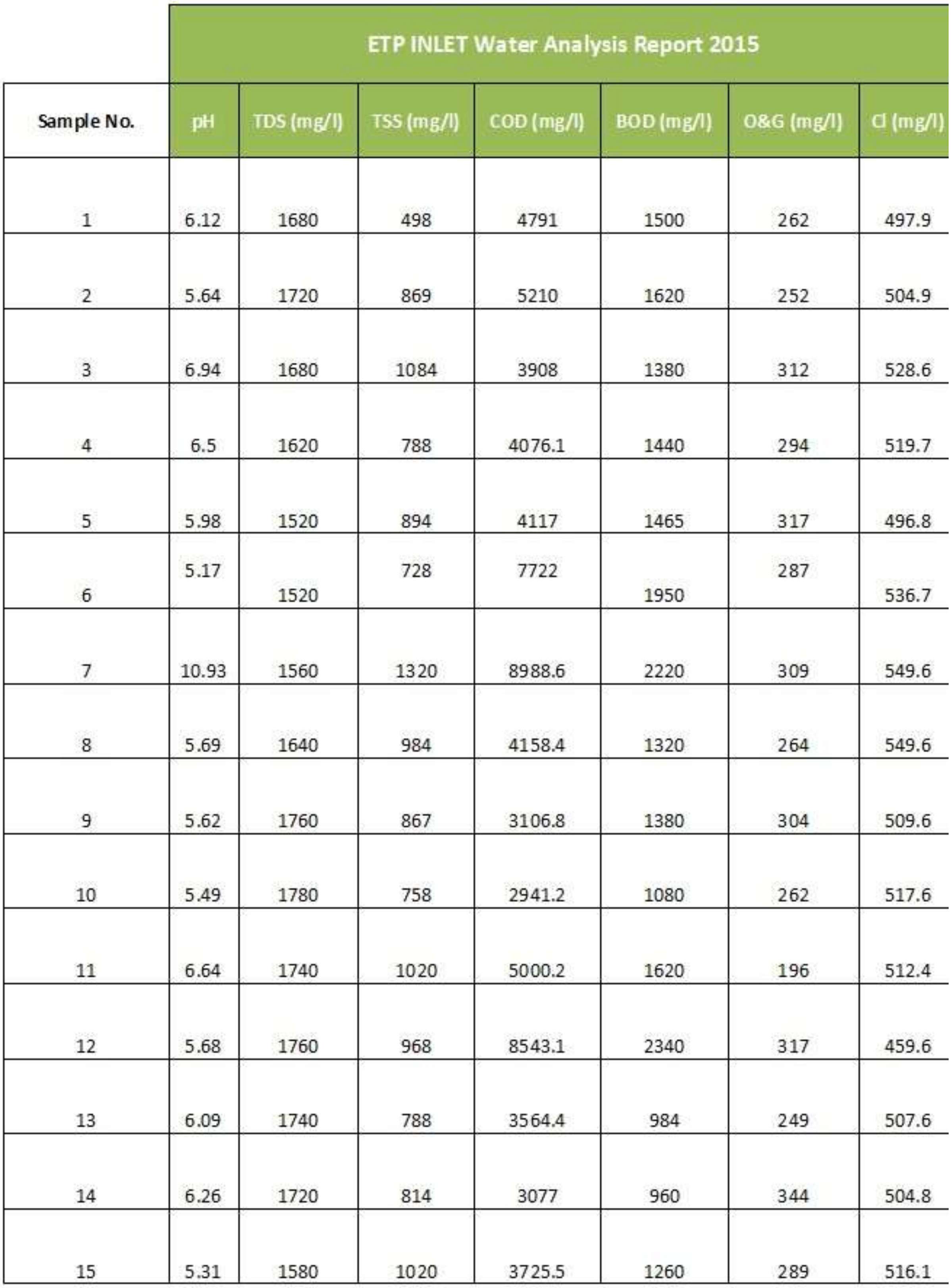
Chloride of the each sample was measured immediately after its collection. Table 11 represents the chloride of different samples. The chloride of the effluent varied from 459 to 549 before the treatment, whereas the average value of the chloride after physical & biological treatment was found 152.3 mg/l. The percentage reduction of 70.37 % was achieved. The findings of the present study are in agreement with PCB standards.

Biological Oxygen Demand (BOD): For BOD5 samples were immediately processed after the collection for determination of initial oxygen and incubated at 20 °C for 5 days for the determination of BOD5. The BOD of the effluent varied from 1500 to 1220 mg/l before treatment whereas after treatment the average value obtained was 11.4 mg/l. The percentage reduction of 99.51 % was achieved. The value of BOD after treatment was under PCB standards.

Oil & Grease (O&G):

O&G of the each sample was measured immediately after its collection. Figure 4.6 represents the O&G of different samples. The O&G of the effluent varied from 262 to 344 before the treatment, whereas the average value of the O&G after physical & biological treatment was found 7.4mg/l. The percentage reduction of 97.39 % was achieved. The findings of the present study are in agreement with PCB standards.

Table5: Inlet Water Quality Analysis



	ETP INLET Water Analysis Report 2015						
Sample No.	pH	TDS (mg/l)	TSS (mg/l)	COD (mg/l)	BOD (mg/l)	O&G (mg/l)	Cl (mg/l)
1	6.12	1680	498	4791	1500	262	497.9
2	5.64	1720	869	5210	1620	252	504.9
3	6.94	1680	1084	3908	1380	312	528.6
4	6.5	1620	788	4076.1	1440	294	519.7
5	5.98	1520	894	4117	1465	317	496.8
6	5.17	1520	728	7722	1950	287	536.7
7	10.93	1560	1320	8988.6	2220	309	549.6
8	5.69	1640	984	4158.4	1320	264	549.6
9	5.62	1760	867	3106.8	1380	304	509.6
10	5.49	1780	758	2941.2	1080	262	517.6
11	6.64	1740	1020	5000.2	1620	196	512.4
12	5.68	1760	968	8543.1	2340	317	459.6
13	6.09	1740	788	3564.4	984	249	507.6
14	6.26	1720	814	3077	960	344	504.8
15	5.31	1580	1020	3725.5	1260	289	516.1

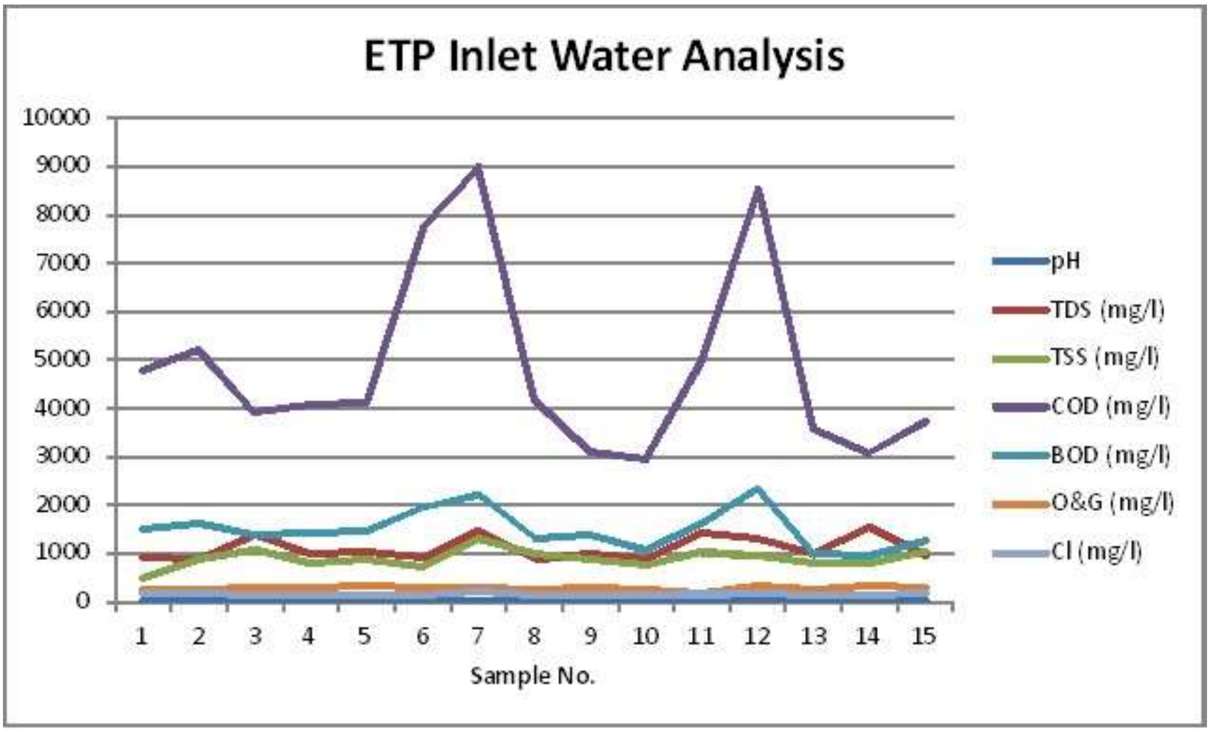


Fig. 11: Graphical Representation of ETP Inlet water analysis

Table 6: pH analysis of Inlet & Outlet water

pH Analysis		
Sample No.	**Inlet pH**	**Outlet pH**
1	6.12	8.31
2	5.64	8.34
3	6.94	8.35
4	6.5	8.39
5	5.98	8.36
6	5.17	8.36
7	10.93	8.4
8	5.69	8.4
9	5.62	8.41
10	5.49	8.36
11	6.64	8.44
12	5.68	8.38
13	6.09	8.36
14	6.26	8.34
15	5.31	8.35
Average	6.270666667	8.37

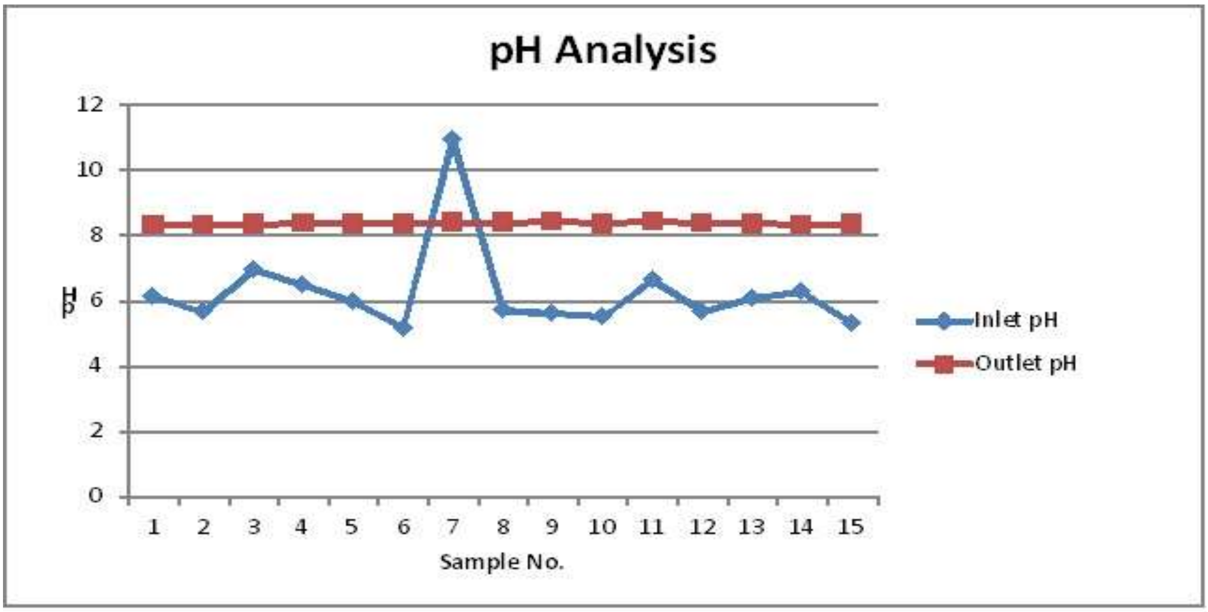


Fig. 12: Graphical Representation of pH analysis

Table 7: TSS analysis of Inlet & Outlet water

TSS Analysis			
Sample No.	Inlet TSS (mg/l)	Outlet TSS (mg/l)	Outlet Permissible TSS (mg/l)
1	498	88	100
2	869	89	100
3	1084	84	100
4	788	89	100
5	894	79	100
6	728	89	100
7	1320	91	100
8	984	89	100
9	867	92	100
10	758	94	100
11	1020	86	100
12	968	94	100
13	788	92	100
14	814	97	100
15	1020	74	100
Average	893	88.46666667	

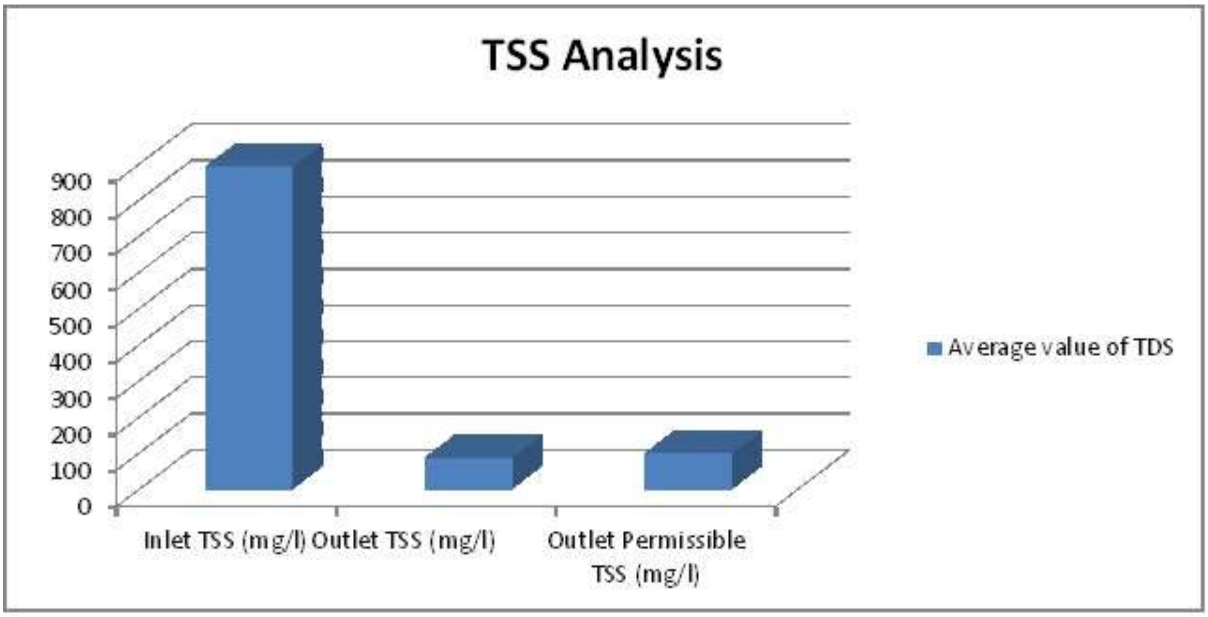


Fig. 13: Graphical Representation of TSS analysis

Table 8: TDS analysis of Inlet & Outlet water

TDS Analysis			
Sample No.	**Inlet TDS (mg/l)**	**Outlet TDS (mg/l)**	**Outlet Permissible TDS (mg/l)**
1	1680	917	2100
2	1720	864	2100
3	1680	1380	2100
4	1620	1000	2100
5	1520	1040	2100
6	1520	904	2100
7	1560	1460	2100
8	1640	898	2100
9	1760	980	2100
10	1780	894	2100
11	1740	1420	2100
12	1760	1320	2100
13	1740	980	2100
14	1720	1530	2100
15	1580	956	2100
Average	1668	1102.866667	

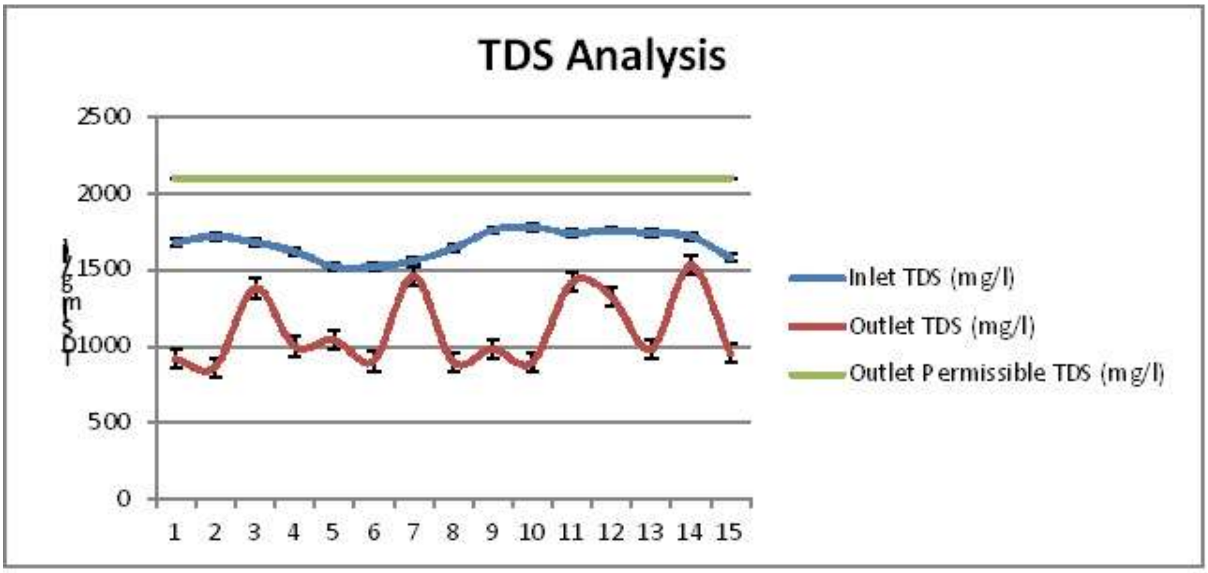


Fig. 14: Graphical Representation of TDS analysis

Table 9: COD analysis of Inlet & Outlet water

COD Analysis			
Sample No.	**Inlet COD (mg/l)**	**Outlet COD (mg/l)**	**Outlet Permissible COD (mg/l)**
1	4791	122.6	250
2	5210	128.7	250
3	3908	119.6	250
4	4076.1	118.2	250
5	4117	133.4	250
6	7722	133.6	250
7	8988.6	142.2	250
8	4158.4	133.4	250
9	3106.8	139.6	250
10	2941.2	140.6	250
11	5000.2	135.6	250
12	8543.1	132.6	250
13	3564.4	137.2	250
14	3077	128.7	250
15	3725.5	137.3	250
Average	4861.96	132.2226667	

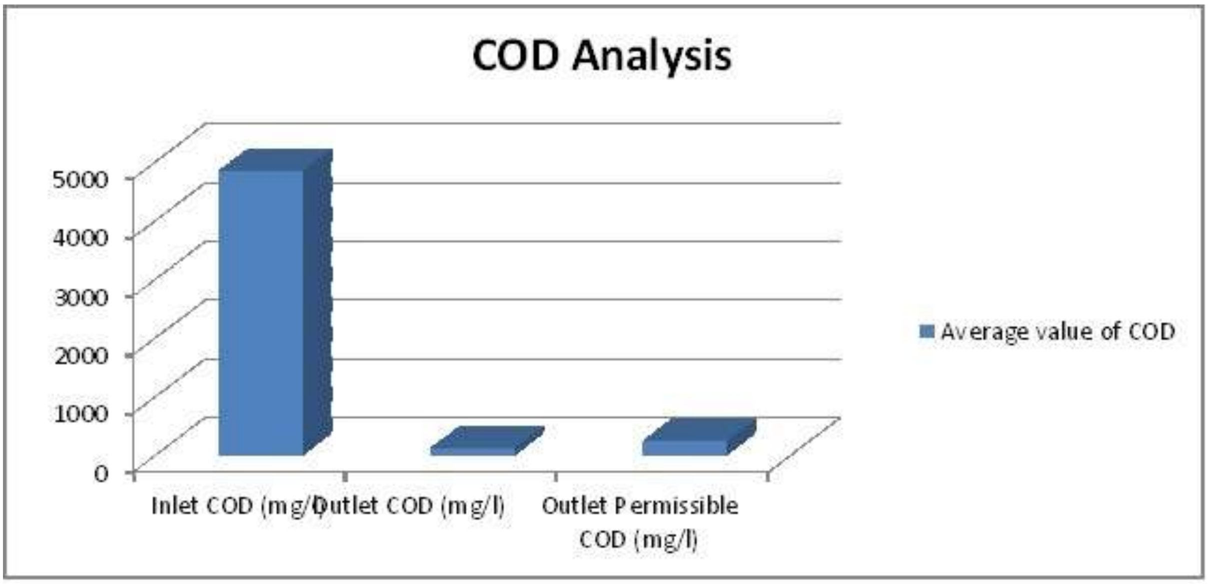


Fig. 15: Graphical Representation of COD analysis

Table 10: BOD analysis of Inlet & Outlet water

BOD Analysis			
Sample No.	Inlet BOD (mg/l)	Outlet BOD (mg/l)	Outlet Permissible BOD (mg/l)
1	1500	9	30
2	1620	9.6	30
3	1380	11.4	30
4	1440	12.0	30
5	1465	14.4	30
6	1950	15	30
7	2220	10.8	30
8	1320	10.8	30
9	1380	11.4	30
10	1080	10.8	30
11	1620	12	30
12	2340	11.4	30
13	984	12.6	30
14	960	10.4	30
15	1260	11.2	30
Average	1501.266667	11.52	

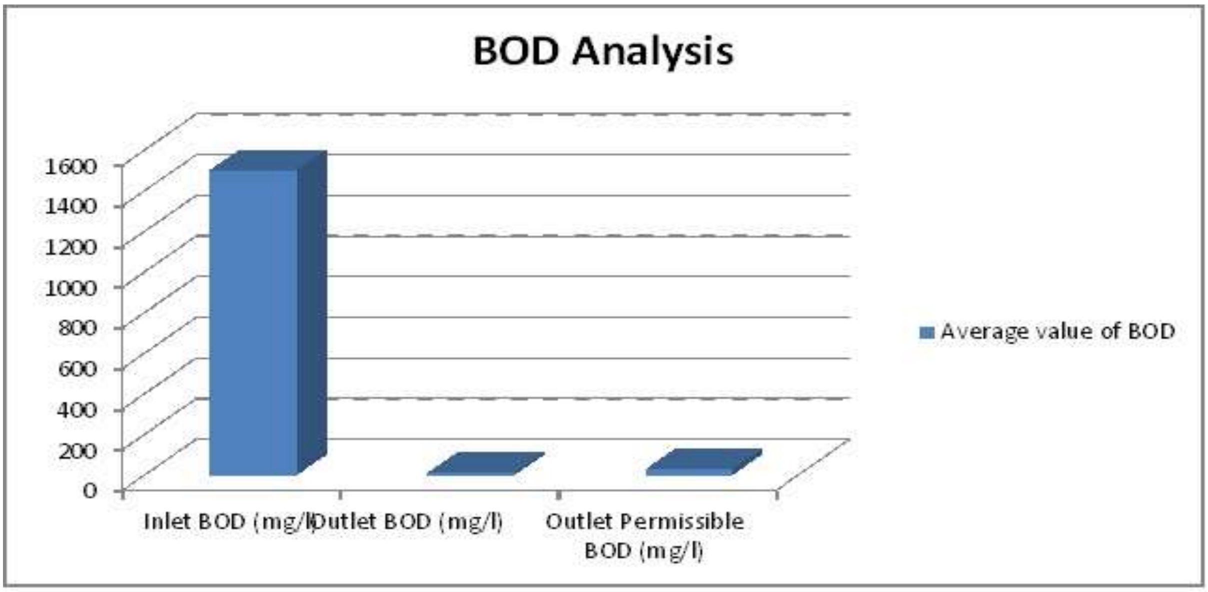


Fig. 16: Graphical Representation of BOD analysis

Table 11: Cl analysis of Inlet & Outlet water

Cl Analysis			
Sample No.	Inlet Cl (mg/l)	Outlet Cl (mg/l)	Outlet Permissible Cl (mg/l)
1	497.9	169.7	600
2	504.9	168.9	600
3	528.6	129.6	600
4	519.7	129.4	600
5	496.8	139.4	600
6	536.7	129.4	600
7	549.6	217.9	600
8	549.6	149.8	600
9	509.6	139.7	600
10	517.6	149.6	600
11	512.4	158.7	600
12	459.6	169.8	600
13	507.6	127.9	600
14	504.8	135.4	600
15	516.1	169.7	600
Average	514.1	152.3	

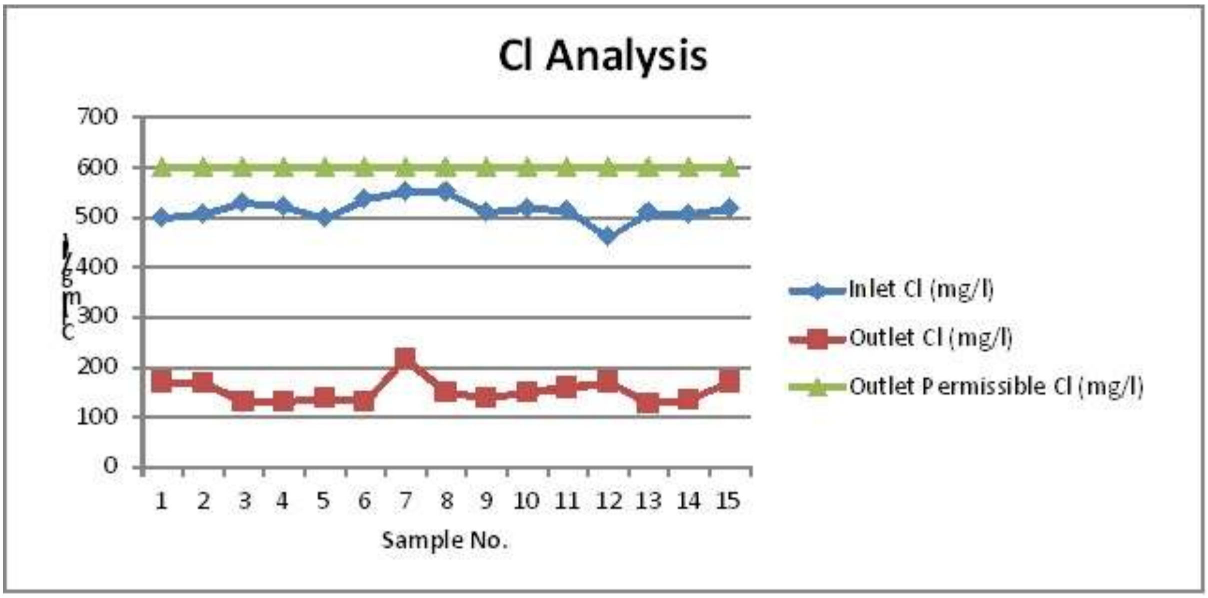


Fig. 17: Graphical Representation of Cl analysis

Table 12: O&G analysis of Inlet & Outlet water

O&G Analysis			
Sample No.	**Inlet O&G (mg/l)**	**Outlet O&G (mg/l)**	**Outlet Permissible O&G (mg/l)**
1	262	6	10
2	252	6	10
3	312	7	10
4	294	7	10
5	317	7	10
6	287	8	10
7	309	8	10
8	264	8	10
9	304	8	10
10	262	8	10
11	196	8	10
12	317	7	10
13	249	8	10
14	344	8	10
15	289	7	10
Average	283.8666667	7.4	

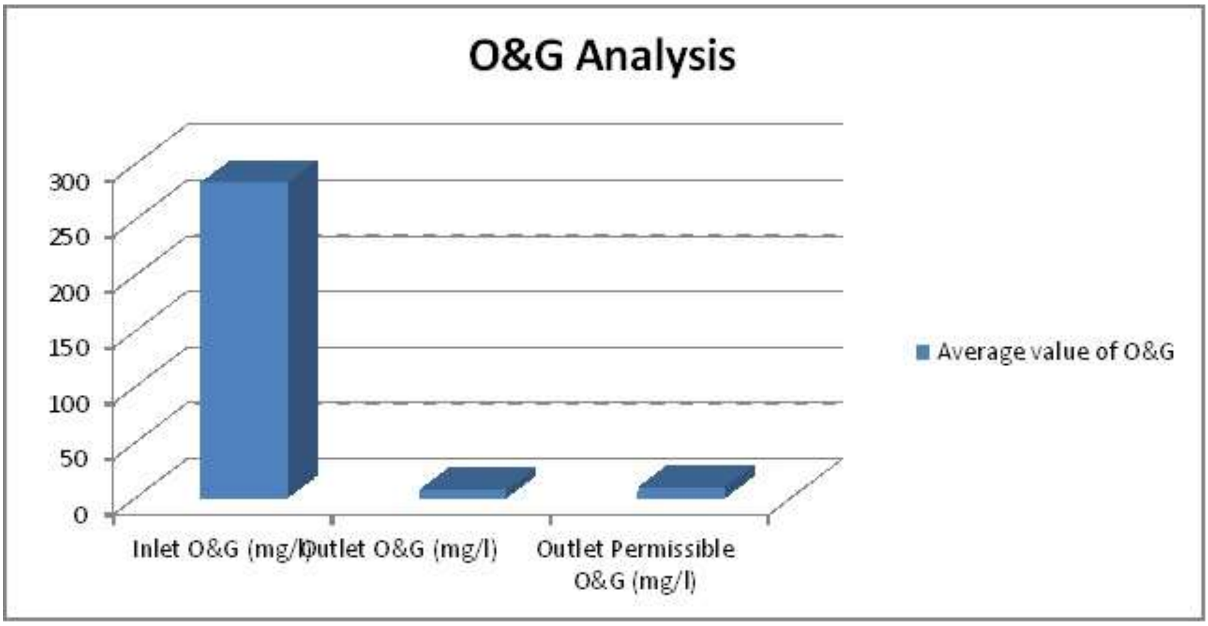
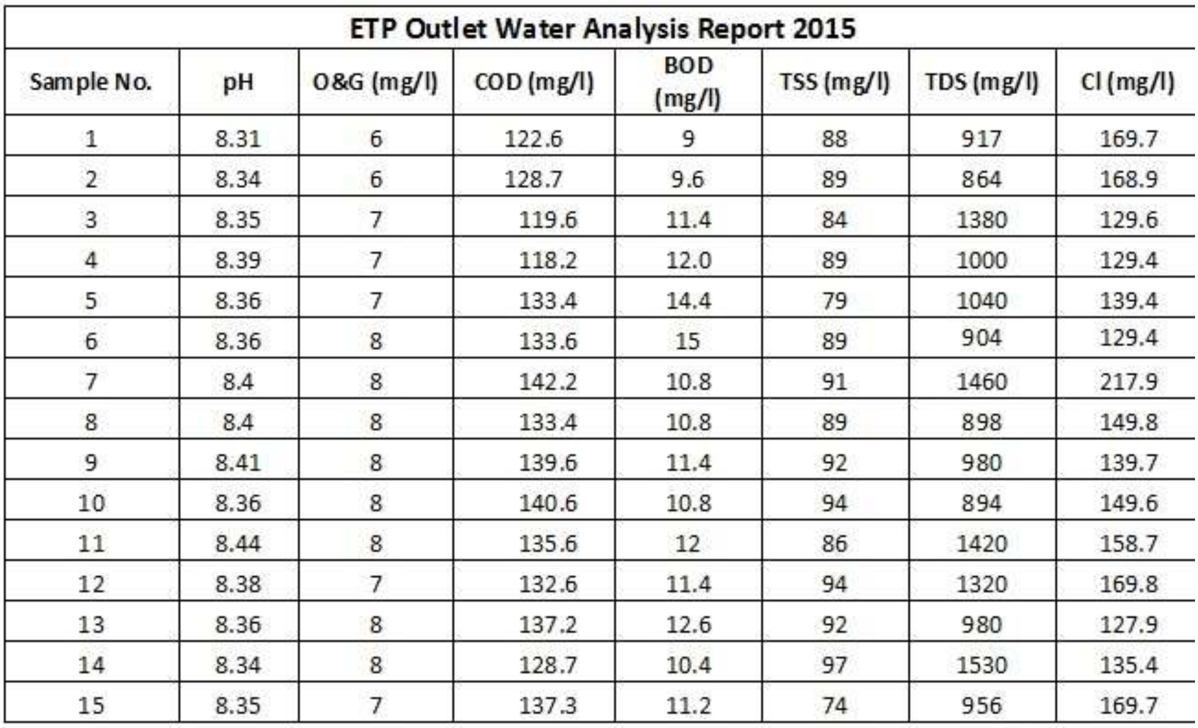


Fig. 18: Graphical Representation of O&G analysis

2. WWTP Performance Evaluation & Efficiency of treatment

The physico-chemical & biological characterization of the inlet water in WWTP is given in Table 13.

Table 13: Outlet Water Quality Analysis



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Sample No.	pH	O&G (mg/l)	COD (mg/l)	BOD (mg/l)	TSS (mg/l)	TDS (mg/l)	Cl (mg/l)
1	8.31	6	122.6	9	88	917	169.7
2	8.34	6	128.7	9.6	89	864	168.9
3	8.35	7	119.6	11.4	84	1380	129.6
4	8.39	7	118.2	12.0	89	1000	129.4
5	8.36	7	133.4	14.4	79	1040	139.4
6	8.36	8	133.6	15	89	904	129.4
7	8.4	8	142.2	10.8	91	1460	217.9
8	8.4	8	133.4	10.8	89	898	149.8
9	8.41	8	139.6	11.4	92	980	139.7
10	8.36	8	140.6	10.8	94	894	149.6
11	8.44	8	135.6	12	86	1420	158.7
12	8.38	7	132.6	11.4	94	1320	169.8
13	8.36	8	137.2	12.6	92	980	127.9
14	8.34	8	128.7	10.4	97	1530	135.4
15	8.35	7	137.3	11.2	74	956	169.7

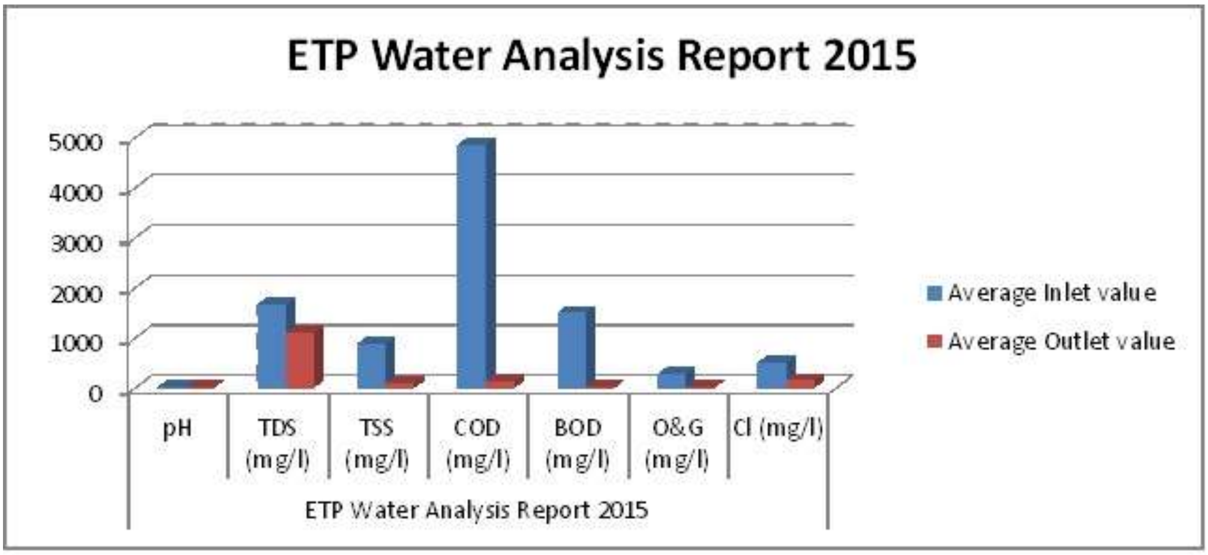
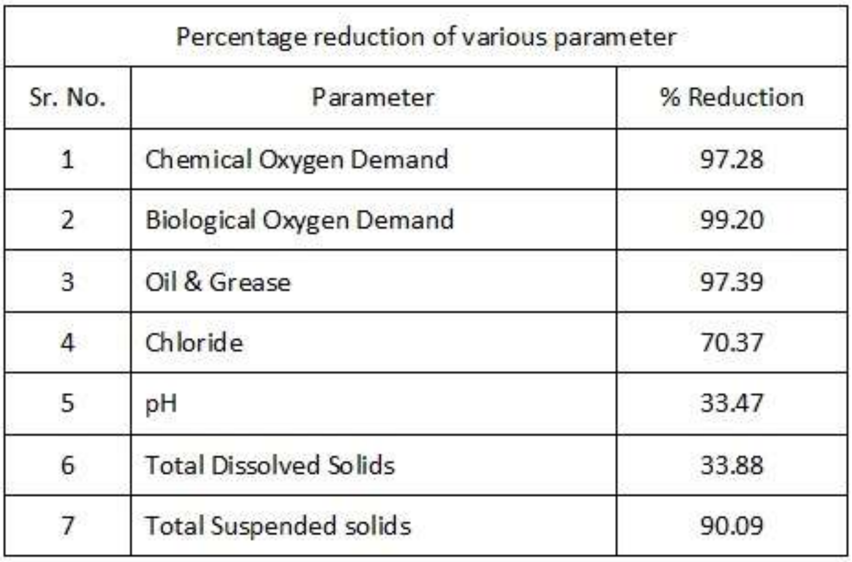


Fig. 19: Graphical Representation of ETP water analysis

The performance of WWTP in terms of average reduction (%) in the pollution parameters is given in Table 14.

Table 14: Removal efficiency of WWTP



Percentage reduction of various parameter		
Sr. No.	Parameter	% Reduction
1	Chemical Oxygen Demand	97.28
2	Biological Oxygen Demand	99.20
3	Oil & Grease	97.39
4	Chloride	70.37
5	pH	33.47
6	Total Dissolved Solids	33.88
7	Total Suspended solids	90.09

CONCLUSION

Overall based on this study, we can conclude that current result shows that the treated effluent water is within the range of standards of the PCB and can be utilized in the irrigation. The COD reduction efficiency of WWTP was found 97.28%. The BOD reduction efficiency of WWTP was found 99.23%. The Total suspended solid reduction efficiency of WWTP was found 90.09%. The Total dissolved solid reduction efficiency of WWTP was found 33.88%. All the units are performing well and their reduction efficiencies are very satisfactory. It shows that the capability of the plant to work under the shock load. The treated effluent meets the PCB standard for discharge the surface water .So we can state that the plant is working very efficiently. This waste water treatment plant is very high potential for BOD, TSS and COD removal. So this technology can be considered as a potential plant for the industrial wastewater treatment.

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