Treatability Study and Design Adequacy of Effluent Treatment Plant (ETP) of a Rubber Industry

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Submitted by

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DECLARATION CUM CERTIFICATE

I hereby declare that the project work entitled **"Treatability Study and Design Adequacy of Effluent Treatment Plant (ETP) of a Rubber Industry"** is an authentic record of my own work carried out at Tesla Innovations Pvt. Ltd. as requirements of project internship for the award of the degree of M.Tech. Environmental Science and Technology, Thapar Institute of Engineering and Technology, Patiala, under the guidance of Mr. Rohit Kumar Gupta and Dr. B. R. Yadav, during December 2017 to June 2018.

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Certified that the above statement made by the student is correct to the best of our knowledge and belief.

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Abstract

The stages of the entire study can be segregated as follows; firstly, site visit was conducted to study the effluent generation sources and the existing effluent management practices within the organization. Secondly, laboratory scale setup was made for studying and finding out the key parameters required for primary and secondary treatment of trade effluent from latex and rubber plant. Thirdly, based on the design data of each treatment unit provided by client, the adequacy assessment of the existing ETP was carried out with respect to the maximum existing and consented hydraulic load. Based on the findings, conclusion and recommendations were formulated.

For primary treatment of latex effluent, the optimum dosage of coagulant (Alum, PAC or Ferric chloride) comes in the range of 600-800 ppm, optimum lime dose of 400 ppm and polyelectrolyte dose of 2 ppm.

For rubber effluent, the optimum coagulant (Alum and PAC) dose comes to be in the range of 300-400 ppm. Optimum lime dose is 300 ppm and for polyelectrolyte it is 1 ppm.

In the design adequacy study, all the treatment units of the effluent treatment plant except dual media filter were found to be hydraulically adequate to treat the consented volume of 435 CMD including trade effluent. The existing bio-reactor of the ETP has a capacity to handle a maximum of 435 CMD of effluent as per the treatability studies considering a range of 20-22 hrs HRT and operating at MLSS of 5000-6000 mg/l. However, theoretically considering an F/M ratio in the range of 0.1-0.15, the bio-reactor can adequately handle 435 CMD of trade effluent.

In future, CLIENT is recommended to consider an additional STP of 40 KLD if the trade effluent generation goes beyond 400 KLD. As per the historic data & present data, CLIENT can utilize the existing bioreactor for trade & sewage effluent due to reduced hydraulic load on the existing ETP.

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Glossary of Terms

ACF	Activated Carbon Filter
APC	Air Pollution Control
ASP	Activated Sludge Process
BOD	Biochemical Oxygen Demand
CETP	Common Effluent Treatment Plant
CHWTSDF	Central Hazardous Waste Treatment Storage and Disposal Facility
CMD	Cubic Meter per Day
COD	Chemical Oxygen Demand
CPHEEO	Central Public Health and Environmental Engineering Organisation
DO	Dissolved Oxygen
DMF	Dual Media Filter
ET	Equalisation Tank
ETP	Effluent Treatment Plant
HRT	Hydraulic Retention Time
HSR	High Styrene Rubber
IIT	Indian Institute of Technology
MLSS	Mixed Liquor Suspended Solids
MLVSS	Mixed Liquor Volatile Suspended Solids
MT	Metric Ton
NBR	Nitrile Butadiene rubber
PNBR	Powdered Nitrile Butadiene Rubber
PPM	Parts Per Million
SB	Styrene Butadiene
SOP	Standard Operating Procedure
SVI	Sludge Volume Index
SWD	Side Water Depth
TIPL	Tesla Innovations Private Limited
TDS	Total Dissolved Solids

TSS	Total Suspended Solids
VP	Vinyl Pyridine
XSB	Carboxylated Styrene Butadiene

Chapter 1 : Introduction

Wastewater pollution from rubber processing industries has been on the increase in Africa and Asia as a result of the increasing number of rubber producing factories due to the presence of virgin forests with large number of mature rubber trees. Rubber processing industry is one of the most important industries. Rubber generally occurs in plants as milky white latex but the chemical composition however, varies from species to species. Chemically, rubber is a polyterpene consisting of a long chain (500 – 5000) of isoprene units joined together end to end to form giant molecules called polymers which are coiled up like tiny springs (Iyagba et al., 2008). Raw material products from natural rubber processing sector provide huge benefits to human beings as they are exploited to manufacture many kinds of important rubber goods (Anon, 2007). Rubber processing industry usually generates large quantities of wastewater containing high concentration of organic matter, suspended solids and nitrogen (Rakkoed et al., 1999). Wastewater from the rubber industry has high concentrations of gaseous and liquid effluent, if not properly treated and disposed, can severely damage the environment.

Client is one of the principal producers of Synthetic Rubber (NBR, HSR, PNBR and polyblend) and Synthetic Latex (Nitrile, VP latex, XSB and Acrylic latex) in India. The various grades of Synthetic Rubber find application in products such as Automotive Components, Hoses, Gaskets, Rice De-Husking Rollers, Printing and Industrial Rollers, Friction Materials, Belting and Footwear. The range of Latexes produced in Client Industries are used for Paper/Paper Board Coating, Carpet Backing, Tyre Cord Dipping, Construction etc.

1.1.Objectives of the study

The objectives of the treatability study conducted at CLIENT (Rubber Industry (with a maximum annual production of 40800 MT)) were framed to ascertain the sufficiency or adequacy of the existing wastewater management system in the industry with respect to the hydraulic as well as pollution load. Following are the primary objectives of the treatability study:

- To determine the characteristics of the raw effluent such as pH, COD, BOD, TSS, TDS etc. generated from different industrial processes at CLIENT.
- To assess the temporal variation in the raw effluent to understand the maximum pollution load to the ETP.
- To find out the optimum dosage of chemicals by jar tests in the primary treatment for maximum reduction of COD and TSS
- To assess the COD reduction efficiency w.r.t bio mass concentration and hydraulic retention time for primary treated effluent of the existing wastewater in pilot scale bio-reactors.
- To assess the maximum allowable organic load handling capacity of the bio reactors.
- To evaluate the adequacy of all unit operations installed in the ETP.
- Unit wise assessment of current infrastructure and operating parameters of ETP.
- To formulate the conclusions and recommendations based on the detailed study.

1.2.Scope of Work

1. Detailed Analysis of Effluent (Latex and Rubber effluent)
    a) Stage wise: Raw-Inlet, Primary, Secondary and Tertiary treated effluent quality analysis for following parameters.
        1. pH
        2. Chemical Oxygen Demand (COD)
        3. Total Dissolved Solids (TDS)
        4. Total Suspended Solids (TSS)
    b) Testing of all key operational and quality parameters for temporal variations.
    c) Determination of treatment efficiency of each unit.

2. Process Evaluation (adequacy) of effluent treatment facility at CLIENT to treat the effluent in terms of quantity and quality.
    a) Study of DPR (Detailed Project Reports) for ETP
    b) Evaluate the existing technologies for effluent treatment
        - ➢ Unit wise assessment of the current infrastructure, which includes:
            - ✓ Equalization tank/Primary collection tank.
            - ✓ Primary treatment
            - ✓ Biological Treatment
                a. For Biodegradable stream
                b. For Refractories
            - ✓ Tertiary Treatment
        - ➢ Unit wise SOP assessment
            - ✓ Existing SOP evaluation and suggesting the possible changes for better operations
        - ➢ Unit wise operating parameters evaluation
            - ✓ Evaluation of the existing operating parameters (unit wise) and suggesting the way to enhance the performance of the system.
3. Laboratory scale Treatability studies
    a) Primary treatment (laboratory scale)
    b) Secondary treatment (laboratory scale)
4. Laboratory scale studies for alternative solutions if the existing treatment technologies are found to be inadequate.
5. Detailed analysis of all the data generated during the treatability studies and their interpretation.
6. Preparation of report along with compilation of the observations, recommendations and conclusions.

Chapter 2 : Description of Facilities

The raw water consumption by the industry and the details of wastewater stream generated from the industrial process in terms of quantity and quality are specified along with the effluent management practices.

2.1 Production Details

M/s CLIENT is primarily engaged in the manufacturing of synthetic rubber and synthetic latex as the main products with a maximum annual production of 40800 MT[1].

2.2 Manufacturing Process

The manufacturing process of the products manufactured at the industry is mentioned in the sections below. The manufacturing process description is provided by the industry.

2.2.1 Manufacturing Process of synthetic latex:

2.2.1.1 VP Latex:

It is a terpolymer (a polymer that results from copolymerization of three discrete monomers) of styrene, butadiene and 2-vinyl pyridine. It is manufactured by conventional emulsion polymerization process. The first step is to ensure that the reactor is clean and empty. The bottom valve of reactor is closed and then the aqueous charge is prepared. The aqueous charge consists of de-mineralized water and other water-soluble ingredients like alkali, primary emulsifier, secondary emulsifier etc. These ingredients are added in definite proportion and after required stirring the sample are given to laboratory. The lid of reactor is next closed and pressure test is taken with compressed air at 5 Kg/cm^2. After pressure test, the pressure is vented out and series of nitrogen purging, and evacuations is carried out. After final evacuation, monomers like styrene, butadiene and 2-Vinyl Pyridine are added in definite proportion. Then the initiator is added, and batch is heated to a specified temperature. The heat then gets evolved as a result of polymerization, which is controlled by controlling the temperature of reactor by circulating chilled water through the jacket of the reactor. The reaction is continued till all monomers are

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[1] The annual production of client is as per the latest consent from MPCB.

consumed. Then the un-reacted monomer namely butadiene is vented off into atmosphere with proper safety precautions and un-reacted styrene and 2-vinyl pyridine is removed by distillation. Then the batch is cooled, post incorporations are carried out and the batch is transferred to storage vessel from where it is transferred to auxiliary packing vessel and packed. The temperature of the batch is kept in the range of 50^0C to 70^0C. Reaction time is about 24 hours.

2.2.1.2 SBR latex / Acrylic Latex (By Pre-Mix Method):

It is a terpolymer of styrene, butadiene / butyl acrylate, carboxylic acid and other functional monomers. It is manufactured by state of art emulsion polymerization technology. The first step is to ensure that reactor is clean and empty. The bottom valve of reactor is closed and then the aqueous charge is prepared. The aqueous charge comprises of de-mineralized water and other water-soluble ingredients like alkali, chelating agent etc. These ingredients are added in definite proportion and after required stirring the sample are given to laboratory. The lid of reactor is closed, and pressure test is taken with compressed air at $5Kg/cm^2$. After pressure test, the pressure is vented out and series of nitrogen purging, and evacuations is carried out. Also, the required monomers like styrene and butadiene are collected into pre-mix vessel, emulsifier solution and initiator solutions are prepared in respective vessels and kept ready. The contents of the reactor are then heated to specified temperature. After achieving this temperature, the monomer, emulsifier and initiator are fed continuously into reactor over a period of 4 to 6 hours. The heat then gets evolved as a result of polymerization, which is controlled by controlling the temperature of reactor by circulating chilled water through the jacket of the reactor. The reaction is continued till all monomers are consumed. Then un-reacted monomer namely butadiene is vented off into atmosphere with proper safety precautions and un-reacted styrene is removed by chemical stripping. Then the batch is cooled, post incorporations are carried out and the batch is transferred to storage vessel from where it is packed. Then the batch is cooled, post incorporations are carried out and the batch is transferred to storage vessel from where it is transferred to auxiliary packing vessel and packed. Temperature of the batch is kept in the range of 80°C to 95°C. Reaction time is about 8 hours.

2.2.1.3 SBR latex / Acrylic Latex (By Direct Dozing Method).

It is a terpolymer of styrene, butadiene / butyl acrylate, carboxylic acid and other functional monomers. It is manufactured by state of art emulsion polymerization technology. The first step is to ensure that reactor is clean and empty. The bottom valve of reactor is closed and then the aqueous charge is prepared. The aqueous charge comprises of de-mineralized water and other water-soluble ingredients like alkali, chelating agent etc. These ingredients are added in definite proportion and after required stirring the sample are given to laboratory. The lid of reactor is closed, and pressure test is taken with compressed air at 5Kg/cm^2. After pressure test, the pressure is vented out and series of nitrogen purging, and evacuations is carried out. Also, the required ingredients like emulsifier solution and initiator solutions are prepared in respective vessels and kept ready. The contents of the reactor are then heated to specified temperature. After achieving this temperature, the monomers (Directly from storage Vessel), emulsifier and initiator are fed continuously into reactor over a period of 4 to 6 hours. The heat then gets evolved as a result of polymerization, which is controlled by controlling the temperature of reactor by circulating chilled water through the jacket of the reactor. The reaction is continued till all monomers are consumed. Then the batch is transferred to stripper where un-reacted monomers are further made react to each other by chemical stripping. Then steam stripping is carried out to remove volatile organic content. The batch is then cooled, post incorporations are carried out and the batch is transferred to storage vessel from where it is packed either in carboys or in tankers. Temperature of the batch is in the range of 80°C to 95°C. Reaction time is about 8 hours.

2.2.1.4 Nitrile Latex

It is a co-polymer of Butadiene and Acrylonitrile. It is manufactured by conventional emulsion polymerization process. The first step is to ensure that reactor is clean and empty. The bottom valve of reactor is closed and then the aqueous charge is prepared. The aqueous charge comprises of water and other water-soluble ingredients like alkali, primary emulsifier, secondary emulsifier, chelating agent, electrolyte etc. These ingredients are added in definite proportion and after required stirring the sample are given to lab. The lid of reactor is closed and pressure test is taken with compressed air at 5 Kg/cm^2. After pressure test, the pressure is vented out and series of nitrogen purging, and evacuations is carried out. After final evacuation, monomers like acrylonitrile and butadiene are added in definite proportion. Then the whole mass is cooled. Then the initiator is added. The heat then gets evolved as a result of polymerization, which is controlled by controlling the temperature of reactor by circulating chilled brine through the jacket of the reactor. The reaction is continued till all monomers are consumed. Then un-reacted monomer namely butadiene is vented off into atmosphere with proper safety precautions and un-reacted acrylonitrile is removed by vacuum degassing. Then post incorporations are carried out and the batch is transferred to storage vessel from where it is transferred to auxiliary packing vessel and packed. Temperature of the batch is kept in the range of 20°C to 60°C. Reaction time is about 48 hours.

2.2.1.5 Nitrile Latex for Hand gloves:

It is a terpolymer of acrylonitrile, butadiene, carboxylic acid and other functional monomers. It is manufactured by state of art emulsion polymerization technology. The first step is to ensure that reactor is clean and empty. The bottom valve of reactor is closed and then the aqueous charge is prepared. The aqueous charge comprises of de-mineralized water and other water-soluble ingredients like alkali, chelating agent etc. These ingredients are added in definite proportion and after required stirring the sample are given to laboratory. Meanwhile the lid of reactor is closed, and pressure test is taken with compressed air at 5Kg/cm^2. After pressure test, the pressure is vented out and series of nitrogen purging, and evacuations is carried out. Also, the required ingredients like emulsifier solution and initiator solutions are prepared in respective vessels and kept ready. The contents of the reactor are then heated to specified temperature. After achieving this temperature, the monomers (Directly from storage Vessel), emulsifier and initiator are fed continuously into reactor over a period of 4 to 6 hours. The heat then gets evolved as a result of polymerization, which is controlled by controlling the temperature of reactor by circulating chilled water through the jacket of the reactor. The reaction is continued till all monomers are consumed. Then the batch is transferred to stripper where un-reacted monomers are further made react to each other by chemical stripping. Then steam stripping is carried out to remove volatile organic content. The batch is then cooled, post incorporations are carried out and the batch is transferred to storage vessel from where it is packed either in carboys or in tankers. Temperature of the batch is maintained from 30˚C to 70˚C. Reaction time is about 24 hours.

2.2.1.6 Latex for captive consumption to manufacture rubber

2.2.1.6.1 SL 700: It is a copolymer of styrene and butadiene. It is manufactured by conventional emulsion polymerization process. The basic manufacturing process is similar to that of VP latex. The first step is to ensure that reactor is clean and empty. The bottom valve of reactor is closed and then the aqueous charge is prepared. The aqueous charge comprises of water and other water-soluble ingredients like alkali, primary emulsifier, secondary emulsifier, chelating agent, electrolyte etc. These ingredients are added in definite proportion and after required stirring the sample are given to lab. The lid of reactor is closed, and pressure test is taken with compressed air at 5 Kg/cm^2. After pressure test, the pressure is vented out and series of nitrogen purging, and evacuations is carried out. After final evacuation, monomers like styrene and butadiene are added in definite proportion. Then the initiator is added, and batch is heated to specified temperature. This is the initial time when reaction starts. The heat then gets evolved as a result of polymerization, which is controlled by controlling the temperature of reactor by circulating water through the jacket of the reactor. The reaction is continued till all monomers are consumed. Then un-reacted monomer namely butadiene is vented off into atmosphere with proper safety precautions and un-reacted styrene is removed by vacuum degassing. Then the batch is cooled, post incorporations are carried out and the batch is transferred to storage vessel where it is used for making rubber. Temperature of the batch is kept in between 60˚C to 120˚C. Reaction time is about 8 hours.

2.2.1.6.2 BL700: It is a copolymer of styrene and butadiene. It is manufactured by conventional emulsion polymerization process. The first step is to ensure that reactor is clean and empty. The bottom valve of reactor is closed and then the aqueous charge is prepared. The aqueous charge comprises of water and other water-soluble ingredients like alkali, primary emulsifier, secondary emulsifier, chelating agent, electrolyte etc. These ingredients are added in definite proportion and after required stirring the sample are given to laboratory. The lid of reactor is closed and pressure test is taken with compressed air at 5 Kg/cm^2. After pressure test, the pressure is vented out and series of nitrogen purging, and evacuations is carried out. After final evacuation, monomers like styrene and butadiene are added in definite proportion. Then the whole mass is cooled. Then the initiator is added. This is the initial time when reaction starts. The heat then gets evolved as a result of polymerization, which is controlled by controlling the temperature of reactor by circulating chilled brine through the jacket of the reactor. The reaction is continued till all monomers are consumed. Then un-reacted monomer namely butadiene is vented off into atmosphere with proper safety precautions and un-reacted styrene is removed by vacuum degassing. Then post incorporations are carried out and the batch is transferred to storage vessel where it is used for making rubber. Temperature of the batch is in the range of $20^{\circ}C$ to $60^{\circ}C$. Reaction time is about 20 hours.

2.2.2 Manufacturing Process of synthetic rubber:

The basic manufacturing process is same for all the grades and it is described below. Two latexes namely SL 700 and BL 700 are blended in definite proportion and the blend is made for particular grade. This blend is transferred to creaming tank. In this tank, under agitation, creaming ingredients are added, and the latex gets converted into partially destabilized cream. This cream is then further transferred to coagulation tank. In this tank, sulphuric acid is added and latex gets totally separated into rubber crumb and water. The water layer formed is drained to ETP and the rubber layer that settles at bottom of reactor is passed to next process. The rubber crumb along with water overflows onto a filter cloth on which continuous washing by water spray is on and is then fed to expeller press. Here the water from rubber gets squeezed to get about 10 to 15% water content. This squeezed material is then fed to expander extruder where further dewatering takes place and totally dried material comes out of expander having water content less than 1%. The water from de-watering process goes to the ETP. The dried material is cooled in horizontal conveyor and spiral elevator by spray of air and conveyed into a silo. It is then packed into bags.

2.3.Raw water consumption

The raw water consumption for different areas in CLIENT as per the MPCB consent to operate along with the actual water consumption for one year is shown in table 2.1.

Table 2-1: Raw water consumption details of the industry as per MPCB consent.

Sr. no	**Purpose of Water Consumed**	**Water Consumption Quantity (CMD) as per the consent**	**Water consumption as per water budget sheet from April 2016 to March 2017 (in CMD)**
1.	Industrial cooling, spraying in mine pits or boiler feed	300	141
2.	Domestic purpose	54	34
3.	Processing whereby water gets polluted and pollutants are easily biodegradable	535	157
4.	Processing whereby water gets polluted and pollutants are not easily biodegradable	--	--
5.	Gardening*	47	--
Total (CMD)		**936**	**332**

** The water consumption for gardening as per water budget for one year is included in the domestic water consumption.*

As per the water consumption data submitted by the client for the month of April 2016 to March 2017, the average water consumption comes to be 332 CMD. The source of raw water consumption data is the monthly MIDC water bills for the industry. The values of water consumption for different areas is provided by the industry from the readings of the different water meters installed in the industry.

2.4.Waste Streams

2.4.1 Wastewater

The sources of trade effluent generation in the latex plant are from the washing of different process reactors and finished product tanker cleaning. On the other hand, effluent is generated from the supernatant of creaming tank and de-watering of rubber from expeller press and extruder in the rubber plant. As the production of rubber unlike latex is not continuous, the trade effluent is not generated.

Apart from the trade effluent, there is sewage generated from washrooms, lavatories, canteens, floor cleaning etc. As per the monthly data submitted by the industry regarding trade effluent generation for one year (April-2016 to March-2017), the average value of trade effluent from latex plant is 36.84 CMD, from rubber plant it is 92 CMD[2] and the average sewage generation is 11.85 CMD. As per the consent to operate by MPCB, the maximum trade effluent generation from all sources should be 435 CMD and maximum domestic effluent should be 40 CMD. Table 2.2 shows the characteristics of raw effluent from rubber and latex plant.

Table 2-2: Raw effluent characteristics from latex and rubber plant[3]

Unit	pH	COD (ppm)	TSS (ppm)	TDS (ppm)	BOD (ppm)	BOD/COD
Latex Effluent	7.54	11809	1251	737	3070	0.26
Rubber Effluent	3.15	2128	270	9715	575	0.27

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[2] The effluent generation from rubber plant is very intermittent and uneven. In the past year, rubber plant was in operation for only two months due to plant strengthening work. The rubber effluent generation of 92 CMD is the average of per day whereas for a period of two months the total effluent from rubber plant is 510 m^3.

[3] The raw effluent characteristics are the average of the results obtained during the treatability study and from external accredited laboratory analysis reports.

2.4.2 Existing Effluent Management Practices

The industry has an effluent treatment plant consisting of primary treatment, secondary (biological) treatment and tertiary treatment units. The process flow of the effluent treatment plant at CLIENT as per the observations is as shown in fig 2.1. There are two main effluent streams from the manufacturing processes of latex effluent and rubber effluent. The primary treatment of both the effluent stream is done seperately in different primary treatment units. The primary treated latex and rubber effluent are then fed to a bio-reactor which acts as a combined secondary treatment unit. The tertiary treatment unit consist of a dual media filter.

Description of existing effluent treatment process:

The existing treatment scheme of ETP as per site observations is shown in fig. 2.1. The existing effluent treatment practices at CLIENT described below is as per the site observations and verification by TIPL representatives during the study period. The primary treatment system of latex plant, consists of a raw effluent tank (as shown in fig. 2.2) in which the raw effluent from the manufacturing plant is first collected. From this tank the effluent is pumped to a primary collection tank/equalization tank shown in fig. 2.3. The primary collection tank has a hydrofoil impeller type agitator for mixing purpose having a rotational speed of 33 rpm. From the primary collection tank, the effluent is pumped to flash mixer which is also known as chemical mixing tank where chemicals such as HCl, NaOH, PAC and polyelectrolyte are added and mixed by an agitator at a speed of 70 rpm. The chemicals are added in the flash mixer from dosing tanks by manually throttling the outlet valves of dosing tanks. PAC acts as a coagulant for the charge neutralization and destabilization of the colloidal particles in the effluent. Polyelectrolyte is a flocculant which helps to coalesce the flocs to form a heavy mass which can easily settle in settling tank. HCl and NaOH are added for pH correction. Fig. 2.4 shows the picture of the flash mixer tank with chemical dosing system.

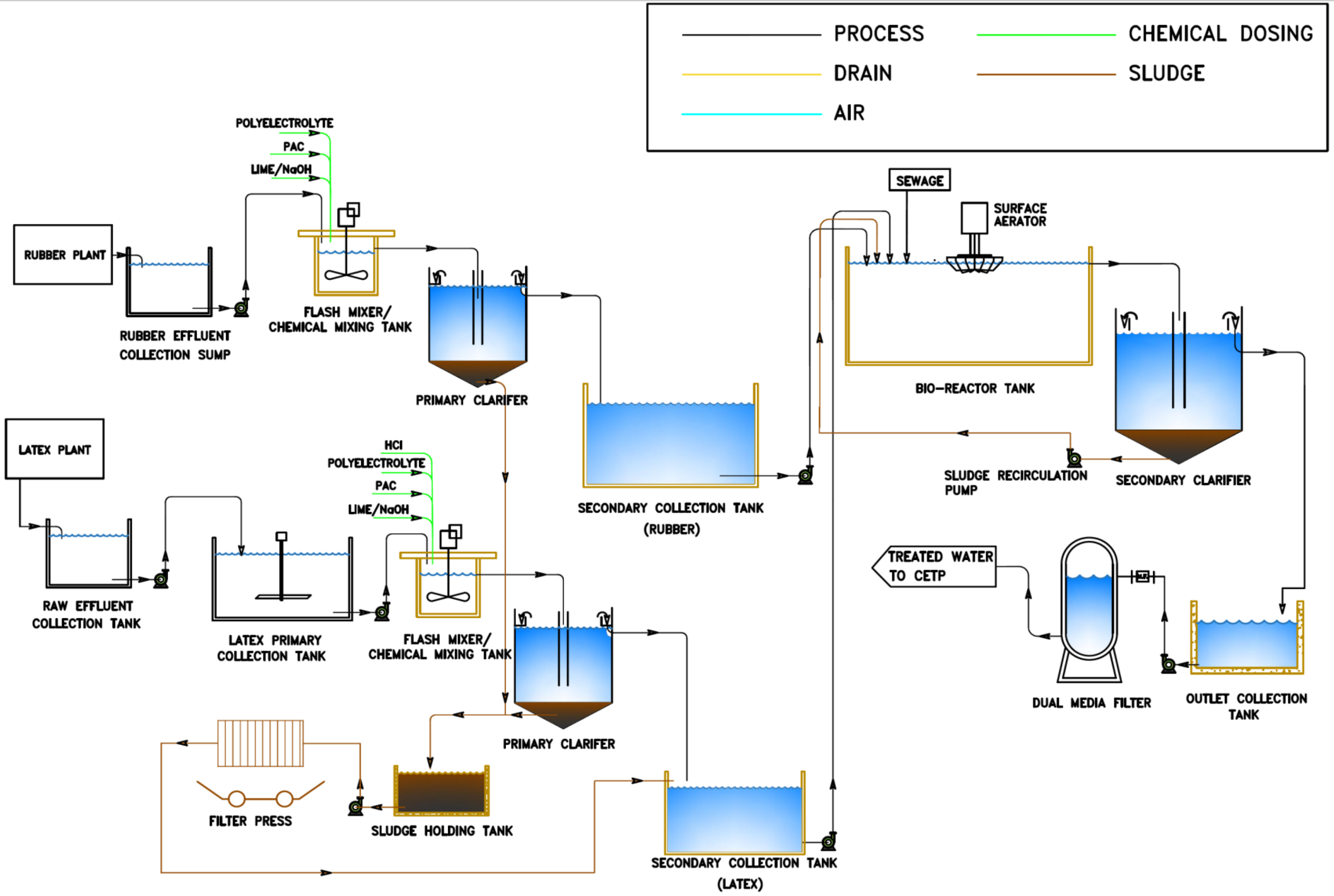

Fig. 2.1 Process flow diagram of existing ETP

Fig. 2.2: Raw latex effluent collection tank

From the chemical mixing tank, the effluent goes into a clarifier. The suspended and colloidal solids from the effluent forms flocs in the flash mixer and gets settled in the clarifier by solid liquid seperation due to gravity. The primary treated latex effluent is then collected in a secondary collection tank.

Fig. 2.3: Equalization tank of Latex effluent

Fig. 2.4: Chemical mixing tank (Flash mixer) for latex effluent

The primary treatment system of rubber plant has similar process as that of latex plant. The rubber effluent from the rubber manufacturing plant is directly pumped to the flash mixer/chemical mixing tank as there is no primary collection tank for rubber effluent. In the chemical mixing tank lime, PAC and polyelectrolyte are added for coagulation-flocculation process. The effluent from chemical mixer then goes to the clarifier for solid liquid seperation by gravity settling. The sludge gets settled at the bottom of the tank from where it is pumped to sludge holding tank. Fig. 2.5 and fig. 2.6 shows the clarifier of latex and rubber effluent respectively. The primary treated effluent is then collected in a secondary collection tank. As the temperature of raw rubber effluent is usually high about 50-60 °C, which is not suitable for feeding to bio-reactor, the industry has made an arrangement for spraying of clarified rubber effluent in the secondary collection tank as shown in fig. 2.7. As the effluent in sprayed in the form of fine droplets in the secondary collection tank, this increases the exposure and provides contact of hot effluent with atmospheric air causing it to cool down.

Fig. 2.5: Clarifier for latex effluent

Fig. 2.6: Clarifier for rubber effluent

Fig. 2.7: Secondary collection tank of rubber effluent

The primary treated latex effluent and rubber effluent from secondary collection tank are then fed to bio-rector for secondary treatment. The latex and rubber effluent are fed with equal flow rates to the bio-reactor. Also, the sewage generated from the CLIENT premises is pumped from the sewage collection tank to the bio-reactor tank. The bio-reactor has surface aerators for maintaining the dissolved oxygen level in the bioreactor. Surface aerators push water from under the water's surface up into the air, then the droplets fall back into the water, mixed with oxygen. Fig. 2.8 shows the pictorial view of bio-reactor tank with the surface aerator in operation. The bacterial culture in the bioreactor degrades the organic matter in the incoming wastewater and further reduces the COD/BOD of the effluent by oxidizing the organic matter to CO_2 and H_2O. The overflow from the bioreactor goes into a secondary clarifier (fig. 2.9) where the bio-solids gets separated from the liquid by gravity settling. The clear effluent after secondary treatment is stored in a final collection tank.

The sludge generated from the primary clarifiers of rubber and latex and the waste sludge from secondary clarifier is collected in a sludge holding tank. From the sludge holding tank, the sludge is pumped to filter press for sludge de-watering. Fig. 2.10 shows the picture of filter press used for sludge-dewatering at the ETP of the industry. The liquid separated from the wet sludge in the filter press flows to the secondary collection tank from which it goes to the bio-reactor.

Fig. 2.8: Bio-reactor tank with surface aerator

Fig. 2.9: Secondary clarifier

Fig. 2.10: Filter press for sludge de-watering

The effluent from the final collection tank is pumped to a dual media filter as shown in fig. 2.11. The dual media filter contains beds of gravel, pebble, graded sand and activated carbon. The sand layer traps the minute suspended matter which may be carried over from secondary clarifier and the activated carbon layer removes the color and odor from the effluent. The treated effluent after passing through dual media filter is discharged to CETP. The industry has installed a magnetic flowmeter to measure the quantity of effluent discharged to CETP. An online meter for monitoring of treated effluent characteristics is also installed prior to final discharge.

DUAL MEDIA FILTER DETAIL

PARTICULARS	DETAILS
TYPE	DUAL MEDIA FILTER
MODE OF OPERATION	MANUAL
DESIGN FLOW RATE	$15\ m^3/hr$
NORMAL OPERATING PRESSURE	$3.5\ kg/cm^2$
DESIGN	$7.0\ kg/cm^2$
PRESSURE VESSEL DIAMETER	1200 mm
HEIGHT (HOS)	2000 mm
MATERIAL OF CONSTRUCTION OF VESSEL (SHELL & DISH)	M S
THICKNESS OF SHELL	8 mm WITH HAND HOLE
THICKNESS OF DISH	10 mm WITH MANHOLE & 3" LEG SUPPORT ON BOTTOM OF THE DISH
HADDER	75 N B
LATTER	25 N B
OUTSIDE PIPE LINE	75 N B
VALVE	5 Nos . BUTTERFLY VALVE
FILTER MEDIA	GRADED SAND, GRAVEL AND PEBBLES CARBON WITH LODINE VALUE > 1000
INTERNALLY	BLACK EPOXY
EXTERNALLY	RED OXIDE WITH FEROZI BLUE PAINT
BACKWASH FLOW RATE	$15\ M^3/hr$
DURATION OF BACKWASH	20 mins.

Fig 2.11: Dual media filter before final disposal to CETP

Chapter 3 : Treatability Study

3.1.Primary Treatability Study

Objectives:

Following were the objectives of the primary treatability study:

- To carry out jar tests to choose the best coagulant and flocculant for pre-treatment of the effluent generated in the company
- To determine optimum dosages of coagulant and flocculant for highest reduction in TSS and COD
- To assess the temporal variation in the raw effluent to understand the maximum pollution load to the ETP and the average persisting organic load

3.2. Materials and instruments:

Table 3.1 illustrates the list of instruments, apparatus, chemicals, and reagents used for the primary treatability studies.

Table 3-1: Instruments and apparatus

PARAMETER	INSTRUMENTS and APPARATUS	CHEMICALS/REAGENTS
pH	➢ pH meter ➢ pH paper	HCl/ NaOH
Total Dissolved Solids (TDS)[4]	➢ TDS meter ➢ Evaporating dish ➢ Oven ➢ Desiccators ➢ Analytical balance ➢ Graduated cylinder ➢ Dish Tongs ➢ Whatman filter paper (1.5 µm)	

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[4] Standard Analysis Procedure as per IS 3025 for TDS

Total Suspended Solids (TSS)[5]	➢ Evaporating dish ➢ Oven ➢ Desiccators ➢ Analytical balance ➢ Graduated cylinder ➢ Dish Tongs ➢ Whatman filter paper (1.5 µm)	
Dosage optimization	➢ Jar apparatus	➢ Alum ➢ Ferric Chloride ➢ Ferrous Sulphate ➢ Poly-Aluminium Chloride (PAC) ➢ Lime ➢ HCl ➢ Polyelectrolyte.
Chemical Oxygen Demand (COD)[6]	➢ COD digester ➢ Burette and stand ➢ COD vials with stand ➢ 250ml conical flask ➢ Pipettes, with sucker ➢ Wash Bottles, etc.	➢ Mercuric Sulphate ➢ Silver Sulphate ➢ Ferrous Ammonium Sulphate ➢ Ferroin Indicator ➢ Distilled water ➢ Conc. H_2SO_4

3.2.Methodology: -

i. Sample Collection and preparation

The raw effluent samples of composite type (rubber and latex) were collected from the raw effluent collection tank. As the HRT of raw latex effluent collection tank is about 2 days, composite sampling was done by collecting samples directly from collection tank. In case of rubber effluent, the quality of effluent doesn’t change periodically as the source of effluent generation is from a same process. The raw effluent samples were collected and analyzed for pH, TSS, TDS, COD.

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[5] Standard Analysis Procedure as per IS 3025 for TSS

[6] Standard Analysis Procedure as per IS 3025 for COD

ii. pH adjustment

After collection of latex effluent sample from the effluent collection tank, the pH of the latex effluent sample was noted and brought down in the range of 4.5-5 by addition of 50% concentrated Hydrochloric Acid (HCl). It was observed during jar tests that the flocs formation and settling was better after addition of HCl. After addition of HCl the pH was again raised to 8.5 to 9 by lime/NaOH addition. The lime and NaOH solution of 10% were prepared for jar tests. For rubber effluent, the pH of raw effluent was in the range of 3 to 4. Therefore, no acid was added to drop the pH, only lime solution was added to bring pH in the range of 8.5-9.

The jar tests were performed at the pH of 8.5-9 so that the pH of the supernatant after jar test becomes neutral.

iii. Dose optimization

The coagulant dose optimization was done by using a jar test apparatus. The apparatus had a provision of six jars. The jar tests were performed in 500 ml jars; various coagulants as mentioned in table 3.1 were tried for the jar tests. Cationic polyelectrolyte was used as a flocculant for the jar test. The concentration of coagulants used in this study was 10 % and that of flocculant it was 0.1 %.

Following procedure was adopted for performing the jar test.

- Initially the collected samples were analyzed for pH, TSS, TDS and COD.
- After detailed characterization of the samples, one-liter sample was taken in each jar.
- Before proceeding for jar test, the pH was adjusted to the desired level using HCl and NaOH/Lime.
- Coagulant was added in varying quantities to respective jars and rapid mixing was done with the help of the jar test apparatus. The speed of the stirrer was adjusted to 120 rpm during the rapid mixing for 2 minutes.
- After 2 minutes, the speed was reduced to 20 rpm and polyelectrolyte was added to all the jars in equal amount.
- The slow mixing at 20 rpm was continued for 10 minutes. After 10 minutes, the flocs were allowed to settle for duration of 30 minutes.

- The observations such as type of sludge and its volume, visual appearance of the supernatant in each jar was noted down.

iv. **Analysis of samples.**

The supernatant from different jars obtained from the Jar tests were analyzed for parameters such as pH, TSS, TDS, COD. The analysis was done as per the standard procedures in the plant's laboratory.

3.4. Jar test Results

A series of Jar tests were performed as a part of primary treatability studies. As the effluent generated from latex plant and rubber plant is treated in different primary treatment units, primary treatability studies were done separately for both the effluent.

The raw effluent samples of composite nature were collected from the primary collection tank of latex and rubber effluent. Different trials were conducted using HCl, NaOH and Lime for pH correction with varying dosages of chemicals. The coagulants- Alum, Poly Aluminium Chloride (PAC), Ferrous Sulphate and Ferric Chloride were experimented with varying dosage to find out the best coagulant with optimum dose giving maximum TSS and COD reduction.

3.4.1. Jar test results on Latex effluent:

Table 3.2 shows the results of the Jar test trials on the latex effluent. The results showed in the table 3.2 are the optimum results out of number of trials conducted on the particular day with different coagulants. The raw effluent characteristics, chemical dosage and the characteristics of the primary treated effluent is shown in the table 3.2. Out of the four coagulants, the reduction (COD and TSS) with Ferric chloride, Alum and PAC was more or less similar. It can be seen from the results that the acid dose of 1 ml of 50% HCl per litre of effluent was adequate and as the acid dose was increased upto 2-4ml with same amount of coagulant dose there were no significant changes in terms of TSS and COD. From the trial on second day, it was observed that among lime and caustic, lime gave better results in terms of COD reduction and dense sludge formation with same amount of coagulant dose. The sludge generation was also about 40 % by volume as observed in the jar tests.

The optimum dosage of coagulant (Alum, PAC or Ferric Chloride) obtained from the series of jar tests conducted was in the range of 600-800 ppm and lime dose of 400 ppm was found to be adequate. The average COD reduction of around 97% was obtained and the TSS reduction upto 85% was obtained. This shows that most of the COD in the raw latex effluent is due to the particulate matter and the dissolved COD is very low as compared to particulate COD.

Fig. 3.1 and fig. 3.2 shows the images of some of the trials after jar test on latex effluent with different coagulants at 600 and 800 ppm dosages with a fixed flocculant dosage of 2 ppm.

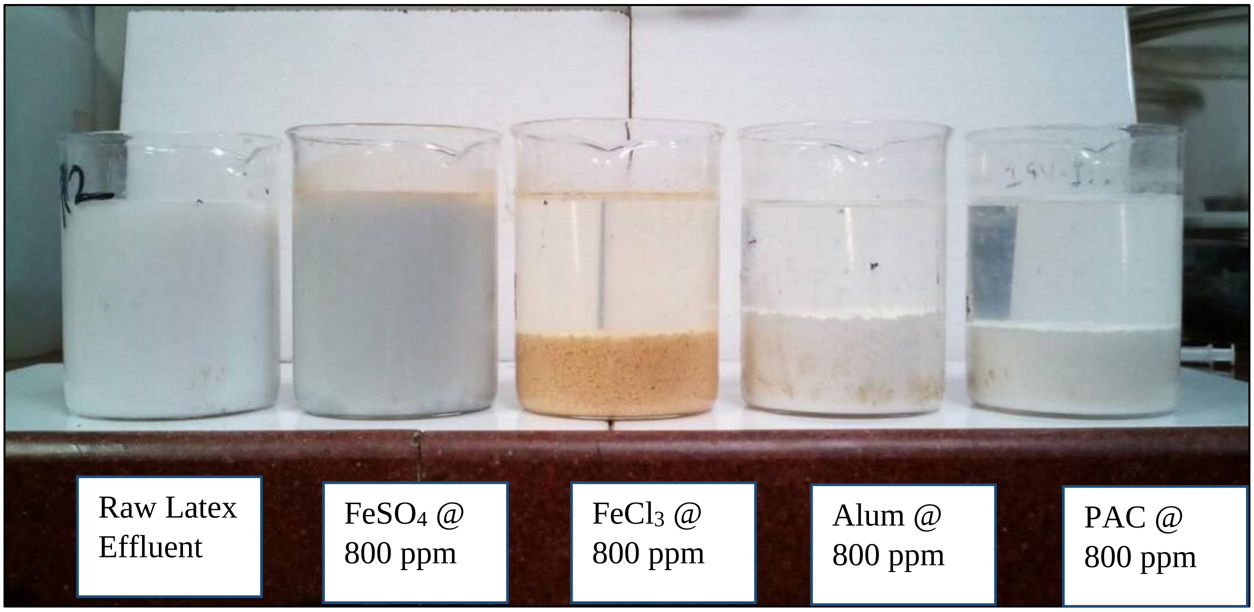

Fig. 3.1: Jar test (Day 3 sample) on latex effluent with different coagulant dosages with a fixed flocculant dosage of 2 ppm

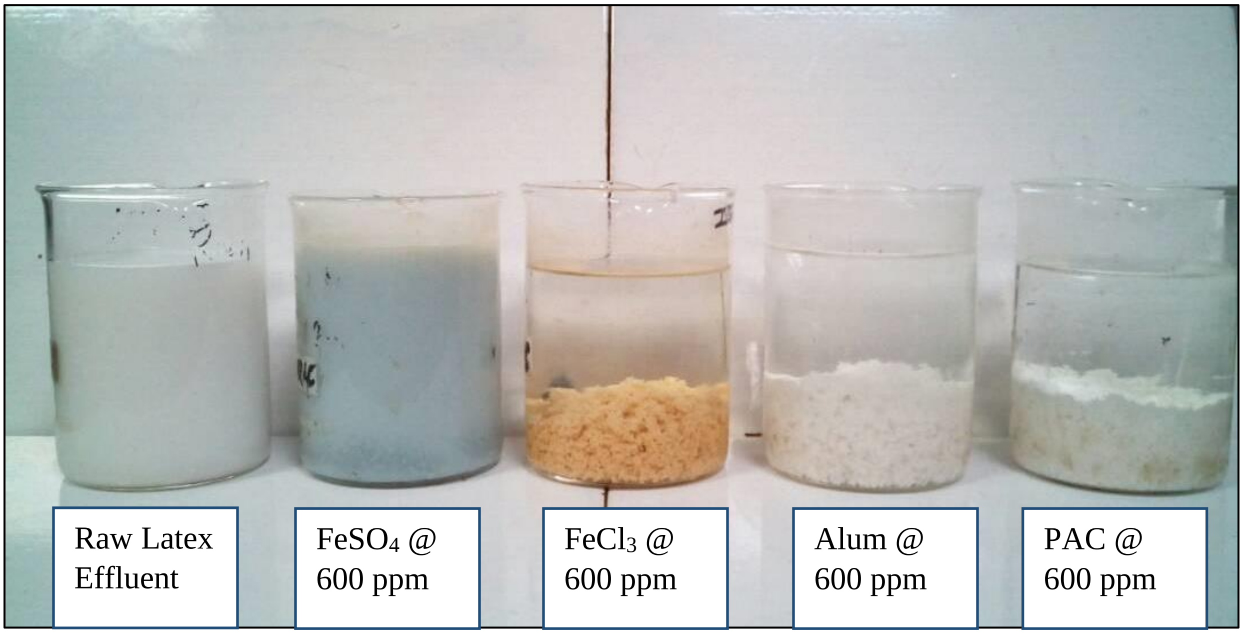

Fig. 3.2: Jar test (Day 4 sample) on latex effluent with different coagulant dosages with a flocculant dosage of 2 ppm.

Table 3-2: Consolidated results of the Jar test on latex effluent

Day	Raw effluent characteristics				Acid Dose (50%) in ml.	Coagulant Dose (ppm)	Lime/ NaOH Dose (ppm)	Flocculant Dose (ppm)	Primary treated effluent characteristics			
	pH	COD (mg/l)	TSS (mg/l)	TDS (mg/l)					pH	COD (mg/l)	TSS (mg/l)	TDS (mg/l)
Day 1	8.15	9820	846	701	6	PAC-600	NaOH-800	2	7.27	348	380	1160
Day 2	7.51	12880	3600	752	1	Alum-800	Lime-800	2	6.85	208	440	1204
					1	PAC-800	Lime-800	2	6.79	176	480	1164
					1	Alum-800	NaOH-100	2	6.83	404	620	1312
					1	PAC-800	NaOH-100	2	6.73	432	410	1322
					1	$FeSO_4$- 800	NaOH-100	2	7.23	1056	1240	1284
Day 3	8.15	13200	1220	653	1	$FeCl_3$-800	Lime-400	2	7.12	304	180	1242
					1	Alum-800	Lime-400	2	7.24	320	220	1198
					1	PAC-800	Lime-400	2	7.41	352	240	1176
					1	$FeSO_4$- 800	Lime-400	2	7.82	1280	350	1152

Table 3.2: Consolidated results of the Jar test on Latex effluent (continued)

Date	Raw effluent characteristics				Acid Dose (50%) in ml.	Coagulant Dose (ppm)	Lime/ NaOH Dose (ppm)	Flocculant Dose (ppm)	Primary treated effluent characteristics			
	pH	COD (mg/l)	TSS (mg/l)	TDS (mg/l)					pH	COD (mg/l)	TSS (mg/l)	TDS (mg/l)
Day 4	7.36	17920	1146	645	1	$FeCl_3$-600	Lime-400	2	7.09	320	248	1140
					1	Alum-600	Lime-400	2	6.98	368	308	1210
					1	PAC-600	Lime-400	2	7.14	400	320	1230
					1	$FeSO_4$-600	Lime-400	2	7.46	864	568	1090
Day 5	7.04	10408	1124	653	1	$FeCl_3$-600	Lime-800	2	7.42	342	246	1092
					1	Alum-600	Lime-800	2	7.12	368	232	1130
					1	PAC-600	Lime-800	2	7.33	372	180	1120
					1	$FeSO_4$-600	Lime-400	2	7.88	764	802	1040
Day 6	8.91	9846	564	1079	4	$FeCl_3$-400	Lime-600	2	6.99	240	184	2320
					4	Alum-400	Lime-600	2	6.87	266	202	2130
					4	PAC-400	Lime-600	2	6.81	278	166	2210
					4	$FeSO_4$-400	Lime-600	2	7.7	964	422	1765

Table 3.2: Consolidated results of the Jar test on Latex effluent (continued)

Date	Raw effluent characteristics				Acid Dose (50%) in ml.	Coagulant Dose (mg/l)	Lime/ NaOH Dose (mg/l)	Flocculant Dose (mg/l)	Primary treated effluent characteristics			
	pH	COD (mg/l)	TSS (mg/l)	TDS (mg/l)					pH	COD (mg/l)	TSS (mg/l)	TDS (mg/l)
Day 7	5.63	8586	256	679	2	$FeCl_3$-400	Lime-400	2	7.29	198	150	1280
					2	Alum-400	Lime-400	2	7.09	232	120	1260
					2	PAC-400	Lime-400	2	6.99	212	130	1240
					2	$FeSO_4$- 400	Lime-400	2	7.41	872	216	1190

Fig. 3.3 shows graphical representation of performance of different coagulants with respect to COD and TSS reduction of latex effluent.

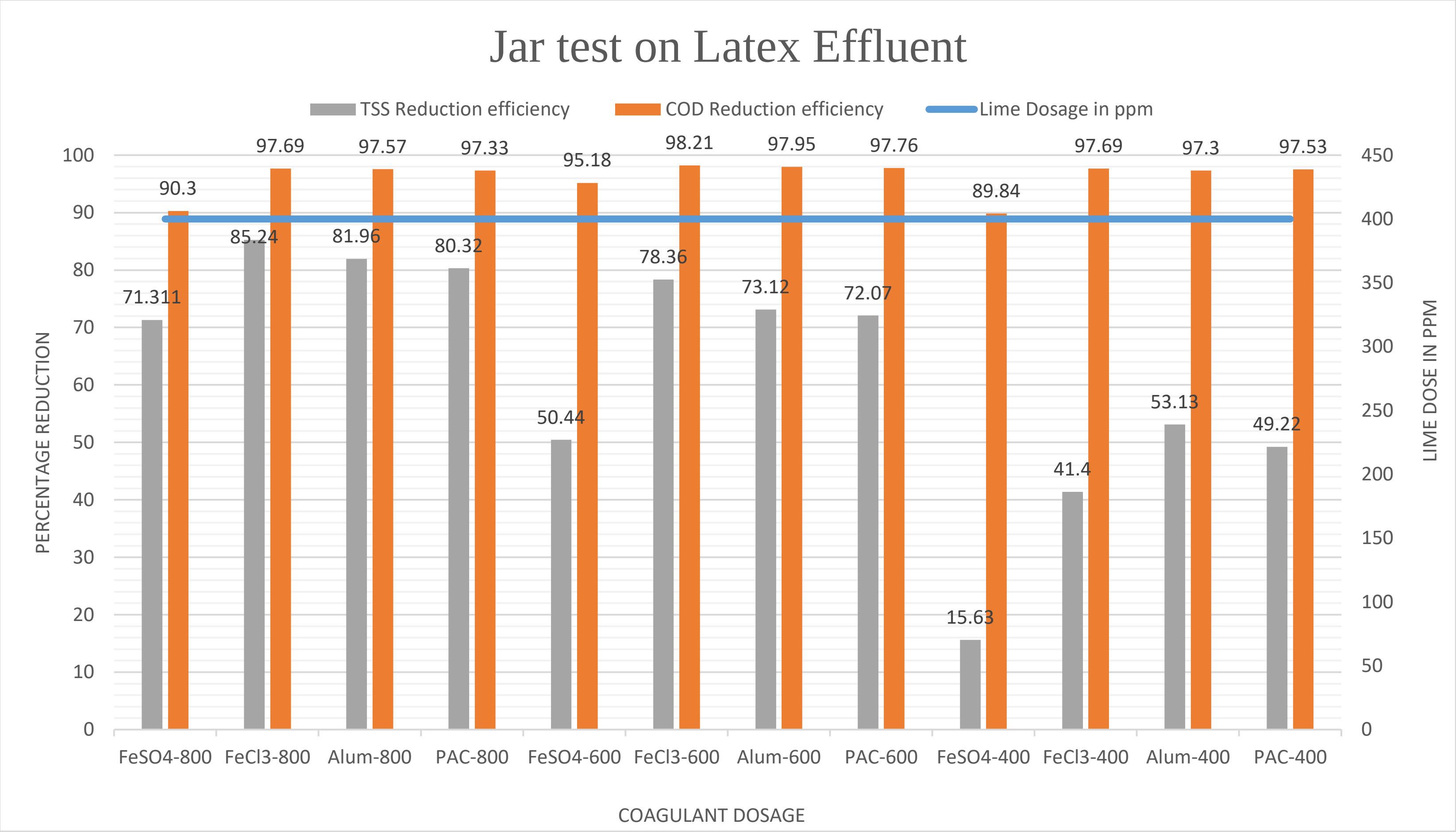

Fig. 3.3: COD and TSS reduction with respect to different coagulants for latex effluent with a flocculant dosage of 2 ppm.

The fig. 3.4 represents the average COD reduction and average TSS reduction for latex effluent with the four coagulants as obtained from the Jar tests. Out of the four coagulants used, except Ferrous Sulphate rest of the coagulants didn't show any appreciable difference in the results in terms of TSS and COD reduction. The difference in COD reduction efficiency using ferrous sulphate as compared to other coagulants seems low (5-6%). However, from the absolute values of COD as shown in table 3.2 there is much difference in the clarified effluent COD with ferrous sulphate as compare with other coagulants.

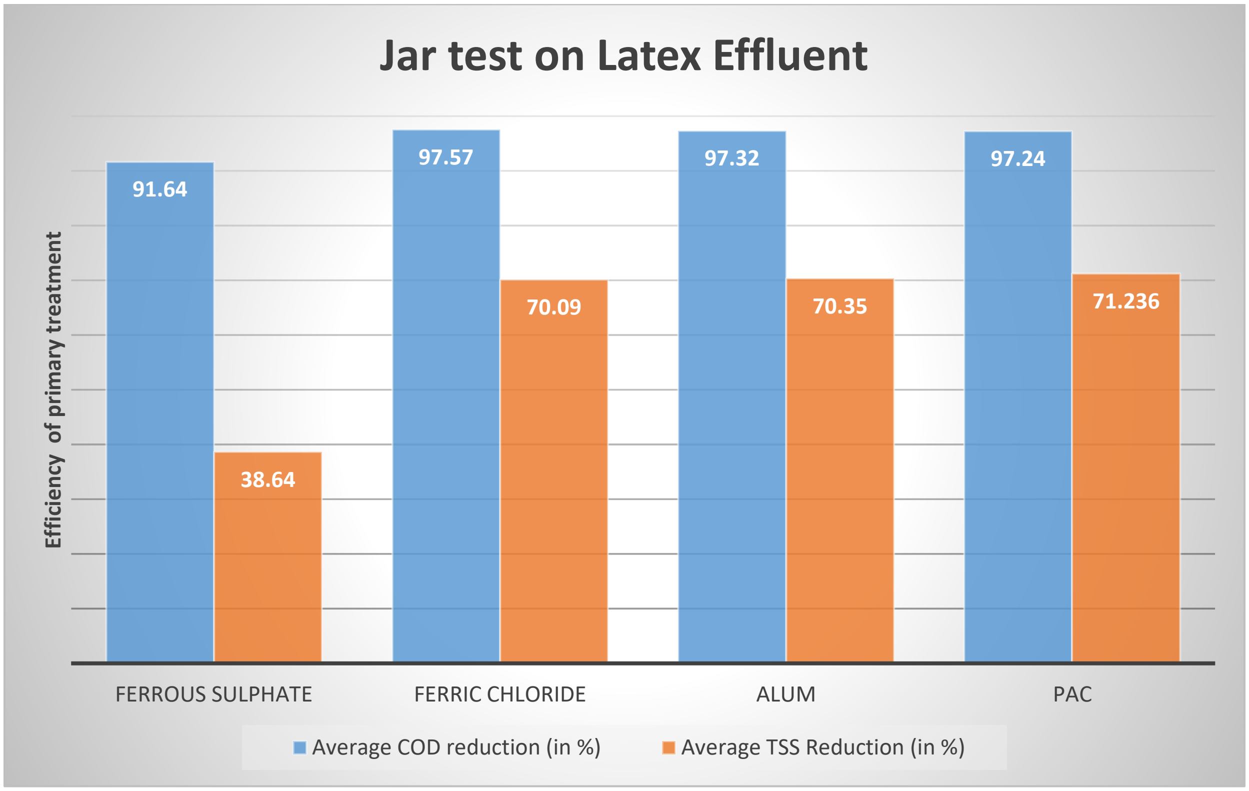

Fig. 3.4: COD and average TSS reduction by four different coagulants on latex effluent

3.4.2. Jar test results on Rubber effluent:

The Jar tests on rubber effluent were carried out using the coagulants Ferrous Sulphate, Alum, Ferric Chloride and PAC. Fig. 3.5 and fig. 3.6 shows the images of jar test trials on rubber effluent with different coagulants and dosage. The consolidated optimum results obtained from multiple trials of jar tests on rubber effluent is shown in table 3.3. It can be seen from the table that the raw effluent from rubber plant is acidic in nature. The TSS and COD of the raw rubber effluent stream is quite low as compared to the latex effluent, whereas the TDS is higher. Lime/ Caustic was used only for pH correction and significant changes on TSS and COD reduction was not observed with varying dosage of lime keeping same dose of coagulant.

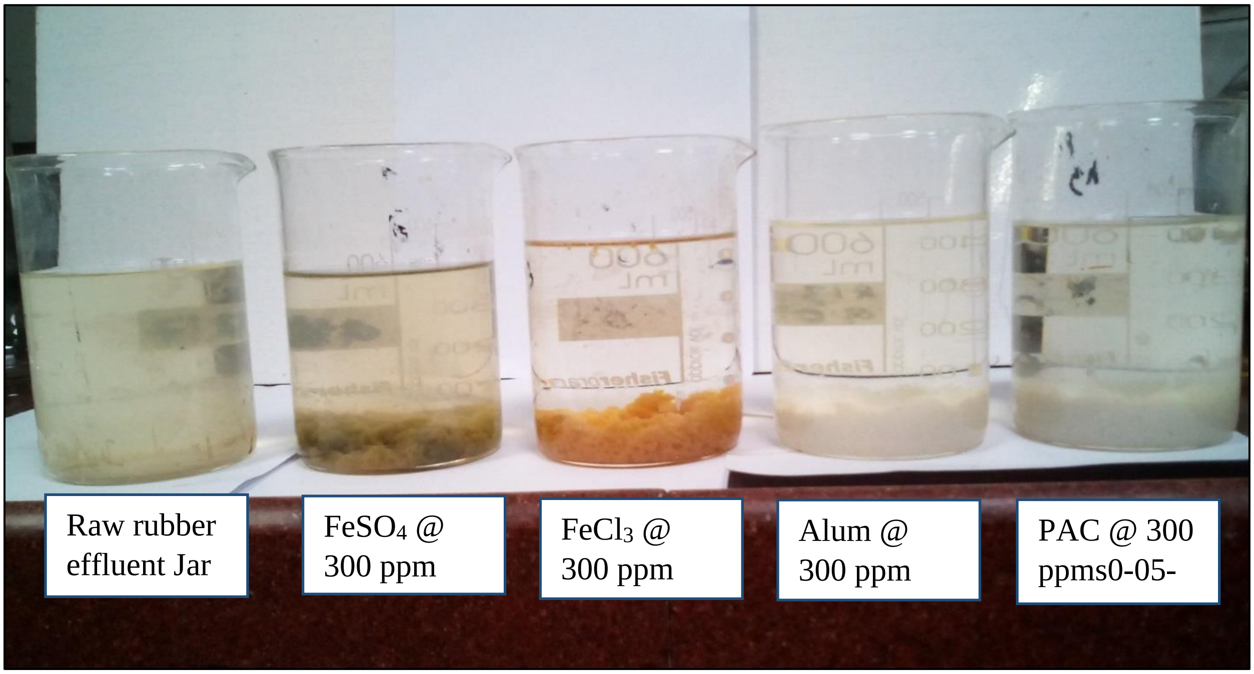

Fig. 3.5: Jar test (Day 6 sample) on rubber effluent with different coagulants with a flocculant dosage of 1 ppm.

Amongst the four coagulants, best results were obtained in the jar tests by Alum and PAC as can be seen from the fig.3.8 showing comparison of four coagulants with respect to COD and TSS reduction efficiency. From the graph, it can be noted that there is not much difference in percentage reduction of COD and TSS with alum as compared to PAC. Also, from the table 3.3 it can be noted that the absolute values of TSS and COD for treated effluent with alum and PAC don’t have much difference. COD reduction of around 60% and TSS reduction upto 35% was obtained in the jar tests. The adequate dose obtained were 300 ppm alum/PAC, 200 ppm lime and 1 ppm polyelectrolyte. It was observed that polyelectrolyte dose of 1 ppm was enough for effective flocculation of the flocs. Some trials were conducted using caustic for pH correction in place of lime. With caustic, the COD reduction was comparatively less as compared with lime. Also, better clarity in supernatant was observed with lime as compared with caustic.

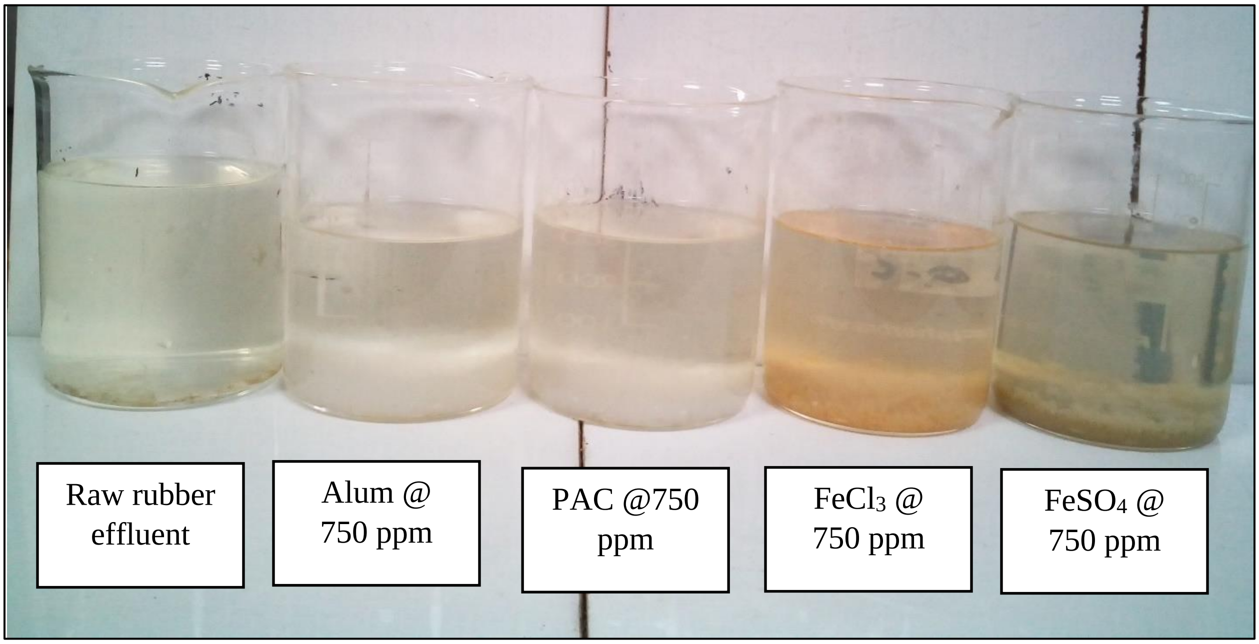

Fig. 3.6 Jar test (Day 5 sample) on rubber effluent with different coagulants with a flocculant dosage of 1 ppm.

Table 3-3: Consolidated results of Jar test on Rubber effluent

Day	Raw effluent characteristics				Coagulant Dose (mg/l)	Lime/NaOH Dose (mg/l)	Flocculant Dose (mg/l)	Primary treated effluent characteristics			
	pH	COD (mg/l)	TSS (mg/l)	TDS (mg/l)				pH	COD (mg/l)	TSS (mg/l)	TDS (mg/l)
Day 5	3.13	2196	320	9580	Alum-750	Lime-500	1	7.28	768	184	8780
					PAC-750	Lime-500	1	6.93	788	200	9180
					$FeSO_4$-750	Lime-500	1	7.56	1568	280	8880
					$FeCl_3$- 750	Lime-500	1	7.13	1021	210	9010
Day 6	3.16	2059	220	9850	Alum-300	NaOH-200	1	6.71	916	198	8790
					PAC-300	NaOH-200	1	7.03	955	160	9030
					$FeSO_4$-300	NaOH-200	1	7.31	1741	190	9050
					$FeCl_3$- 300	NaOH-200	1	6.83	936	175	9080
					Alum-300	Lime-200	1	6.65	736	144	8650
					PAC-300	Lime-200	1	6.89	848	132	8980

Fig. 3.7 and fig. 3.8 shows the graphical representation of the Jar test results on the rubber effluent.

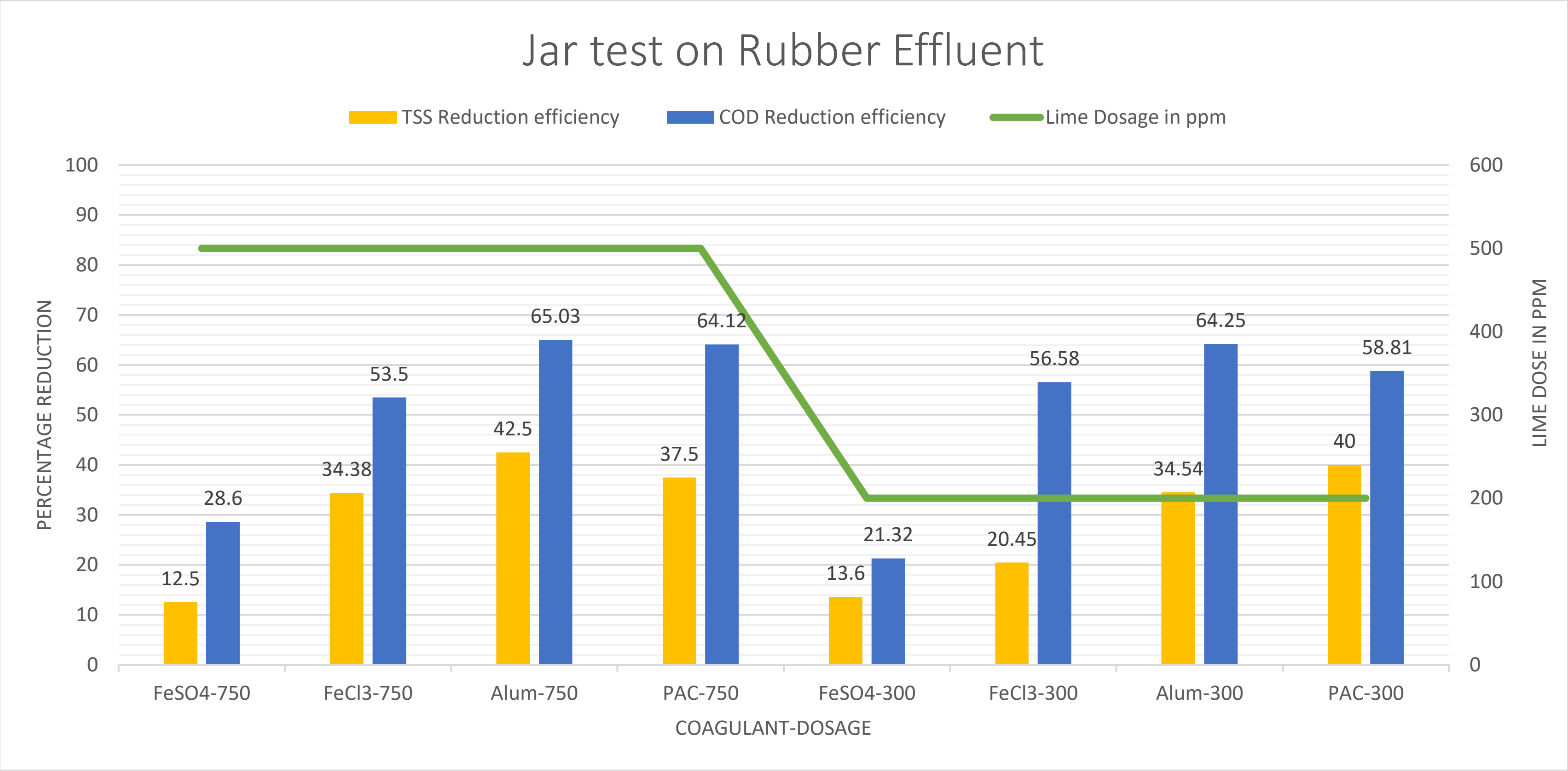

Fig. 3.7: COD and TSS reduction with respect to different coagulants for rubber effluent with a flocculant dosage of 1 ppm.

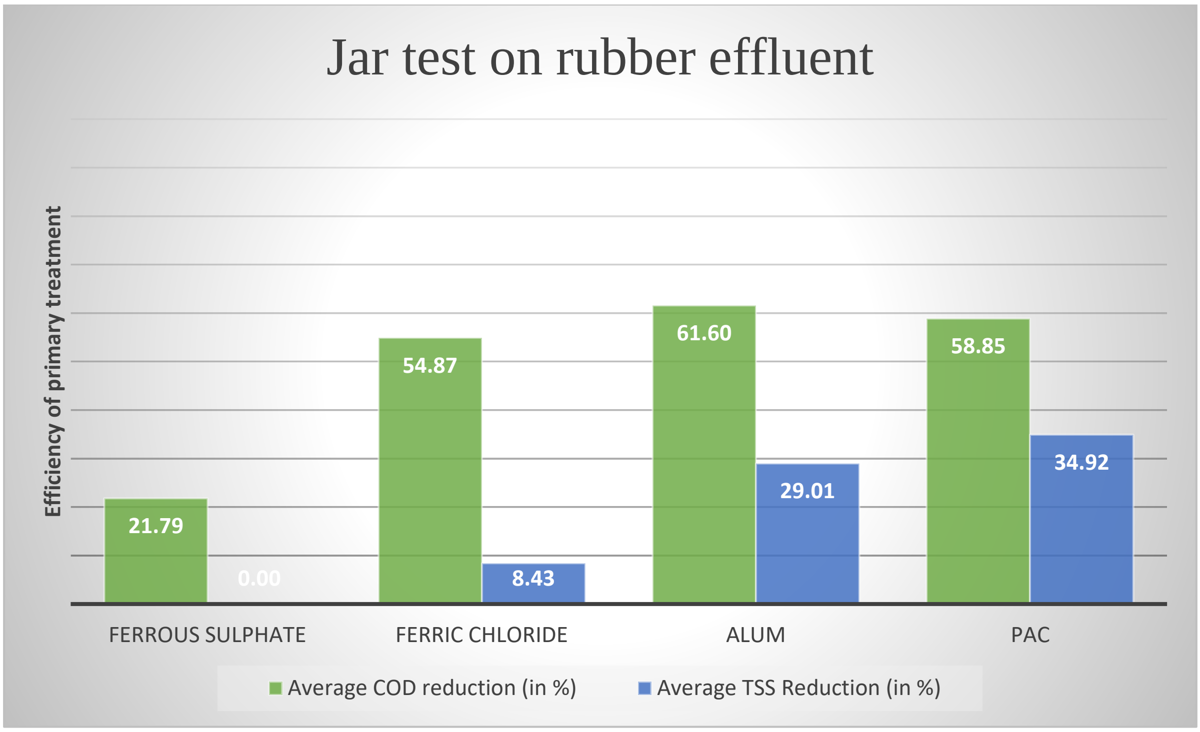

Fig. 3.8: Graph of average COD and average TSS reduction by four different coagulants on rubber effluent

3.5.Concluding Comments from primary treatability studies

After primary treatability study on both latex and rubber effluent samples, it was found that for latex effluent coagulants- Alum, PAC and Ferric chloride gave almost close results in terms of COD reduction (61.6%, 58.85% and 54.87% respectively). The TDS increase was also in the same range for all the coagulants tried. Lime was found more suitable than caustic for pH correction. It was noted that HCl is also required for the primary treatment of latex effluent as a pH dropping agent before lime dosing so that the final pH of treated effluent becomes neutral. The optimum dose of coagulant for latex effluent was found to be in between 600 to 800 ppm, lime dose of 400 ppm and the optimum dose of polyelectrolyte was found to be 2 ppm. HCl (50%) dose of 1ml per 1000 ml was found to be adequate. The maximum COD and TSS reduction efficiency of latex effluent in jar tests was found to be 97% and 85% respectively.

In case of rubber effluent best results were obtained using Alum or PAC as a coagulant. There was not much difference in COD and TSS reduction using Alum and PAC. Lime gave better results over caustic for COD reduction. The adequate dose of coagulant for rubber effluent was found to be 300 ppm, lime dose of 200 ppm and that of polyelectrolyte was found to be 1 ppm. The maximum COD and TSS reduction efficiency of rubber effluent sample was found to be 60 % and 40 %.

As can be seen from the figure 3.1, 3.2, 3.5 and 3.8, the sludge generation in the primary treatment of latex effluent is about 40-50% by volume of raw effluent and for rubber effluent it is 10-20% by volume of raw effluent. There is not much difference in the volume of sludge generated by different coagulants like Alum, PAC and ferric chloride at same dosage. The nature of sludge like fluffy or dense etc. changes with the effluent quality. It was observed that with proper mixing and chemical dosing the sludge formed is uniform and dense in nature.

The pH of the primary treated effluent was in the range of 6.5 to 7.5 which is favorable for the secondary biological treatment. Therefore, no pH correction is needed for primary treated effluent if the dosing is done as per the jar tests.

3.6.Secondary Treatability Study

The secondary treatability study was carried out for the latex and rubber effluent. For conducting the study, three laboratory scale batch bio-reactors were prepared replicating the activated sludge process (ASP) in batch mode.

3.6.1. Objectives:

The objectives of the Laboratory scale study are highlighted below-

- To assess the COD reduction efficiency with respect to bio mass concentration and hydraulic retention time for primary treated latex and rubber effluent.
- To assess the maximum organic load handling capacities of the bio reactors and to determine the maximum ratio in which rubber and latex effluent can be fed to the bioreactor.
- To determine the optimum HRT required in order to treat the primary treated effluent for highest COD reduction.
- To determine the range for the MLSS that must be maintained in order to achieve highest percentage of reduction in the organic load.

Table 3-4: Materials and instruments for secondary treatability study

TESTS	INSTRUMENTS and APPARATUS	CHEMICALS/REAGENTS
pH	➢ pH meter ➢ pH paper (0-14 range)	Conc. HCl/ NaOH
Total Dissolved Solids (TDS)	➢ TDS meter	
Mixed liquor suspended solids (MLSS) and Mixed Liquor Volatile Suspended solids (MLVSS)[g]	➢ Evaporating dish ➢ Oven ➢ Desiccators ➢ Glass funnel (75mm, 100 mm) ➢ Analytical balance ➢ Graduated cylinder (100 ml) ➢ Forceps. ➢ Whatman filter paper (1.5 µm) ➢ Porcelain crucibles ➢ Crucible tongs ➢ Muffle furnace	
Chemical Oxygen Demand (COD)	➢ COD digester ➢ Burette and stand ➢ COD vials with stand ➢ 250ml conical flask ➢ Pipettes, with sucker ➢ Wash Bottles, etc.	➢ Mercuric Sulphate ➢ Silver Sulphate ➢ Ferrous Ammonium Sulphate ➢ Ferroin Indicator ➢ Distilled water ➢ Conc. H_2SO_4
Dissolved Oxygen (DO)[h]	➢ 300 ml DO bottle ➢ Burette (25 ml) ➢ Burette stand ➢ Pipette (5ml and 10 ml) ➢ Conical flask (250 ml) ➢ Measuring cylinder (100-250 ml) ➢ Wash bottles.	➢ Manganous sulphate solution. ➢ Alkali iodide azide reagent. ➢ Concentrated sulphuric acid. ➢ Starch indicator. ➢ Sodium thiosulphate solution. ➢ Distilled water.

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[g] Standard Analysis Procedure as per IS 3025 for MLSS and MLVSS

[h] Standard Analysis Procedure as per IS 3025 for DO

3.6.2. Methodology-

i. Sample Preparation

In the existing ETP, the primary treated latex and rubber effluent are fed in equal volume to the bioreactor. For this study, primary treated latex and rubber effluent were mixed in a proportion of 1:1 and treatability study was done on the mixed effluent.

ii. Description of Laboratory scale Activated Sludge Process(ASP) batch reactor

Three laboratory scale ASP batch reactors of 50 liters capacity without sludge recycling system were made available. Fig 3.9 shows the laboratory scale batch reactors which were used for the secondary treatability study. Compressed air was purged into the reactor in order to maintain a dissolved oxygen level between 2-4 mg/l required for proper bacterial growth. For proper air diffusion, stone diffusers as shown in figure 3.10 were attached to the compressed air line and placed at the bottom of the pilot bioreactors.

Fig. 3.9: Pilot scale bio-reactors with compressed air line

iii. Seeding and start-up:

For reactor start-up, it is important that the sludge gets slowly acclimatized to the incoming wastewater. This process is called seeding of the sludge. Activated sludge was collected from the existing ETP, since the sludge used in the existing plant is already accustomed to the effluent characteristics. For this study, the return activated sludge was taken from return sludge line of secondary clarifier of existing ETP and seeded into the batch reactor. For first 1-2 days, the sludge was allowed to get acclimatized by adding 5-10% by volume of primary treated effluent to the aeration tank along with jaggery as a food source. Compressed air was supplied to the bioreactor, to suffice the oxygen requirement of the microorganisms.

For the start-up phase, the mixed latex and rubber primary treated effluent was fed to the respective bio-reactors having different MLSS concentration. The study was carried out at MLSS concentrations of 2000 ppm, 3000 ppm and 4000 ppm.

Fig. 3.10: Stone type diffusers used in the pilot bio-reactor.

iv. Wastewater characterization

Following parameters were analyzed for the primary treated wastewater before feeding to the pilot bioreactor.

- pH
- Chemical oxygen demand (COD)
- Total suspended solids (TSS)

- Total dissolved solids (TDS).

The primary treated water was then fed into each laboratory scale batch bio-reactor. At different time intervals, the samples were withdrawn from the bio-reactor and was analyzed for pH, Chemical oxygen demand (COD), Total dissolved solids (TDS), Mixed liquor suspended solids (MLSS), Mixed liquor volatile suspended solids (MLVSS), Sludge volume index (SVI) and Dissolved oxygen (DO).

3.6.3. Results of laboratory scale ASP study

3.6.3.1. Secondary treatability results on 1:1 proportion of Latex and rubber effluent:

In the first trial, the primary treated latex and rubber effluent were mixed in the ratio of 1:1 before feeding to the pilot bio-reactor.

The table 3.5-3.7 shows the results of the secondary treatability studies on the latex and rubber effluent in 1:1 proportion.

At, MLSS of 2000 mg/l, the maximum COD reduction obtained was 49.22% at HRT of 36 hours. The MLVSS/MLSS ratio was maintained to 0.6 and DO was also between 2-3 mg/l which indicates a healthy environment for the microbial culture in the pilot bio-reactor. From the values of SVI, it can be inferred that the sludge is dense and has rapid settling rates. A typical image of settled sludge in measuring cylinder is shown in figure 3.11.

Table 3-5: Results obtained at MLSS of 2000 mg/l for 1:1 latex and rubber effluent.

Parameters	Units	Hydraulic Retention Time (Hrs.)				
		0	12	18	24	36
pH	No units	7.76	7.76	7.76	6.82	7.3
TDS	ppm	7540	8820	8250	7820	8540
TSS	ppm	754	684	400	230	232
TSS reduction Efficiency	%	---	9.28	46.95	69.50	69.23
COD	ppm	1024	624	586	548	520
COD reduction Efficiency	%	---	39.06	42.77	46.48	49.22
MLSS	ppm	1980	2120	2248	2428	2428
MLVSS	ppm	1188	1290	1370	1260	1428

MLVSS/MLSS	No units	0.6	0.61	0.61	0.52	0.59
Dissolved Oxygen	mg/l	2.4	2.6	2.6	2.4	2.1
Sludge volume index	ml/g	49	47	53	45	49

At MLSS of 2000 mg/l, the maximum COD reduction of about 49% was obtained at HRT of 36 hrs. The TSS reduction was also observed. The results are not satisfactory for disposal under compliance.

Table 3-6: Results obtained at MLSS of 3000 mg/l for 1:1 latex and rubber effluent.

Parameters	**Units**	**Hydraulic Retention Time (Hrs.)**				
		0	**12**	**18**	**24**	**36**
pH	No units	7.21	7.28	7.24	7.42	7.42
TDS	ppm	7020	6740	6200	5840	5470
TSS	ppm	684	562	280	170	150
TSS reduction Efficiency	%	---	17.84	59.06	75.15	78.07
COD	ppm	910	510	473	406	340
COD reduction Efficiency	%	---	43.96	48.02	55.38	62.64
MLSS	ppm	2920	3080	3226	3140	3264
MLVSS	ppm	1752	1910	1940	1870	1980
MLVSS/MLSS	No units	0.6	0.62	0.60	0.60	0.61
Dissolved Oxygen	mg/l	2.3	2.3	2.4	2.4	1.9
Sludge volume index	ml/g	66	65	68	64	67

At MLSS of 3000 mg/l, the maximum COD reduction of about 62.64% was obtained at HRT of 36 hrs. The TSS reduction was also good after 24 and 36 hours which is about 75%.

Table 3-7 Results obtained at MLSS of 4000 mg/l for 1:1 latex and rubber effluent.

Parameters	Units	Hydraulic Retention Time (Hrs.)				
		0	**12**	**18**	**24**	**36**
pH	No units	7.14	7.59	7.51	8.07	7.32
TDS	ppm	7940	8450	8380	7670	6180
TSS	ppm	648	520	240	190	48
TSS reduction Efficiency	%	---	19.75	62.96	70.67	93.75
COD	ppm	624	460	373	225	125
COD reduction Efficiency	%	---	26.28	40.22	63.94	79.97
MLSS	ppm	4120	4160	4108	4244	4308
MLVSS	ppm	2472	2620	2670	2540	2508
MLVSS/MLSS	No units	0.6	0.63	0.65	0.60	0.58
Dissolved Oxygen	mg/l	2.4	2.9	2.2	2.1	2.2
Sludge volume index	ml/g	79	70	80	73	77

At MLSS of 4000 mg/l, the maximum COD reduction of about ~80% was obtained at HRT of 36 hrs. The TSS reduction was also good after 36 hours which is about 93%.

Fig. 3.11: Typical mixed liquor sample from the pilot bioreactor.

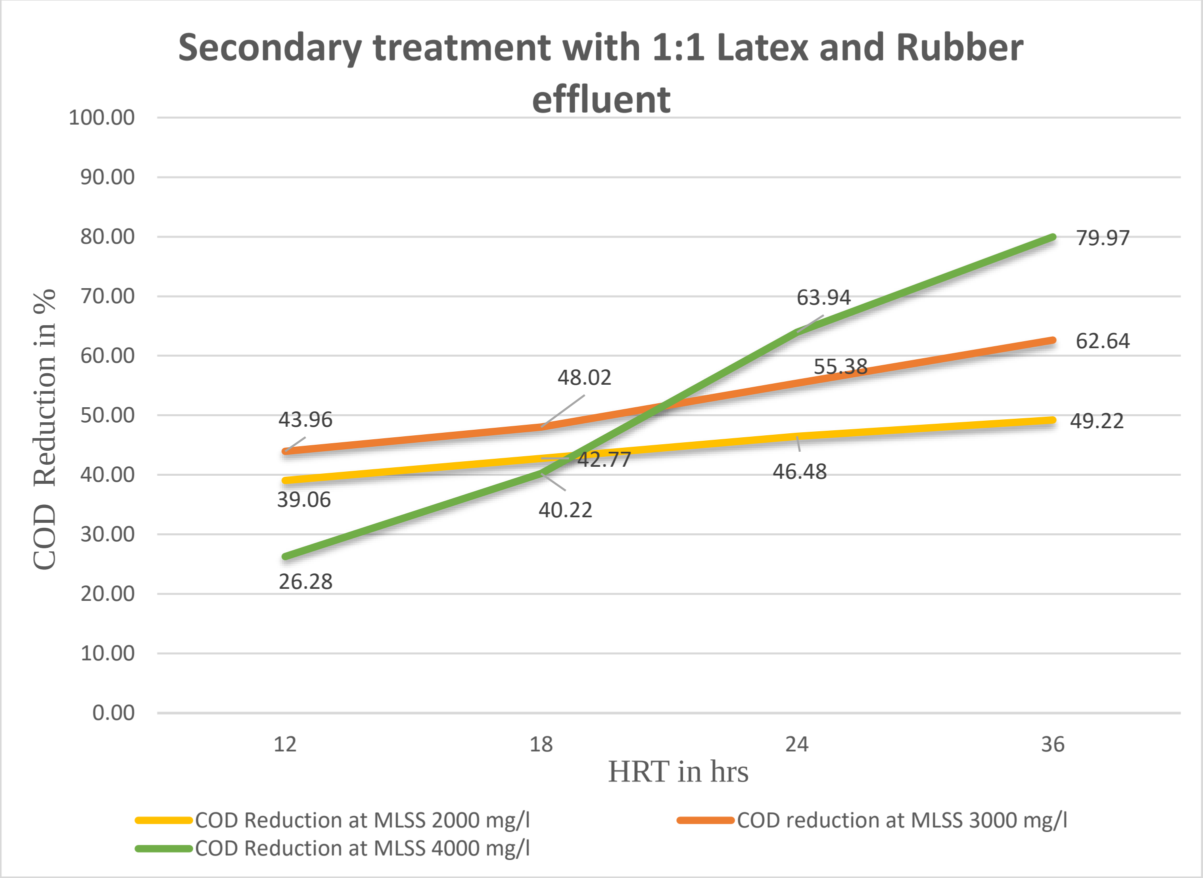

Fig. 3.12: COD reduction in secondary treatability study on 1:1 Latex and Rubber effluent

From the COD reduction graph shown in fig. 3.12, for 1:1 ratio of rubber and latex effluent, it can be inferred that best result (80 % COD reduction) is obtained at MLSS of 4000 mg/l and HRT of 36 hours. In the first 18 hours, the COD reduction is low at MLSS 4000 mg/l as compared with MLSS 2000 mg/l and 3000 mg/l. But after 24 hours there is an increase in the rate of COD reduction (64 %) with MLSS of 4000 mg/l. It can be noted from table 3.7 that COD value of below 250 mg/l which is within permissible limit by MPCB is achieved after 24 hours with 4000 mg/l MLSS. The values of percentage COD reduction for 2000, 3000 and 4000 mg/l at different time intervals can be seen from the graphs in fig. 3.13, fig. 3.14 and fig. 3.15 respectively. The graph shows polynomial curve of COD reduction trend along with the equation of curves. To get the highest correlation between the plotted data polynomial equation with second order is fitted. The fitted curve gives the COD reduction values at any time in between 12 hrs to 36 hrs which would be close to the actual values obtained experimentally.

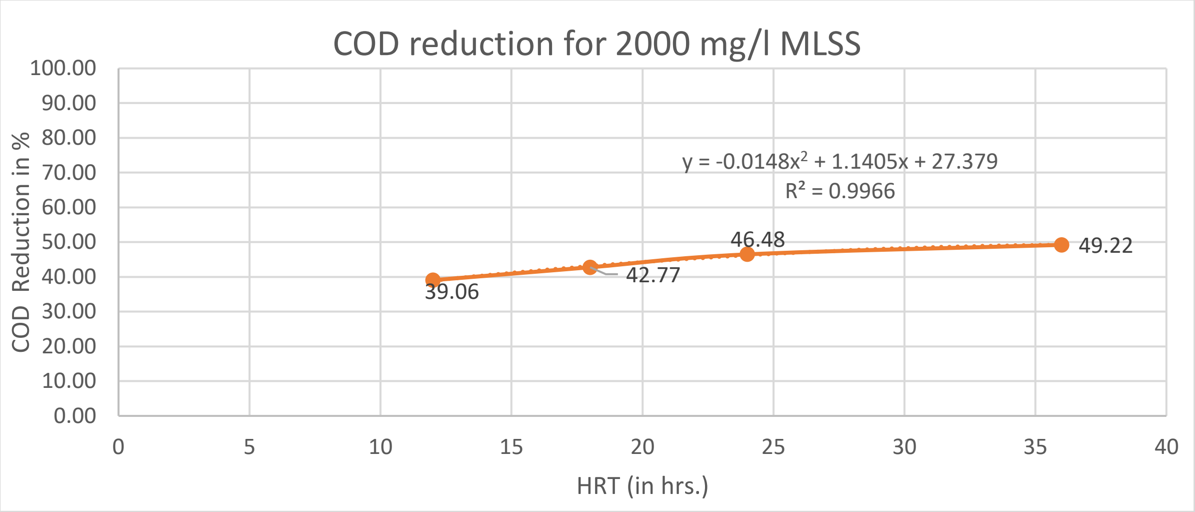

Fig. 3.13: COD reduction against HRT for a MLSS of 2000 mg/l.

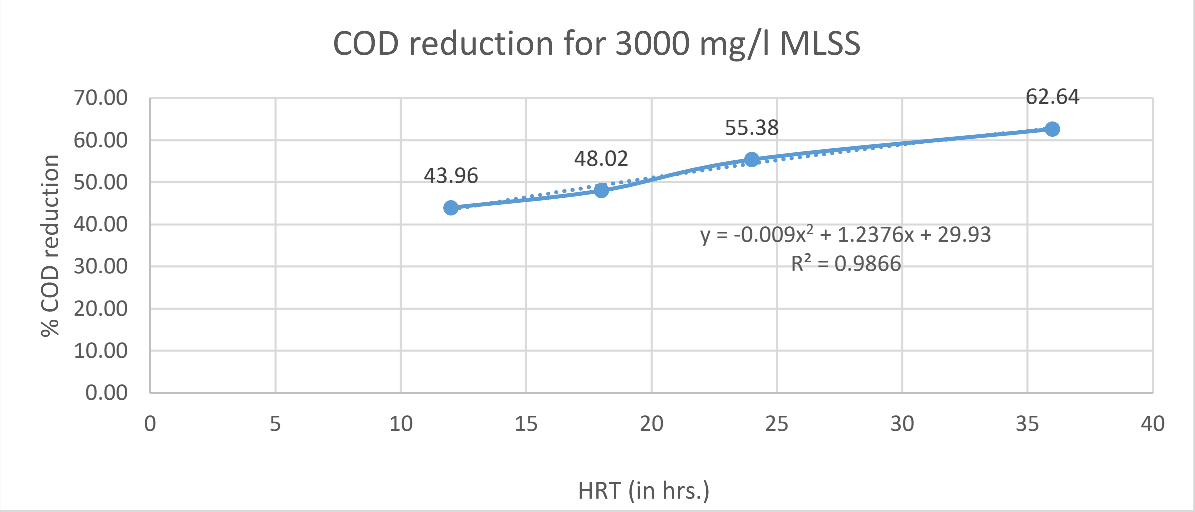

Fig. 3.14: COD reduction against HRT for a MLSS of 3000 mg/l.

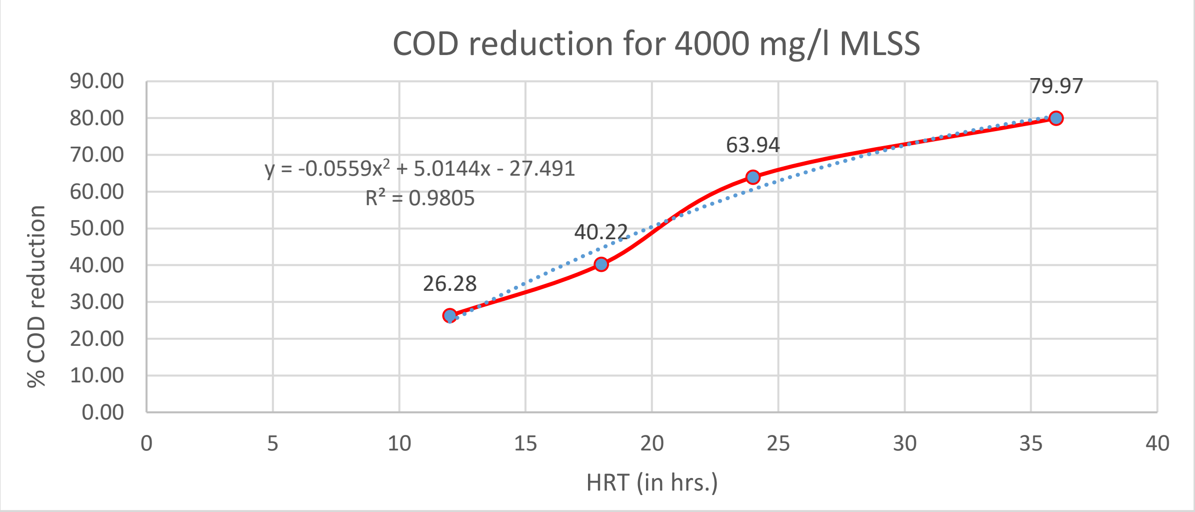

Fig. 3.15: COD reduction against HRT for a MLSS of 4000 mg/l.

From the equations on graphs of percentage COD reduction against HRT for different MLSS values, graphs of percentage COD reduction against MLSS at particular HRT can be plotted as shown in fig. 3.16-3.19, all the curves are parabolic in nature which is showing that the downward trend as the MLSS is growing which is a bit of contradiction in reality since more the MLVSS/MLSS higher the metabolic rate & COD removal. The downward trend of the COD reduction curves at higher values of MLVSS can be attributed to experimental uncertainty or sampling error. Due to lack of ample data, the projection of the curve for 22 hrs is considered to interpret the practical outcomes as the projections from curves for 18 hrs to 22 hrs shows declining trend in COD reduction due to experimental error.

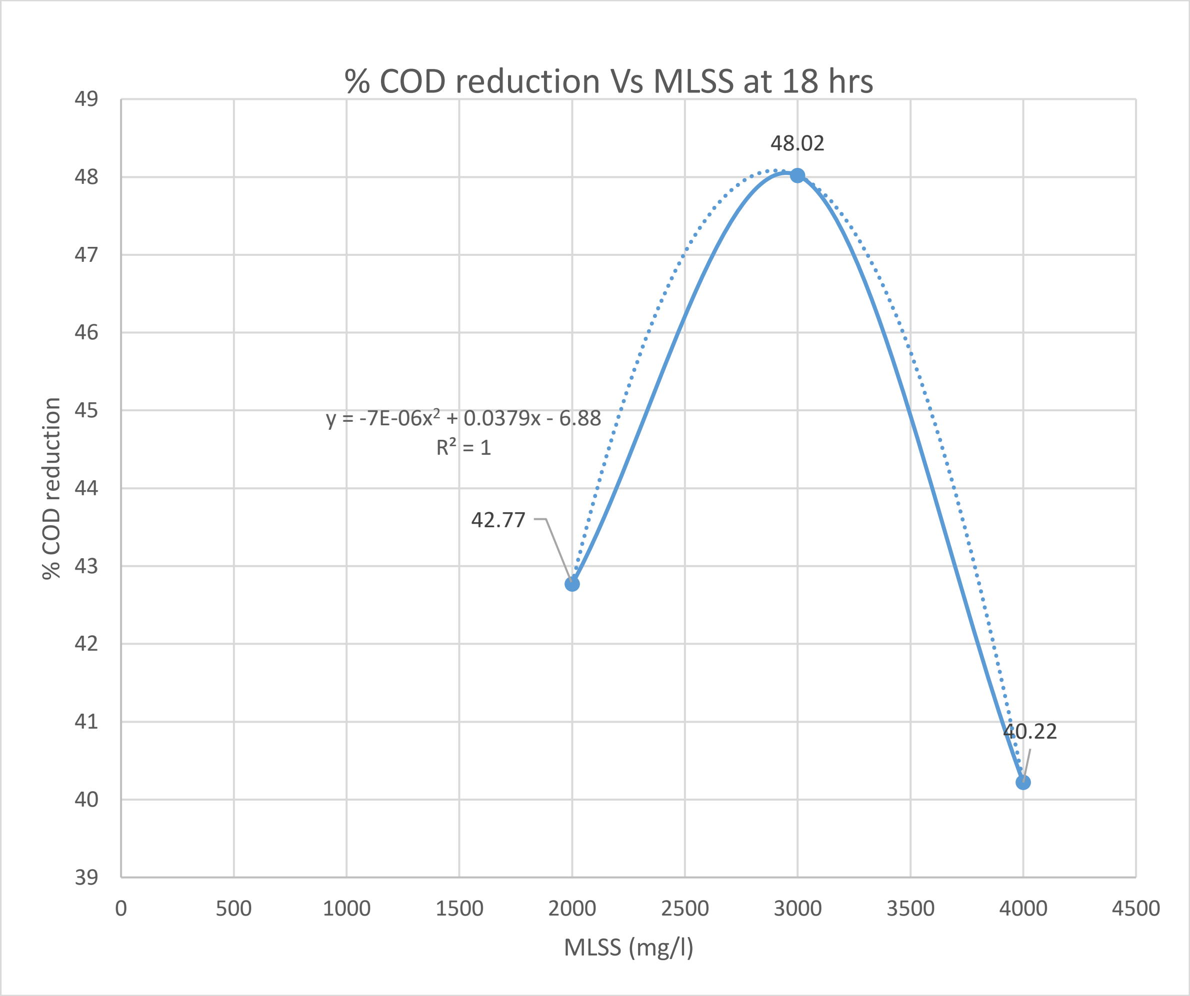

Fig. 3.16: COD reduction against MLSS at 18 hrs.

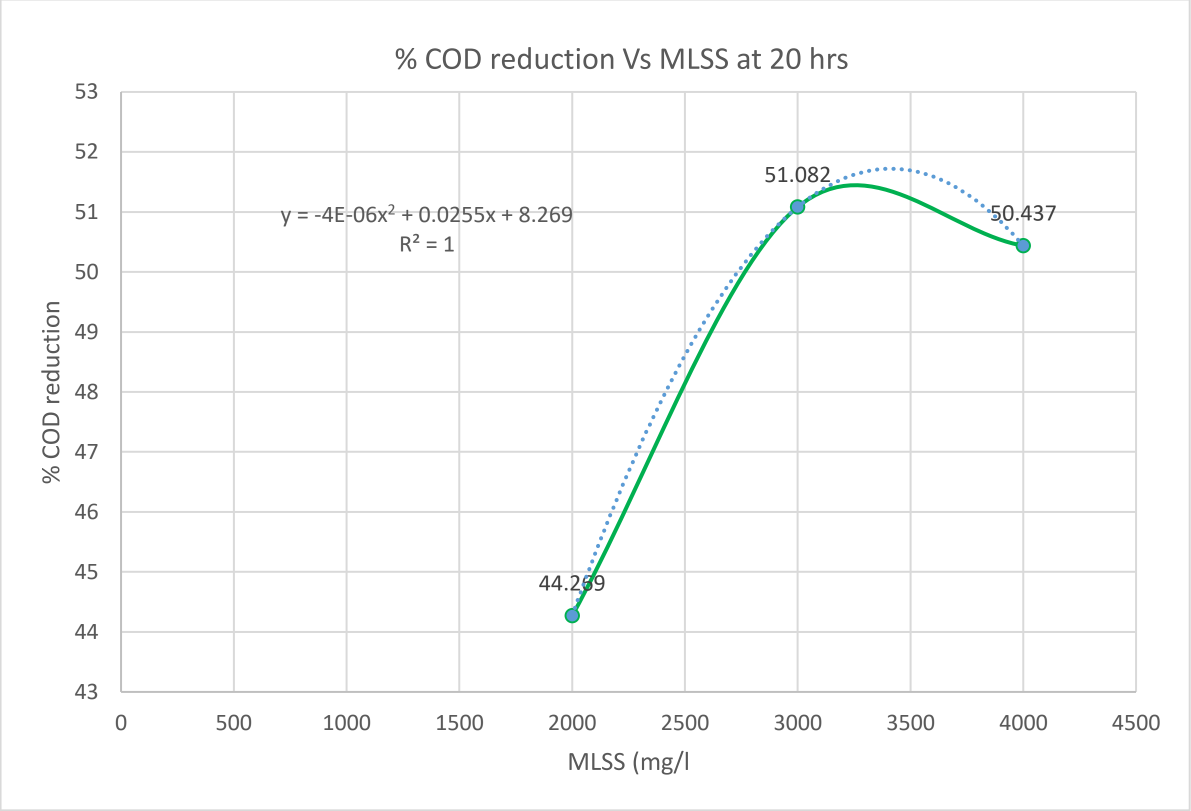

Fig. 3.17: COD reduction against MLSS at 20 hrs.

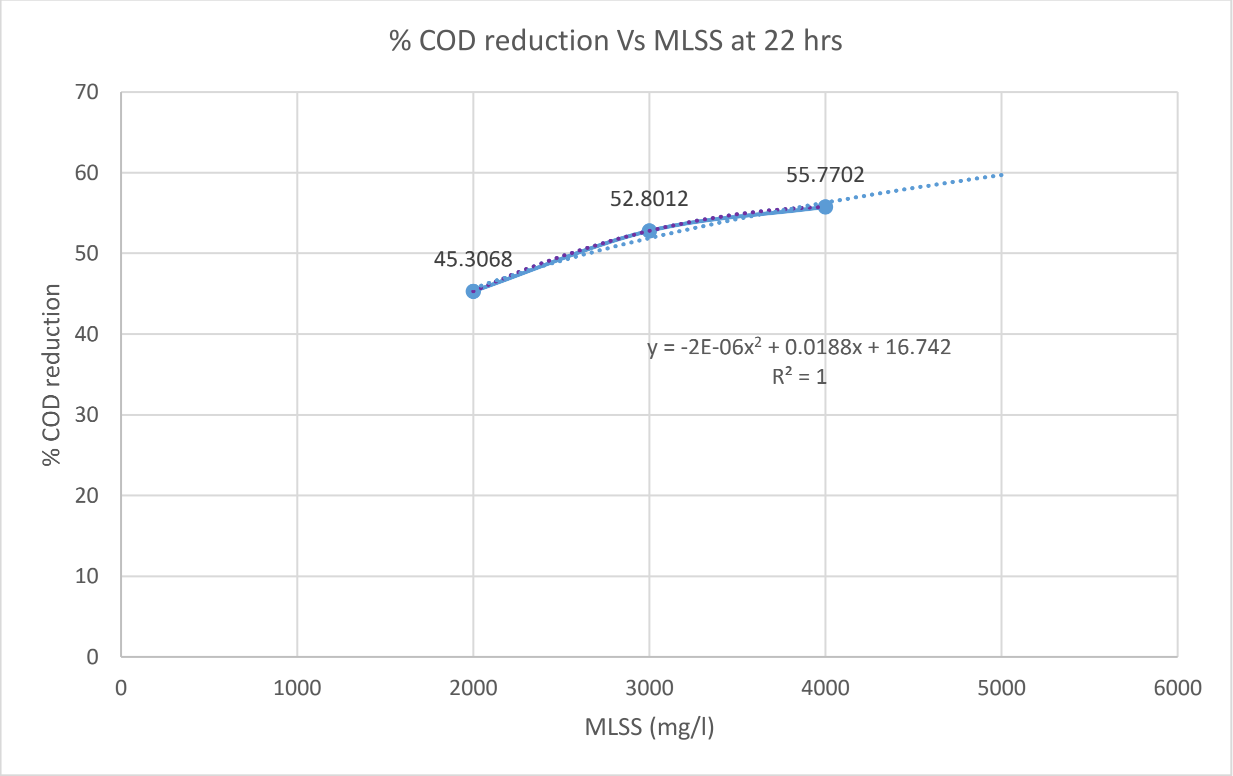

Fig. 3.18: sCOD reduction against MLSS at 22 hrs.

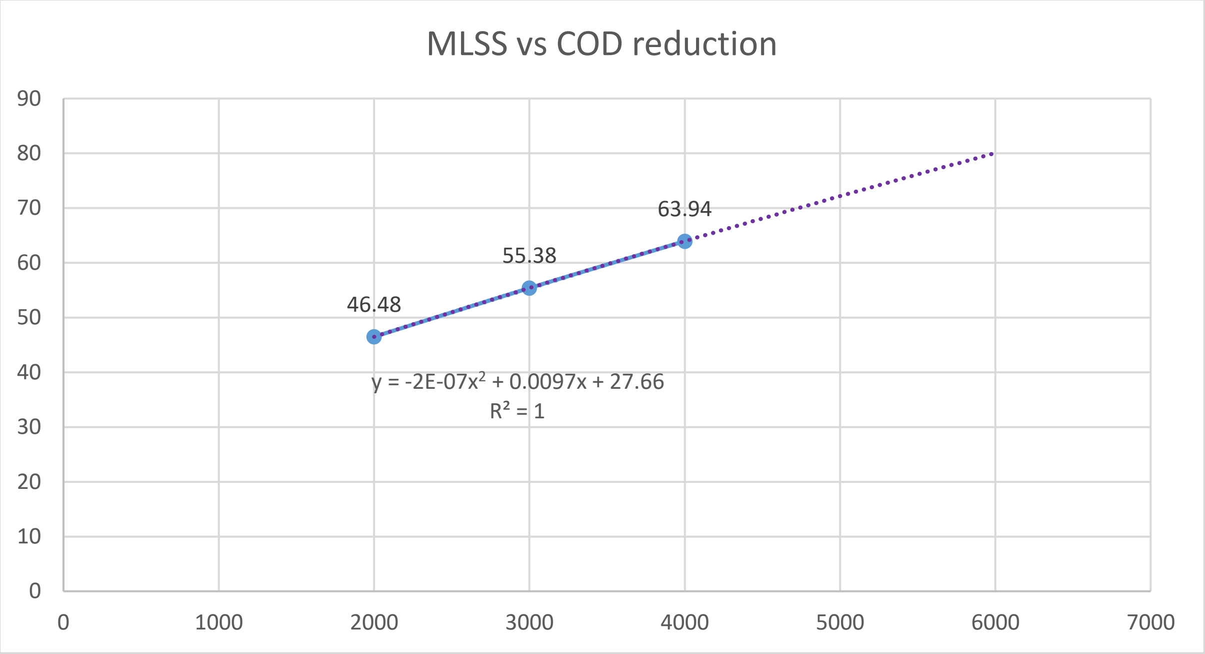

Fig. 3.19: COD reduction against MLSS at 24 hrs.

The COD reduction values from the graph of percentage COD reduction against MLSS at HRT of 22 hrs. and 24 hrs. are extrapolated to 5000-6000 mg/l MLSS as shown in fig. 3.18 and fig. 3.19. The value of COD reduction at higher MLSS can be obtained by extrapolation with minimum deviation (about 1-2 %) from the actual values as the curve is derived from experimentally determined values at 2000, 3000 and 4000 mg/l of MLSS. Also, the curve is extrapolated only upto practically achievable values of MLSS i.e. 5000-6000 mg/l based on field experience. From the extrapolated values, it can be noted that about 71%-79% COD reduction is possible for MLSS of 5000 and 6000 mg/l respectively at HRT of 24 hrs. At 22 hrs. HRT, 60 % COD reduction is possible for MLSS of 5000mg/l. As can be seen from table 3.7 the initial COD value is 624 mg/l and with 60 % reduction, the COD value reaches within the prescribed norms by MPCB. Therefore, it can be inferred from the secondary treatability study results that with 1:1 volumetric proportion of primary treated latex and rubber effluent at HRT of 22 hours for 5000 mg/l MLSS, the COD of the effluent can be brought below the permissible limit of 250 mg/l by biological treatment. However, the operating range can be restricted to 20-22 hours of HRT with elevated concentrations of 5000-6000 mg/l of MLVSS with 0.6-0.7 MLVSS/MLSS ratio. The same is not possible to justify with fig no. 3.16 & 3.17 because of the parabolic nature of the curve indicates that at 6000 mg/l the COD reduction will reduce which is not possible in biological oxidation, rather in realty more the concentration of biomass lesser the time required to consume (metabolize) the organic load.

Therefore, the high values of MLVSS will create starvation conditions & will yield in high metabolism rate & it will also serve improved adsorption rate (which is beyond the scope of the study) of the organic compounds due to sticky outer surface of biomass. The optimum HRT can be further reduced if COD reduction is enhanced in the primary setup as per the recommendations, if that is achieved then the optimum conditions in the bioreactor may drop below 20 hrs. of HRT where in 435 KLD trade effluent can be easily operated. A care of the operating conditions in the bioreactor is must to achieve the MPCB compliance if 435 KLD effluent is generated.

3.6.3.2. Secondary treatability results on 30% Latex effluent & 70% rubber effluent:

To determine the maximum ratio in which rubber effluent can be mixed with latex effluent without compromising with efficiency of bio-reactor, second trial was conducted with latex and rubber effluent in the ratio of 3:7 by volume. In this trial, the primary treated latex and rubber effluent were mixed in the proportion of 30% Latex effluent and 70% rubber effluent respectively, before feeding to the pilot bio-reactor. The table 3.8-3.10, shows the results of the secondary treatability studies on the latex and rubber effluent mixed as 30% and 70% in proportion.

Table 3-8: Secondary treatability study results at MLSS of 2000 mg/l for 30% Latex effluent & 70% rubber effluent

Parameters	Units	Hydraulic Retention Time (Hrs.)				
		0	12	18	24	36
pH		7.18	6.9	6.91	7.47	7.31
TDS	mg/l	6610	6620	6534	7080	7160
COD	mg/l	4568	3972	3898	3266	2980
COD reduction Efficiency	%	---	13.05	14.67	28.50	34.76
MLSS	mg/l	1860	1820	1860	1790	1720
MLVSS	mg/l	1116	1010	1128	1014	1010

MLVSS/MLSS	No units	0.60	0.55	0.61	0.57	0.59
Dissolved Oxygen	mg/l	3.2	3.3	3.2	3.1	3.2
Sludge volume index	ml/g	43	44	43	45	41

It can be seen from the results at MLSS of 2000 mg/l that, maximum COD reduction of 35% is obtained after 36 hours of retention time.

Table 3-9: Secondary treatability study results at MLSS of 3000 mg/l for 30% Latex effluent & 70% rubber effluent

Parameters	**Units**	**Hydraulic Retention Time (Hrs.)**				
		0	**12**	**18**	**24**	**36**
pH	No units	6.95	6.81	6.74	7.61	7.24
TDS	mg/l	6010	6040	5948	6170	6250
COD	mg/l	3994	2732	2446	2376	1876
COD reduction Efficiency	%	---	31.60	38.76	40.51	53.03
MLSS	mg/l	2710	2760	2640	2746	2846
MLVSS	mg/l	1626	1620	1664	1620	1700
MLVSS/MLSS	No units	0.60	0.59	0.63	0.59	0.60
Dissolved Oxygen	mg/l	3.5	3.7	3.4	3.7	3.1
Sludge volume index	ml/g	67	69	72	66	60

With a MLSS of 3000 mg/l, the COD reduction was better as compared to 2000 mg/l MLSS. Upto 53% reduction in COD was obtained after 36 hours. The SVI values shows a healthy state of activated sludge.

Table 3-10: Secondary treatability study results at MLSS of 4000 mg/l for 30% Latex effluent & 70% rubber effluent rubber effluent.

Parameters	Units	Hydraulic Retention Time (Hrs.)				
		0	12	18	24	36
pH	No units	7.16	6.91	6.72	7.5	7.31
TDS	mg/l	6180	6250	6482	6320	6450
COD	mg/l	2965	1920	1633	1524	1361
COD reduction Efficiency	%	---	35.24	44.92	48.60	54.10
MLSS	mg/l	3860	3810	3780	3742	3660
MLVSS	mg/l	2316	2140	2428	2340	2220
MLVSS/MLSS	No units	0.60	0.56	0.64	0.63	0.61
Dissolved Oxygen	mg/l	3.8	3.9	3.7	3.9	3.5
Sludge volume index	ml/g	74	73	74	75	74

In the third pilot bio-reactor in which MLSS of around 4000 mg/l was kept, the maximum COD reduction obtained was 54 %. The maximum COD reduction after 24 and 36 hours is not much higher as compared with that obtained at 3000 mg/l MLSS. Hence, it can be concluded that the bio-reactor performance can be optimized at 24 hours.

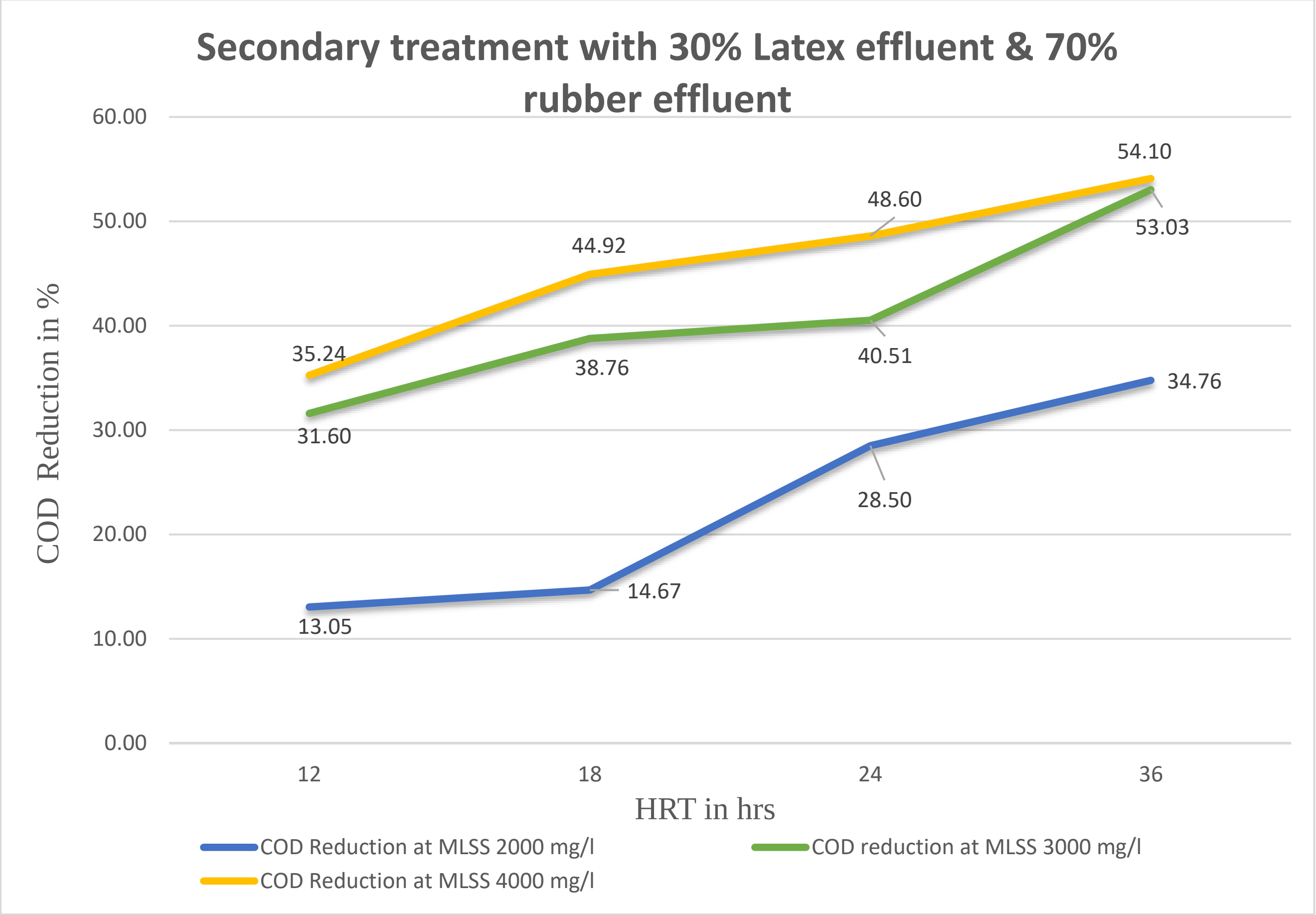

Fig. 3.20: COD reduction efficiency in secondary treatability study on 3:7 Latex and Rubber effluent.

As seen from the COD reduction graph in fig. 3.20 for secondary treatability studies with latex and rubber effluent in the ratio of 3:7, it is evident that the best results are obtained at MLSS of 4000 mg/l. However, it can also be noted that after 36 hours, there is not much difference in the percentage reduction in COD for MLSS of 3000 mg/l and 4000 mg/l. If the reduction for 12 to 24 hours is considered, then the efficiency is better for MLSS of 4000 mg/l as compared to 3000 mg/l.

3.6.4. Concluding Comments

In the secondary treatability studies, two variation of feed effluent samples were prepared. In the first trial, the latex and rubber effluent were mixed in a ratio of 1:1 and in second trial the ratio of latex to rubber effluent was 3:7 volumetrically. From the results obtained it can be noted that, the bio-reactor performance was more efficient with respect to COD removal for first trial of 1:1 ratio of latex and rubber effluent. For 1:1 ratio, the maximum COD reduction of about 80 % was obtained and for 3:7 ratio, the maximum COD reduction of 54% was obtained at similar MLSS values of 4000 mg/l. Therefore, it can be inferred that if the proportion of rubber effluent in the blending of rubber and latex effluent is increased above 50% then the performance of the bioreactor decreases.

The sewage generated from the industry is about 20 CMD as per the historical data. This sewage is directly fed to the bio-reactor. But as the volume and organic load from sewage is much less than the effluent, it gets diluted in the bio-reactor tank. Due to this reason, the sewage load is not considered in the secondary treatability studies.

To conclude, for 1:1 mixing proportion of primary treated latex and rubber effluent at HRT of 36 hours and MLSS of 4000 mg/l about 80 % reduction in the COD can be obtained. At HRT of 24 hours 70-80 % COD reduction can be obtained if the MLSS is further increased to 5000-6000 mg/l. At HRT of 22 hours with MLSS of 5000 mg/l 60 % of COD reduction was obtained. Even with 60 % COD reduction the outlet COD from bio-reactor can be achieved within the permissible norm of 250 mg/l by MPCB.

However, the operating range can be restricted to 20-22 hours of HRT with elevated concentrations of 5000-6000 mg/l of MLVSS with 0.6-0.7 MLVSS/MLSS ratio. The same is not possible to justify with fig. 3.17 & 3.18 because of the parabolic nature of the curve indicates that at 6000 mg/l the COD reduction will reduce which is not possible in biological oxidation, rather in reality more the concentration of biomass lesser the time required to consume (metabolize) the organic load. Therefore, the high values of MLVSS will create starvation conditions & will yield in high metabolism rate & it will also serve improved adsorption rate (which is beyond the scope of the study) of the organic compounds due to sticky outer surface of biomass.

The optimum HRT can be further reduced if COD reduction is enhanced in the primary setup as per the recommendations, if that is achieved than the optimum conditions in the bioreactor may drop below 20 hrs. of HRT wherein 435 KLD trade effluent can be easily operated. A care of the operating conditions in the bioreactor is must to achieve the MPCB compliance if 435 KLD effluent is treated in the bioreactor. Therefore, the optimum operating conditions of the bio-reactor which can be inferred from the secondary treatability results are-

- Ratio of primary treated rubber to latex effluent feed- 1:1.
- With 20-22 hour of HRT & 5000-6000 mg/l of MLSS should be maintained. However, as per the historical data the maximum trade effluent flow is below average 250 CMD including rubber effluent, latex effluent and sewage. If the volume of the trade effluent exceeds above 395 CMD then bioreactor volume should be increased to treat additional sewage quantity of 40 CMD.
- Additional, 40 CMD sewage treatment facility is recommended if trade effluent goes beyond 395 CMD.
- Presently, existing bioreactors can be also treat the sewage effluent which is appx. (20 KLD) 10% of the trade effluent.

Chapter 4 : Design Adequacy of the Effluent Treatment Plant

- Effluent volume as per the MPCB consent: 435 CMD (Rubber + Latex).
- Sewage volume as per the MPCB consent: 40 CMD.
- Maximum Latex effluent flow (As per historical data submitted by client): 50 CMD.
- Maximum Rubber effluent flow (As per historical data submitted by client): 150 CMD.
- Maximum Sewage flow (As per historical data submitted by client): 20 CMD.
- Operating hours: Maximum 22 hours (Depending on the quantity of effluent generated)

Average Flowrate: -

For primary treatment:

- Latex effluent- 3 m^3/hr. and Rubber effluent- 6 m^3/hr.
- For secondary and tertiary treatment- 6 m^3/hr.

It may be emphasized that the design adequacy of primary treatment units of latex and rubber effluent is done considering the maximum effluent generation as per the historical data provided by the industry. However, as the secondary treatment is combined for latex and rubber effluent, the design adequacy of secondary treatment units is done considering the flow of 435 CMD(effluent) + 40 CMD (sewage). Table 4.1 shows the design adequacy of each treatment unit of ETP.

Table 4-1: Design Adequacy of the existing ETP.

Sr. No.	**Parameters**	**Actual Design**	**Standard Design Principles**	**Remark**
1.	**Primary collection tank/ Equalization tank(Latex)**			
	Volume (in m^3)	105	6.24-20.8	Adequate
	HRT (in hrs.)	50	3-10[i]	Adequate
	Mixing arrangement	Agitator	Blower/ Agitator	Adequate
	Power of agitator	3 HP	0.42-0.56 HP[j]	Adequate

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[i] Based on Field experience, for designing Equalization tank, the HRT generally varies from 3-10 hours. However, more the HRT better will be the homogeneity in terms of quality and quantity. Hence, an overdesigned Equalization tank will not have any negative impact on the downstream treatment processes.

2.	**Primary Collection tank (Rubber)**			
	Volume (in m^3)	20	18.75-62.5	Adequate
	HRT (in hrs.)	3.2	3-10[k]	Adequate
	Mixing arrangement	Not available.	Blower/Agitator	Inadequate
3.	**Chemical reaction tank/ Flash mixer (Latex)**			
	Volume (in m^3)	8	0.05-0.1	Adequate
	HRT (in minutes)	120-160[l]	1-2[m]	Adequate[n]
	Mixing Arrangement	Agitator	Agitator	Adequate
	Type of Agitator	Plate type turbine blade	Pitched Blade/ Flat Blade/ Propeller Type	Adequate
	Diameter of impeller (m.)	0.7	0.4-0.8[o]	Adequate
	Rotational Speed (RPM)	70	72-143[p]	Inadequate
4.	**Chemical reaction tank /Flash mixer (Rubber)**			
	Volume (in m^3)	8	0.114-0.227	Adequate
	HRT (in minutes)	70.4	1-2	Adequate
	Mixing Arrangement	Agitator	Agitator	Adequate
	Type of Agitator	Plate type turbine blade	Pitched Blade/ Flat Blade/ Propeller Type	Adequate
	Diameter of impeller (m.)	0.7	0.4-0.8	Adequate
	Rotational Speed (RPM)	96	72-143	Adequate
5.	**Clarifier (Latex)**			
	Volume of clarifier (in m^3)	48	6-9	Adequate
	HRT of clarifier (in hrs.)	16[q]	2-3[r]	Adequate

---

[j] As per standard literature- *Wastewater Engineering Treatment and Reuse by Metcalf & eddy 2003, fourth edition- pg-333*, the power requirement of agitator for mixing in equalization tank is 0.003 to 0.004 KW/m^3.

[k] Based on Field experience, for designing Equalization tank, the HRT generally varies from 3-10 hours. However, more the HRT better will be the homogeneity in terms of quality and quantity. Hence, an overdesigned Equalization tank will not have any negative impact on the downstream treatment processes.

[l] The actual HRT provided for Flash mixer is based on the flow rate of 3 m^3/hr. of latex effluent.

[m] Standard reference- *Wastewater Engineering Treatment and Reuse by Metcalf & eddy 2003, fourth edition- pg-346-353*

[n] It was observed on site that there are no negative effects in the formation of flocs due to high retention time of the chemical mixing tank.

[o] Diameter of Impeller of agitator should be 0.2-0.4 times the tank diameter or width. As per standard reference literature: *CPHEEO (Central Public Health and Environmental Engineering Organization) Manual on water supply and treatment, May 1999 third edition pg. 621.*

[p] Considering tip speed of 3 m/s as per reference from *CPHEEO (Central Public Health and Environmental Engineering Organization) Manual on water supply and treatment, May 1999 third edition pg. 621.*

	Speed of sludge scrapper (rph)	7	2-10	Adequate
	Side water depth (in m.)	3	2 (minimum)	Adequate
	Surface Overflow Rate (m3/m2/hr.)	0.188	<1.25[s]	Adequate

6.	**Bio-Reactor Tank**			
	Volume (in m^3)	384	322	Adequate
	HRT (in Hours)	24hrs		Adequate
	Surface aerator	130 kg	**126-216 kg per day**	Adequate
7.	**Secondary Clarifier**			
	Operating Volume (in m^3)	97.26	53.98-64.77	Adequate
	HRT (in Hours)	4.5	2.5-3.5[t]	Adequate
	Side water Depth (in m)	3.12	2 (minimum)	Adequate
	Surface Overflow Rate (m3/m2/hr.)	0.69	<0.75[u]	Adequate
8.	**Dual Media Filter**			
	Diameter (mm.)	1200	1350-1500	Inadequate
	HOS (mm.)	2000	1000 - 2500	Adequate
	Filtration velocity (m3/m2/hr.)	19.09	12-15[v]	Inadequate
9.	**Sludge collection tank**			
	Volume (in m^3)	18	As this tank, serves as a temporary holding tank for sludge generated (which comes to be a maximum of 29.3[w] m^3 per day as per consented volume of 435 CMD) before feeding to filter press, there is no standard criteria as such to design this tank. However as per the sludge volume generated the tank is adequate to hold the sludge considering 3-4 cycles of filter press operation per day.	

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[q] The actual HRT provided for Clarifier is based on the flow rate of 3 m^3/hr. of latex effluent.

[r] As per the standard literature-*Waste water treatment plants by Syed R.Qasim, 1999 second edition, pg. 334.*

[s] As per the standard literature-*Waste water treatment plants by Syed R.Qasim 1999 second edition, pg. 334.*

[t] Reference: *STP guide by Dr. Ananth S Kodavasal, Karnataka state pollution control board 2011 first edition-page 55.*

[u] Reference: *STP guide by Dr. Ananth S Kodavasal, Karnataka state pollution control board 2011 first edition-page 55.*

[v] Standard reference-: *Wastewater Engineering Treatment and Reuse by Metcalf & eddy 2003, fourth edition-pg-1087*

[w] Based on average TSS value of 1000 mg/l and sludge consistency of 1.35 % and 4 cycles per day. Standard reference: *Wastewater Engineering Treatment and Reuse by Metcalf & eddy 2003, fourth edition- pg.- 1568*

10.	**Treated effluent collection tank**			
	Volume (in m^3)	15	As this tank, serves as a temporary holding tank for effluent feed to Dual media filter, there is no standard criteria as such to design this tank.	
	HRT (in Hours)	0.694		
11.	**Filter Press**			
	Dimensions (L X B) in m.	0.9 X 0.9	There are no standard criteria to choose size of plate. Bigger the size lesser number of plates will be required	
	Total Number of Plates (Nos.)	30	25.57	Adequate
	No. of Cycles per day	2-4	4-6	Adequate
	Cake Holding Capacity per day (litres)	1215[x]	1035.71(maximum)	Adequate

As the design adequacy of the primary treatment units was done based on the maximum flow from historical data, the table 4.2 mentions the maximum hydraulic flow which each unit is capable to handle as per standard design principles.

Table 4-2: Maximum hydraulic capacity of each primary treatment unit of ETP.

Sr. No.	Name of the unit	Maximum hydraulic capacity of each unit.
1.	Latex flash mixer/chemical reaction tank	48-240 m^3/hr.
2.	Rubber flash mixer/chemical reaction tank	48-240 m^3/hr.
3.	Latex Clarifier	16-24 m^3/hr.
4.	Rubber Clarifier	24-36 m^3/hr.

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[x] Considering average cake thickness in each plate as 50mm, 35% dry sludge consistency and 1200 kg/m^3 dry sludge density.

Chapter 5 : Conclusions and Recommendations

5.1.Conclusions from the study

Based on the detailed treatability and adequacy study of the ETP, following conclusions have been formulated:

1. For latex effluent, the optimum dosage of coagulant (Alum, PAC or Ferric chloride) comes in the range of 600-800 ppm, optimum lime dose of 400 ppm and polyelectrolyte dose of 2 ppm.
2. For rubber effluent, the optimum coagulant (Alum and PAC) dose comes to be in the range of 300-400 ppm. Optimum lime dose is 300 ppm and for polyelectrolyte it is 1 ppm. Regular jar tests should be conducted to fix the chemical dosages.
3. The maximum COD and TSS reduction in primary treatment of latex effluent obtained were 97 % and 85 % respectively and for rubber effluent COD and TSS reduction obtained were 60% and 40% respectively.
4. For secondary biological treatment, the proportion of feeding of latex and rubber effluent in the ratio of 1:1 gave better results as compared to the ratio of 3:7.
5. In the secondary (biological) treatment, the optimum HRT value was found to be 22 hrs with an MLSS value of 5000 mg/l.
6. Maximum COD reduction of 80% is obtained in the secondary treatment at MLSS of 4000 mg/l with 36 hrs HRT and at 22 hrs HRT it was projected to be 60% at MLSS of 5000 mg/l. However, the trends of the fitted curve showed a decline with rise in the MLSS values which is contradictory to the real situations and can be attributed to experimental errors. The higher MLSS concentrations will yield in high metabolic rate & more adsorption of organic compounds would be possible on the sticky surface of microorganism.
7. In the design adequacy study, all the treatment units of the effluent treatment plant except dual media filter were found to be hydraulically adequate to treat the consented volume of 435 CMD including trade effluent. The existing bio-reactor of the ETP has a capacity to handle a maximum of 435 CMD of effluent as per the treatability studies considering a range of 20-22 hrs HRT and operating at MLSS of 5000-6000 mg/l. However, theoretically considering an F/M ratio in the range of 0.1-0.15, the bio-reactor can adequately handle 435 CMD of trade effluent.

8. In future, CLIENT is recommended to consider an additional STP of 40 KLD if the trade effluent generation goes beyond 400 KLD. As per the historic data & present data, CLIENT can utilize the existing bioreactor for trade & sewage effluent due to reduced hydraulic load on the existing ETP.

5.2.Observations and recommendations

Based on the site visit and assessment of the unit operations and processes of the ETP at CLIENT, following observations and recommendations are being put forth.

Table 5-1: Observations and Recommendations.

Sr. No.	**Observations/Comments**	**Recommendations**
1.	**Effluent distribution system**	
	The industry generates two effluent streams i.e. latex and rubber effluent which are treated separately in different primary treatment units.	The industry should install flowmeters of suitable make at the inlet line of both the effluents. This would facilitate the exact measurement of the quantity and flowrate of latex and rubber effluent pumped to the ETP.
2.	**Screening unit**	
	At present screening units are not present in the ETP.	A bar screen chamber consisting of fine and coarse screens should be installed before the equalization tank to remove the larger particles of floating and suspended matter like floating papers, rages, cloths, plastics, cans stoppers, labels, etc. which may interfere with the downstream unit operations.

3.	**Oil and grease trap**	
	The oil and grease in the raw latex and rubber effluent were found to be about 150 mg/l[y] and there is no provision of oil and grease trap in the ETP.	An oil and grease removal unit must be provided. It will also help skim latex foam (floatable latex solids) and further reduce TSS.
4.	**Equalization tank**	
a. Latex	The industry has an equalization tank of sufficient retention time for latex effluent.	The acid dosing for pH reduction prior to primary treatment should be done in the equalization tank itself which is presently done in the chemical mixing tank.
	During the visit, it was observed that the agitator in the latex equalization tank was not in operation.	The industry has installed an agitator of 33 rpm speed in the equalization tank which operates only when the effluent is being pumped to the flash mixer.
b. Rubber	The rubber effluent from the effluent collection sump (20 m^3) near rubber plant is directly pumped into the Flash mixing tank.	An equalization tank with proper mixing arrangement must be provided between effluent collection sump and chemical mixing tank from where the effluent can be pumped to the chemical mixing tank.
5.	**Primary treatment units**	
	The primary treatment unit for the latex as well as rubber effluent consists of a chemical mixing tank and a Clarifier.	

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[y] The oil and grease values are obtained from the external NABL accredited laboratory reports.

	Currently, the dosing of all the chemicals- HCl, lime/caustic, PAC and Polyelectrolyte is done in the chemical mixing tank.	• It is recommended that pH correction can be done in the equalization tank itself for latex effluent. • For dosing of other chemicals like coagulant, coagulant aid and flocculent, dosing pumps should be provided which would regulate the flow of chemicals and prevent excess dosing of chemicals. • The chemical dosing tanks of PAC and polyelectrolyte should be provided with some mixing arrangements like Blower or agitator so that the solution would be homogenous.
	The agitator in the chemical reaction tank of latex effluent has a speed of 70 rpm.	• As per standard design the rotational speed of the agitator in latex flash mixing tank should be increased for effective mixing. • A separate flocculation tank should be provided for slow mixing before clarification and polyelectrolyte should be dosed in the flocculation tank.
6.	**Secondary Collection tanks**	
	The primary treated latex and rubber effluent are collected in secondary collection tanks from where it is pumped to the bio-reactor.	There should be flowmeters provided at the discharge line of rubber and latex effluent to monitor the flowrates of rubber and latex effluent pumped to the bio-reactor.

	Based on the secondary treatability study it has been observed that if the fraction of rubber effluent exceeds 50% of the total effluent in the bio-reactor, desired level of COD reduction cannot be achieved. It is observed that on weekly basis the volumetric generation of rubber & Latex effluent is roughly the same. But based on the historical data it can be inferred that the Rubber effluent generation on daily basis can go up to 150m^3/day & rubber effluent is drained intermittently, i.e. twice or thrice a week.	Client must have a secondary collection tank having storage of 300 m^3 for rubber effluent or an equalization tank of similar capacity, so that adequate retention time would be given to rubber effluent before feeding to bio-reactor along with latex effluent. This will help to eliminate shock loads on the bio-reactor due to excess flow of rubber effluent in bio-reactor.
	The temperature of the incoming raw rubber effluent is about 50-60˚C.	The temperature of the primary treated rubber effluent in the secondary collection tank should be periodically checked before feeding to the bio-reactor as high temperature of feed effluent (above 40-45˚C) may hamper the microbial growth in the biological process. Therefore, the temperature of the feed effluent to bio-reactor should be below 40˚C.
7.	**Bio-Reactor**	
	The existing bio-reactor was found to be theoretically adequate for consented volume of flow to handle a maximum BOD load of 250mg/L at a MLVSS concentration of 3000 mg/L & the F/M	The existing bio-reactor can handle up to 435 CMD of effluent considering 20-22 hour of HRT & 5000-6000 mg/l of MLSS. However, as per the historical data the maximum trade effluent flow

	ratio maintained in a range of 0.1-0.15. However, from the secondary treatability study results it was found that at HRT of 20-22 hours desirable COD reduction was obtained with MLVSS concentration of 5000-6000 mg/l. Considering this range the exiting bioreactor can handle 435 KLD of trade effluent.	is below average 250 CMD including rubber effluent, latex effluent and sewage. If the volume of the trade effluent exceeds above 395 CMD then bioreactor volume should be increased to treat additional sewage quantity of 40 KLD. Air blower with diffused aeration is recommended to increase the oxygen transfer efficiency and power savings.
	It has been observed from the treatability studies that when the fraction of rubber effluent exceeds 50% of the total effluent, the COD reduction efficiency of bio-reactor reduces.	• It is recommended to keep a constant volumetric ratio of latex & rubber effluent feed to bio-reactor. • Nutrients in the form of Urea for nitrogen requirement and Di-Ammonium phosphate for phosphorus requirement needs to be added to bio-reactor based on the ratio of 100:5:1 as BOD: N: P.[z]
8.	**Secondary Clarifier**	
	The secondary clarifier was found to be hydraulically adequate to handle the consented volume of effluent.	The sludge recirculation rates should be adjusted to maintain the required MLSS in the aeration tank.
	It was observed during the visit that there was some leakage in the sludge recirculation pump due to which some amount of sludge gets spilled on the ground.	The industry should periodically check the maintenance of all electromechanical equipment installed in the ETP.

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[z] *Practice report laboratory & process analysis wastewater treatment nutrients*- by Dipl.-Ing. Michael Winkler. www.hach-lange.com

9.	**Dual Media Filter**	
	The dual media filter works as a tertiary treatment unit in the ETP. The sand bed removes the fine suspended matter which gets carried over from the secondary clarifier. The activated carbon bed removes the color and odor.	Backwash of the dual media filter should be done daily or per shift.
	The design flowrate of the dual media filter which is 17 m^3/hr. is not adequate for the consented hydraulic load of the 475 CMD. However, as the current flow (200 CMD) is well below consented volume, it is adequate to handle load up to 373 CMD.	If the effluent load increases in future, then the dual media filter will have to be redesigned based on the additional flow.
10.	**Sludge Handling systems**	
	The sludge handling system consists of filter press for sludge de-watering.	
	The filter press is adequate to handle the sludge generated from the ETP operation with maximum effluent load. The dewatered sludge from the ETP is sent to CHWTSDF.	The plates of filter press should be periodically cleaned.

5.3.Limitations of the study

- Although specific to the current situation, a solution for appropriate primary treatment was obtained, but the flocculant dosage can be further optimized and reduced.

- Due to lack of preliminary treatment, high amounts of chemical dosing is required for primary treatment which can be expensive.
- Biodegradability of latex and synthetic rubber is very less, hence sewage and nutrients can be added. Incase increase of capacity, alternatives should also be considered.

Chapter 6 : References

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