DECLARATION

This is to certify that the thesis comprises my original work towards the degree of Master of technology in Environmental Process Design at Chemical Engineering Department, Institute of Technology, Nirma University and not been submitted elsewhere for a degree. Due acknowledgement has been made in the text to all other material used.

Darshani Bathia

(16MCHE03)

UNDERTAKING FOR THE ORIGINALITY OF THE WORK

Darshani Bathia (16MCHE03), gives undertaking that the major project entitled "**Optimum process selection of dyes & intermediate industry effluent treatment**" submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in Chemical Engineering (Environmental Process Design) at Chemical Engineering Department, Institute of Technology, Nirma University, Ahmedabad is the original work carried out by me and I give assurance that no attempts of plagiarism has been made. I understand, that in the event of my similarity found subsequently with any published work or any dissertation work elsewhere, it will result in severe disciplinary action.

Darshani Bathia
Date: 15/05/2018
Place: Ahmedabad

Endorsed by

Signature of Guide
Dr. Nimish Shah
Associate Professor
Department of Chemical Engineering
Institute of Technology
Nirma University

CERTIFICATE

This is to certify that the Project Report entitled "Optimum process selection of dyes & intermediate industry effluent treatment" submitted by Ms. Darshani Bathia (Roll No. 16MCHE03), towards the partial fulfillment of the requirements for the award of Degree of Master of Technology in Chemical Engineering (Environmental Process Design) of Nirma University is the record of work carried out by him/her under my/our supervision and guidance. The work submitted has in my/our opinion reached a level required for being accepted for examination. The results embodied in this major project work to the best of my/our knowledge have not been submitted to any other University or Institution for award of any degree or diploma.

Project Guide/Guides:

Dr. Nimish Shah
Associate Professor
Department of Chemical Engineering
Institute of Technology
Nirma University

Mr. Adarsh Pillai
Sr. Process Engineer
Envergy Projects Ltd.
Vadodara

Dr. Jayesh Ruparelia
Head of Department
Chemical Engineering Department
Institute of Technology
Nirma University

Dr. Alka Mahajan
Director
Institute of Technology
Nirma University

Examiners: **i.**

ii.

iii.

iv.

ABSTRACT

The issue of access to fresh water for human beings is getting scarcer these days due to the increase in pollution load to the environment. So, we should focus on purifying the wastewater and stop polluting the fresh water. Adsorption with the help of some biodegradable polymer can be the most promising solution. Chitosan derived from chitin which is the most abundant resource available to us for the adsorption of dyes from the different industries can be used for the adsorption and purification of wastewater. Now with the help of this bio-adsorptive powder and other promising techniques we will adsorb the dyes from the effluent. We would also focus on other parameters such as Chemical Oxygen Demand, Total Suspended Solids, Total dissolved Solids to bring it down to the consent limit of the Pollution Control Board.

Keywords: Chitosan, adsorption, Chemical Oxygen Demands, Dyes Effluent, colour removal, Total Suspended Solids, Total dissolved Solids.

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Darshani Bathia

(16MCHE03)

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NOMENCLATURE

Abbreviation	Fullform
CETP	Common Effluent Treatment Plant
pH	Potential Of Hydrogen
TSS	Total Suspended Solids
TDS	Total Suspended Solids
COD	Chemical Oxygen Demand
BOD	Biological Oxygen Demand
O & G	Oil & Grease
GC - MS	Gas Chromatography-Mass Spectroscopy
EC	Electrocoagulation
MPCB	Maharashtra Pollution Control Board
SBF	Starch Based Flocculant
MCC	Microcrystalline Chitin
RO	Reverse Osmosis
DAF	Dissolved Air Flotation
UF	Ultrafiltration
NF	Nanofiltration
MF	Microfiltration
PAC	Polyaluminium Chloride
Poly-DADMAC	Polydiallyldimethylammonium Chloride
ETP	Effluent Treatment Plant
STP	Sewage Treatment Plant
WWTP	Wastewater Treatment Plant
WHO	World Health Organisation

CHAPTER 1: INTRODUCTION

Treatability studies are an important part of the remedy selection process. It is considered as the core part of any wastewater treatment system and it's designing. Henceforth it plays a major role in the wastewater treatment industry. And now specially a wastewater treatability study is a kind of study or test that exactly tells us which type of pollutant load is present in its effluent stream. It even tells us whether the effluent needs the treatment or not and if effluent really needs the treatment than how it is supposed to be treated. Now if the series of the test that is there is the treatability scheme if it's done correctly without any error than it will help us in clearly knowing the problem in the process and well as the reason for effluent generation so that we can finally come out with a solution [1].

For the wastewater treatability study should also key point of concern is to check whether the effluent is complying with the norms of the concerned state pollution control board or not. For instance, an effluent treatment plant that discharges to the common effluent treatment plant (CETP) would need to comply with the local guidelines outlined by the concerned pollution control board to avoid violating norms for discharging the effluent into the CETP.

Henceforth it becomes a point of key importance to understand the role of treatability study in the designing of effluent treatment plant and organising an efficient wastewater management system.

1.1 NEED FOR WASTEWATER TREATABILITY STUDY

Before we could really understand the need for treatability study we should actually know what benefits it can fetch to our current situation. It is equally important to fully realize just what results can be expected from a well-developed wastewater treatability study. It has also been showcased from the past industrial examples that a well organised wastewater management plays a crucial role in the effluent treatment plant designing.

There are four main parts of carrying out a treatability study efficiently. The four main points which are as follows should be primarily reviewed and then finally after properly evaluating its merits and demerits should than be implemented. They are stated as follows:-

1. Review the local wastewater discharge norms: The importance of the first step of the treatability study needs to be understood thoroughly. If there is already an existing effluent treatment plant for the process of water treatment than also the local discharge norms should be checked at regular intervals of time because either the norms may change or probably the ability of the system to meet them also keeps varying with the changing time period. When the effluent treatment plant is newly installed, the system may show the efficiency to meet local discharge norms but then as the time passes the efficiency gradually comes down. The conventional effluent treatment plant sometimes gives good efficiency but produces sludge in excess and uses more amounts of coagulants and flocculants. Conventional effluent treatment plant is taken to the hydraulic limit by increasing their respective flow rates. From this, we can say that many times it happens that the existing ETP may be outdated as compared to the technology which is available in the market. But sometimes, from the point of view of an industrialist economic feasibility is also to be seen so repairing the existing one becomes more economically feasible than installing the best available technology which is available in the market. There is one good feature of the newly available technology and that is it provides a sound planning for the wastewater treatment and even it meets the local discharge norms very accurately [7].
2. Focussing on current problems: An optimum treatability study starts with the person who is an expertise in the chemical processing of the system because that person an only explain the whole system to the wastewater treatment consultant or may be the environmentalist. Understanding the current problem and analysing the loop in the system becomes the important step in this treatability study. Your concerned environmentalist will analyse the problems with the help of your chemical process engineer and will lead you to an optimum solution. If your consultant is sound enough in his field than will automatically judge half of the data visualizing your plant even without asking the information from your concerned process engineer [7].
3. Review all the solutions obtained: All the series of results which are provided by your consultant are the results of the treatability study. Now the information which obtained on laboratory scale should be correlated with the designing of effluent treatment plant keeping an eye on factors such as economic feasibility, technical feasibility, etc [7].
4. Review Current Process Operations: For a variety of plant processes new pre-treatment standards for wastewater discharge have demanded changes in process

operations. Water volumes have been curtailed. Process chemicals are now available rinse When available, this information can be correlated to exact process times and conditions. When not available, it must be discussed whether such information should be collected. In this day and age, usually basic information exists concerning incoming process water quality and quantity and discharge wastewater quality and quantity many process situations this basic information is enough to start our diagnostic procedure information may be required. For more complicated process designs more detaired [7].

1.2 DIFFERENT PROCESS OF TREATABILITY

1. **Screening:** A grating of steel bars spaced about 2–4 cm on centres is placed at an angle to the flow of sewage through an open channel. Initially, wood chips, leaves, aquatic plants, and floating impurities are removed by screening process. After the screening, a more compact suspended material will be removed to allow water to flow through the chamber in which it will settle to the bottom. The screen even removes coarse and floating solids from the effluent. The screen chamber must be cleaned at regular interval of time and the solids which are stuck on the screen should be removed, buried or disposed off properly. Screens have a variety and they diversified according to their size, shape, its inclination angle, etc. Now making it more simple screens are basically just of two types i.e. coarse and fine screens. Usually, coarse screen removes the particles ranging from 0.25 inches to 6 inches. Large particles or objects such as large size particles, plants debris, organic remains, stick, rags, plastic waste, etc. In this type of screens there are even two subtypes i.e. manually cleaned bar screen and mechanically cleaned bar screen. The difference between the two is one is to be cleaned manually and the other one is more efficient and can be cleaned manually. The second type is fine screen cleans the particle size between 0.06 inches to 25 inches. The small openings in the fine screen allows it to remove the total suspended solids (TSS) and the organic matter present in the effluent, so here the biological oxygen demand (BOD) of the effluent comes down.

2. **Oil skimming:** An oil skimmer is a gadget that is intended to evacuate oil drifting on a fluid surface. Contingent upon the particular plan they are utilized for an assortment of utilizations, for example, oil slick reaction, as a piece of sleek water treatment

frameworks, expelling oil from machine instrument coolant and watery parts washers, and gathering fats oils and oils in wastewater treatment in nourishment fabricating ventures. The utilization of skimmers in mechanical applications is frequently required to expel oils, oil and fats preceding further treatment for environmental compliance of the norms. By evacuating the best layer of oils, water stagnation, smell and unattractive surface rubbish can be decreased. There are three main types of oil skimmers i.e. wier,oleophilic and non-oleophilic. Weir skimmers work by permitting the oil drifting on the surface of the water to stream over a weir. Oleophilic skimmers work by utilizing a component, for example, a drum, circle, rope or clean to which the oil follows. The oil is wiped from the oleophilic surface and gathered in a tank. Non-oleophilic skimmers are recognized by the segment used to gather the oil. A metal circle, belt or drum is utilized as a part of uses where an oleophilic material not appropriate such as hot alkaline washing materials.

3. **Coagulation and Flocculation:** Coagulation is a procedure that happens when a coagulant is added to water to "destabilize" colloidal suspensions. On the other hand, flocculation includes the expansion of polymers that cluster the little, destabilized particles together into bigger totals with the goal that they can be all the more effectively isolated from the water. Coagulation is a compound procedure that includes balance of charge though flocculation is a physical procedure and does not include balance of charge. The coagulation-flocculation process can be utilized as a preparatory or mediator venture between other water or wastewater treatment forms like filtration and sedimentation.

   Coagulation is influenced by the kind of coagulant utilized, its dosage and mass; pH and in the beginning turbidity of the water that is being dealt with; and properties of the contaminations display. Lime and ferrous sulphate are the basic chemicals used in this process.

4. **Aeration:** Wastewater aeration is the process of adding air into wastewater to allow aerobic bio-degradation of the pollutant components. It is an integral part of most biological wastewater treatment systems. Unlike chemical treatment which uses chemicals to react and stabilise contaminants in the wastewater stream, biological treatment uses microorganisms that occur naturally in wastewater to degrade wastewater contaminants. Aeration is mostly a part of secondary type of treatment in

the treatment scheme. A sufficient and uniformly appropriated oxygen supply in an aeration system is the way to fast, financially feasible, and successful wastewater treatment.

5. **Reverse osmosis:** Reverse osmosis (RO) is a water sanitization innovation that uses a semipermeable layer to expel particles, atoms, and bigger particles from drinking water. In reverse osmosis, a connected weight is utilized to conquer osmotic weight, a colligative property that is driven by concoction potential contrasts of the dissolvable, a thermodynamic parameter. Its membranes have been shown to significant reduction in total dissolved solids, heavy metals, organic pollutants, viruses, bacteria, and other dissolved contaminants. RO process removes the minerals from the effluent of boilers and power plants.

6. **Ozonation:** Ozone is an unsteady particle which promptly surrenders one molecule of oxygen giving an effective oxidizing operator which is lethal to most waterborne life forms. It is an extremely solid, expensive range disinfectant that is broadly utilized as a part of Europe. It is a successful technique to inactivate unsafe protozoa that shape growths. It additionally functions admirably against every other pathogen. Ozone is made by going oxygen through bright light or an "icy" electrical release. To utilize ozone as a disinfectant, it must be made nearby and added to the water by bubble contact. A portion of the upsides of ozone incorporate the creation of less hazardous results and the nonappearance of taste and smell issues (in contrast with chlorination). Another favourable position of ozone is that it leaves no leftover disinfectant in the water.

7. **Dissolved air flotation:** At the point when particles to be expelled don't settle out of arrangement effortlessly, dissolved air flotation (DAF) is frequently utilized. After coagulation and flocculation process, water streams to DAF tanks where air diffusers on the tank base make fine air pockets that append to floc bringing about a drifting mass of the concentrated floc. The agglomerated floc cover is expelled from the surface and treated water is pulled back from the base of DAF tank. DAF is often given to the wastewater which have a large mass of algal growth in its water or else the type of water which have low turbidity and high amount of colour content in itself usually prefer it.

8. **Disinfection:** Disinfection evacuates both unsafe smaller scale life forms and non-destructive miniaturized scale creatures by including disinfectant chemicals. Water is cleaned to execute any pathogens which go through the channels and to give a left over measurements of disinfectant to murder or inactivate conceivably destructive miniaturized scale life forms in the capacity and appropriation frameworks. Possible pathogens join contaminations, organisms, including Salmonella, Cholera, Campylobacter and Shigella, and protozoa, including Giardia lamblia and other cryptosporidia. Following the introduction of any substance disinfecting pro, the water is by and large held in momentary limit – routinely called a contact tank or clear well to allow the refining action to wrap up.

9. **Chlorination:** The most well-known sterilization technique includes some type of chlorine or its mixes, for example, chloramine or chlorine dioxide. Chlorine is a solid oxidant that quickly slaughters numerous hurtful miniaturized scale creatures. Since chlorine is a dangerous gas, there is a risk of a discharge related with its utilization. This issue is maintained a strategic distance from by the utilization of sodium hypochlorite, which is a generally cheap arrangement utilized as a part of family fade that discharges free chlorine when broken down in water. Chlorine arrangements can be produced nearby by electrolyzing normal salt arrangements. A strong frame, calcium hypochlorite, discharges chlorine on contact with water. Taking care of the strong, notwithstanding, requires more prominent routine human contact through opening sacks and pouring than the utilization of gas chambers or blanch which are all the more effectively mechanized. The era of fluid sodium hypochlorite is both cheap and more secure than the utilization of gas or strong chlorine and its even effective.

10. **Electrocoagulation:** This term itself defines that using and electric charge for the treatment of water. First, by giving electric charge to water, the charge of the surface particles are changed and then it is followed by the formation of flocs and then agglomeration takes place. This type of process is preferred in the effluent which carry a large amount of oil, grease and other type of emulsion because it breaks the emulsions and forms a layer on the top which can be easily removed. It also removes suspended particles from the effluent upto a greater extent. Electrocoagulation

oxidizes and then eradicates heavy metals from water without the use of filters or the addition of separation chemicals.

11. **Evaporation:** An evaporator is a gadget in a procedure used to turn the fluid type of a compound substance, for example, water into its vaporous film/vapour. The fluid is vanished, or vaporized, into a gas type of the focused on substance in that procedure. This type of process is called evaporation and the system is called evaporation assembly. An evaporator/evaporative-process can be utilized for isolating fluid chemicals and to rescue solvents. Lawfully, all makers of waste must discard squander utilizing techniques perfect with natural rules; these strategies are exorbitant. By evacuating dampness through vaporization, industry can extraordinarily diminish the measure of waste item that must be handled. Typically different impact evaporators are utilized monetarily.

12. **Ultrafiltration and Nanofiltration:** Ultrafiltration (UF) technology uses a membrane barrier to exclude particles as small as 0.01 microns, including bacteria, viruses and colloids. Advantages of UF compared to conventional treatment such as clarifiers and media filters, are its high tolerance to feed water quality upsets, absolute barrier and improved water quality. Nanofiltration is a membrane liquid separation technology that is positioned between reverse osmosis and ultrafiltration. While RO can remove the smallest of solute molecules, in the range of 0.0001 micron in diameter and smaller, nanofiltration (NF) removes molecules in the 0.001 micron range.

CHAPTER 2: LITERATURE REVIEW

H. Momenzadeh et al. made extensive study on reactive dye removal from wastewater using a chitosan nano dispersion. Adsorption of an reactive dye, reactive red 120 (RR120), from aqueous solution on chitosan and on a chitosan nanodispersion has been studied[1]. The nanodispersion was prepared using a mixture of chitosan and sodium tripolyphosphate. The results showed that the adsorption of RR120 on dissolved chitosan and on the chitosan nanodispersion was affected significantly by initial dye concentration, sorbent amount, temperature,pH and ionic strength of the solution. Maximum dye removal for both adsorbents was at a pH of 4–5 and the adsorption of the reactive dye on both dissolved chitosan and the nanodispersion gave good fit to the Langmuir isotherm model. The removal of an azo reactive dye (RR120) from aqueous solution by adsorption on either dissolved chitosan or chitosan nanoparticles has been studied under different experimental conditions [1].The effects of pH, ionic strength, temperature, time and initial dye concentration were studied. The most effective removal was obtained at a pH of 4–5.The adsorption isotherm correlated well with the Langmuir adsorption model and the kinetics followed a pseudo-second order model.

Azam Pirkarami et al. studied about applying electrocoagulation to the dye & intermediate effluent and checking its economic viability and cost analysis at plant scale. In this research, give an account of an exploration into the effect of various parameters of current thickness, anode type, temperature, pH, and electrolyte fixation on the evacuation of Reactive Red 120 in combined wastewater through electrocoagulation utilizing sun based vitality with the end goal of enhancing monetary effectiveness of the procedure. Other ideal choices were iron anode, a temperature level of 25 C, a pH of 7. The portrayal of the post-treatment item utilizing GC– MS thinks about uncovered transitional mixes. Cost investigation was additionally performed for the treatment procedure [2].

Sandip Sharma et al. has made an endeavour has been made in this paper to distinguish impacts of effective ozonation forms for decolourization or potentially debasement of natural poisons for ecological assurance. In colours, since the chromosphere bunches with conjugated twofold bonds, which are in charge of shading, can be separated by ozone either specifically or in a roundabout way framing littler atoms, in this way diminishing the shade of the effluents[3]. Ozonation and its mixes are compelling for wastewater treatment. In the present investigation 99.9% decolourization of RR 135 was proficient by ozonation.

Barun Kumar Nandi et al. discloses the same thing as earlier literatures for removing reactive dyes. This paper displays a trial examine on the expulsion of splendid green colour from watery arrangements in a group mixed electrocoagulation (EC) reactor utilizing iron anodes [4]. The primary destinations of the tests were to explore the impacts of the different working parameters, for example, ebb and flow thickness, bury anode separate, beginning colour fixation, pH of the arrangement, EC span and salt (NaCl) focuses on the splendid green colour expulsion proficiency from engineered wastewater containing in bunch EC process. The trial comes about demonstrated that 99.59% colour removal was watched for starting colour centralization of 100 mg/L , beginning pH of 4.0 toward the finish of 30 min of operation. It was watched that, an expansion in current thickness, time of operation and decline in bury anode separate enhanced the colour expulsion proficiency. Ideal pH for most elevated colour evacuation was 4.0– 10.0.

Suphitcha Wijannarong et al. discloses the same thing that the wastewater contained reactive colours was ozonated in a batch reactor. In the trial, the tank reactor which controls the temperature was 35 C. what's more, water tests were gathered at 5, 10, 20, 30, 45, 60, 90,120, 150, 180, 240, 300 and 360 minutes, separately [5]. Aftereffects of decolourization demonstrated that the shade of wastewater is diminished when the response times expanded. At response times 5 and 120 minutes, the decolourization productivity is 32.83 % and 56.82 %, separately. In any case, the wastewater after essential exploratory still have shading in spite of the fact that the power of shading will be soft.The ozonation can diminish shading in the wastewater more than 90%at response times 6 hours.

Walaikorn Nitayaphatat et al. developed a chitosan/coffee residue composite beads for removal of reactive dye. The adsorption execution of chitosan beads was examined after coffee deposit mixing for the expulsion of Reactive Red 152 as an anionic colour. The investigation of the colour evacuation of chitosan/espresso deposit composite beads as a component of espresso buildup focus showed that mass proportion of chitosan/coffee of 60/40 was the most helpful for upgrading the colour expulsion. The impacts of contact time, starting pH, and adsorbent measurement on the adsorption proficiency were explored efficiently. The balance adsorption isotherm of chitosan/coffee buildup composite globules showed better fit to the Langmuir isotherm demonstrate than to the Freundlich isotherm display. The most extreme adsorption limit of composite dab was 4.27 mg/g. The colour desorption of composite dab was 24.83%. This examination exhibited that the chitosan/espresso buildup composite can adequately expel responsive colour from watery arrangement and essentially with ease [6].

V.S. Ashtekar et al. suggested treating the effluent of dye & intermediates with the help of organic and inorganic coagulants. Wastewater treatment in material and colour industry for the most part includes treatment of exceedingly shaded wastewater containing assortment of colours in various fixations [10]. The wastewater should be dealt with before release by viably expelling colour shading so as to secure condition and according to the statutory rules. Coagulation is the most generally utilized strategy in the treatment of material wastewater. In the present work, we report exploratory work on treatment of engineered squander containing unadulterated receptive colours, expulsion of responsive blue colour, utilizing different business coagulants, for example, alum, polyaluminium chloride (PAC), polydiallyldimethylammonium chloride (poly-DADMAC) and polyamines. The outcomes of this research demonstrated measurement of coagulant dosing like that appeared in our examinations. In this regard, it is conceivable to finish up from our investigations that PAC or alum based plans are similar to that ferric chloride based definitions.

2.1 OBJECTIVE OF THE PRESENT WORK

The objective of the study is to give proper treatment to wastewater so that it will help the primary effluent treatment plant to undergo necessary change for start up and give effective pollutant load as per statuary requirement of MPCB. The dye & intermediate company has appointed M/S. Energy Projects Ltd., Vadodara to carry out treatability study of effluent and hydraulic & pollution load of each stream entering into effluent. Analysis of critical pollution parameters depending upon type of industries and process selection based on analysis results and inlet parameters. The main objectives of current study are:-

- To choose a primary treatment scheme for the treatment of high chemical oxygen demand (COD) and high total dissolved solids (TDS).
- In the primary treatment, selection of the coagulants and flocculants should be optimum and it should help us reducing the COD and TDS.
- The coagulants and flocculants choosen should be available easily and should even be economically feasible.

- The second streams of the effluent contain ammonical nitrogen, so a pre-primary treatment should be suggested to reduce the solvent in the second stream.
- Techno-economic scheme should be selected for the primary treatment and it should comply with the norms of MPCB.

2.2 SCOPE OF THE FUTURE WORK

In the results which are derived in the chapter 3, it can be concluded that we need to work more hard with the selection of chemicals for all the three streams. Some more methods can also be applied on this effluent such as

- Evapouration
- Ozonation
- Electro-coagulation
- Adsorption using chitosan materials

CHAPTER 3: MATERIALS AND METHODS

Process selection of dyes industry effluent treatment is based on literature review and basic practice of M/s. Green Circle Inc.

This study was focused in investigating of optimum treatment of effluent in terms of pollution control board norms and cost effectiveness.

Based on initial analysis of effluent and previous experiences treatment technology is decided.

3.1 MATERIALS

Glassware: Measuring Flask, Beakers, Volumetric Pipette, Burette, Measuring Cylinder, Conical Flask, Crucible, Filter Paper etc.

Instruments: pH Meter, Conductivity Meter, Jar Test Apparatus, Magnetic Stirrer, Evaporation assembly, Gravity Separator, Filtration assembly, Hot Air oven, COD digester, Aeration system with diffuser mechanism, etc.

Chemicals: H_2SO_4, NaOH, Polyelectrolyte, Hydrated Lime, $FeSO_4$, PAC, $FeCl_3$, Bio Culture, $K_2Cr_2O_7$, FAS, etc.

3.2 METHODS AND EXPERIMENT

In this study effluent was collected from a dye & intermediate company located in Mumbai. Three different effluents are collected by client from each unit of production.

1. Effluent stream one – Blue
2. Effluent stream two – Red
3. Effluent stream three – Orange

Overall method has done in six steps listed below:

1. Initial Analysis
2. Pre Primary Treatment
3. Primary Treatment

4. Secondary Treatment
5. Tertiary Treatment
6. Advance Treatment

3.2.1 INITIAL ANALYSIS

3.2.1.1 INITIAL ANALYSIS OF STREAM ONE – BLUE

Blue stream effluent had contained high TDS, High chemical oxygen demand and high solvents during initial analysis.

Table 1: Initial Analysis of stream one – Blue

Sr. No.	Parameters	Unit	Results
1.	Physical Appearance	-	Dark Blue colour liquid sample with few suspended particles & strong characteristic odour.
2.	pH	-	4.6
3.	Electrical Conductivity	m ℧	116.4
4.	TSS	mg/L	3473.8
5.	TDS(Inorganic)	mg/L	103988
6.	TDS(Organic)	mg/L	4611
7.	COD	mg/L	11200
8.	Ammonical nitrogen	mg/L	5.6
9.	Oil & Grease	mg/L	ND

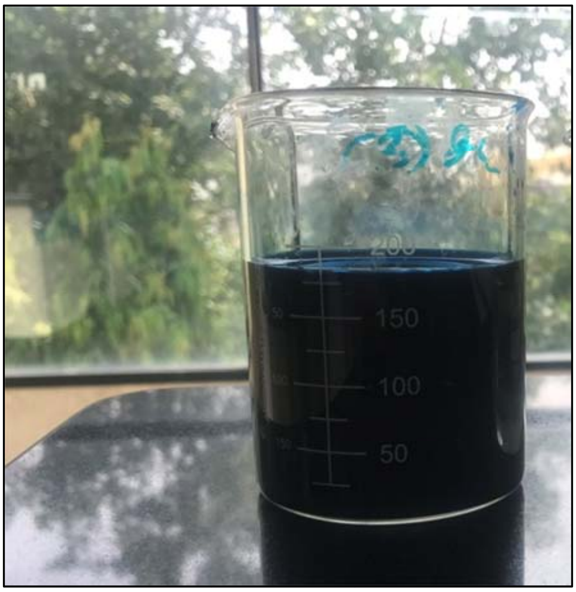


Figure 1: Initial Effluent Stream One - Blue

3.2.1.2 INITIAL ANALYSIS OF STREAM TWO – RED

Red stream were having high TDS, high COD, Ammonical Nitrogen and solvent.

Table 2: Initial Analysis of stream two – Red

Sr. No.	Parameters	Unit	Results
1.	Physical Appearance	-	Red colour liquid sample with few suspended particles &High Ammonia present.
2.	pH	-	3.27
3.	Electrical Conductivity	m ℧	92.3
4.	TSS	mg/L	2768.4
5.	TDS(Inorganic)	mg/L	71308
6.	TDS(Organic)	mg/L	16128
7.	COD	mg/L	28800
8.	Ammonical nitrogen	mg/L	71.68
9.	Oil & Grease	mg/L	ND

Figure 2: Initial Effluent Stream Two - Red

3.2.1.3 INITIAL ANALYSIS OF STREAM THREE – ORANGE

This stream contains high TDS, high Chemical Oxygen Demand, and Solvent.

Table 3: Initial Analysis of stream three – Orange

Sr. No.	Parameters	Unit	Results
1.	Physical Appearance	-	Dark violet colour liquid sample with much suspended particles and high characteristic odour.
2.	pH	-	4.96
3.	Electrical Conductivity	m ℧	135.1
4.	TSS	mg/L	4878.6
5.	TDS(Inorganic)	mg/L	141423
6.	TDS(Organic)	mg/L	16741
7.	COD	mg/L	30400
8.	Ammonical nitrogen	mg/L	9.52
9.	Oil & Grease	mg/L	ND

Figure 3: Initial Effluent Stream Three – Orange

3.2.2 PRE PRIMARY TREATMENT

Based on initial analysis all three streams have high total dissolved, high chemical oxidation demand and stream red has Ammonical Nitrogen.

Ammonical nitrogen was removed by air stripping.

3.2.2.1 AIR STRIPPING OF EFFLUENT STREAM TWO - RED

500 ml effluent sample were taken for air stripping in to graduated cylinder with air diffuser system. Reduction of ammonical nitrogen was analysed after 6 hrs.

Table 4: Analysis of stream Two – Red after Air Stripping

Sr. No.	Sampling duration	Ammonical Nitrogen
1.	0 Hr.	71.68 mg/L
2.	After 6 Hr.	33.6 mg/L

3.2.3 PRIMARY TREATMENT

Primary treatment is physiochemical treatment in these method impurities is removed by physical and chemical means.

As per study of various literatures different chemicals are used for coagulation and flocculation. In this section selection of chemical was done using different combination and observation.

3.2.3.1 SELECTION OF CHEMICALS FOR BLUE STREAM

Each time 100 ml sample was taken in 500 ml Beaker for chemical treatment. Initial COD and pH of said effluent was 11200 mg/L & 4.6.Using different combinations of chemicals, Flocculation and Coagulation was noticed.

Table 5: Analysis of stream one – Blue after Chemical Treatment

Sr. No.	Chemicals	COD After Treatment
1.	Lime – $FeSO_4$	8736
2.	Lime – $FeSO_4$– Poly Electrolyte	9184
3.	NaOH – $FeSO_4$	9744
4.	NaOH – $FeCl_3$	9408
5.	NaOH – PAC – Poly Electrolyte	9520

As per observation Chemical treatment was not effective for this effluent.

3.2.3.2 SELECTION OF CHEMICALS FOR RED STREAM

Each time 100 ml air stripped sample was taken in 500 ml Beaker for chemical treatment.Initial COD and pH of said effluent was28800 mg/L & 3.27.Using different combinations of chemicals, Flocculation and Coagulation was noticed.

Table 6: Analysis of stream two – Red after Chemical Treatment

Sr. No.	Chemicals	COD After Treatment
1.	Lime – $FeSO_4$	22176
2.	Lime – $FeSO_4$– Poly Electrolyte	23904
3.	NaOH – $FeSO_4$	24480
4.	NaOH – $FeCl_3$	25344
5.	NaOH – PAC – Poly Electrolyte	26208

As per observation chemical treatment was not effective for this effluent.

3.2.3.2 SELECTION OF CHEMICALS FOR ORANGE STREAM

Each time 100 ml sample was taken in 500 ml beaker. Initial COD and pH of said effluent was 30400 mg/L & 4.96.Using different combinations of chemicals, Flocculation and Coagulation was noticed.

Table 7: Analysis of stream three – Orange after Chemical Treatment

Sr. No.	Chemicals	COD After Treatment
1.	Lime – $FeSO_4$	22800
2.	Lime – $FeSO_4$– Poly Electrolyte	24928
3.	NaOH – $FeSO_4$	26144
4.	NaOH – $FeCl_3$	25232
5.	NaOH – PAC – Poly Electrolyte	27056

As per observation chemical treatment was not effective for this effluent

Using different chemical combination and analysis of treated effluent we notice that due to the high COD and TDS no chemical was working effectively with the effluent.

3.2.4 SECONDARY TREATMENT

Secondary treatment is biological treatment in these method impurities is removed by microorganisms activity.

In this study microorganism was grown separately and the transfer to 500 ml of each effluent stream (Primary Treated) and place for aeration. Analysis was done after 2 days.

Table 8: Analysis of Secondary Treatment

Sr. No.	Name of Stream	Initial COD	Final COD
1.	Blue Stream	8736	8600
2.	Red Stream	22176	22100
3.	Orange Stream	22800	22600

High pollution load is not favourable condition for growth and survival of microorganism. As a result Secondary/Biological treatment did not work efficiently on the effluent.

CHAPTER 4: EXPERIMENTAL WORK

Mounting demand of fresh water and unexpected decline in fresh water resources have led humans control their environment contaminating activities. Impact; however is much unexpected resulting into extinction of species as well as decline in health friendly atmosphere. Water constitutes major portion of livings including all kinds of flora and fauna. Consumption of water is amongst basic need of every living being whilst many ecosystems are inside water which makes water conservation increased attention.

Industrial usage of water is also crucial in reaction, domestic usage sewage, process water, utilities and many more. But quality on inlet and outlet needs some stringent monitoring and justice before coming out of the premises. But we should not forget if chemicals and processes to make pure. With modern technologies and innovative methods, humans have reached methods to make water of ultimate purity but not as economical as we can get from nature.

Treatability and feasibility of industrial water effluent for treatment is a very good approach which can give a rough tentative estimate of actual process required and its feasibility.

4.1 OBJECTIVES

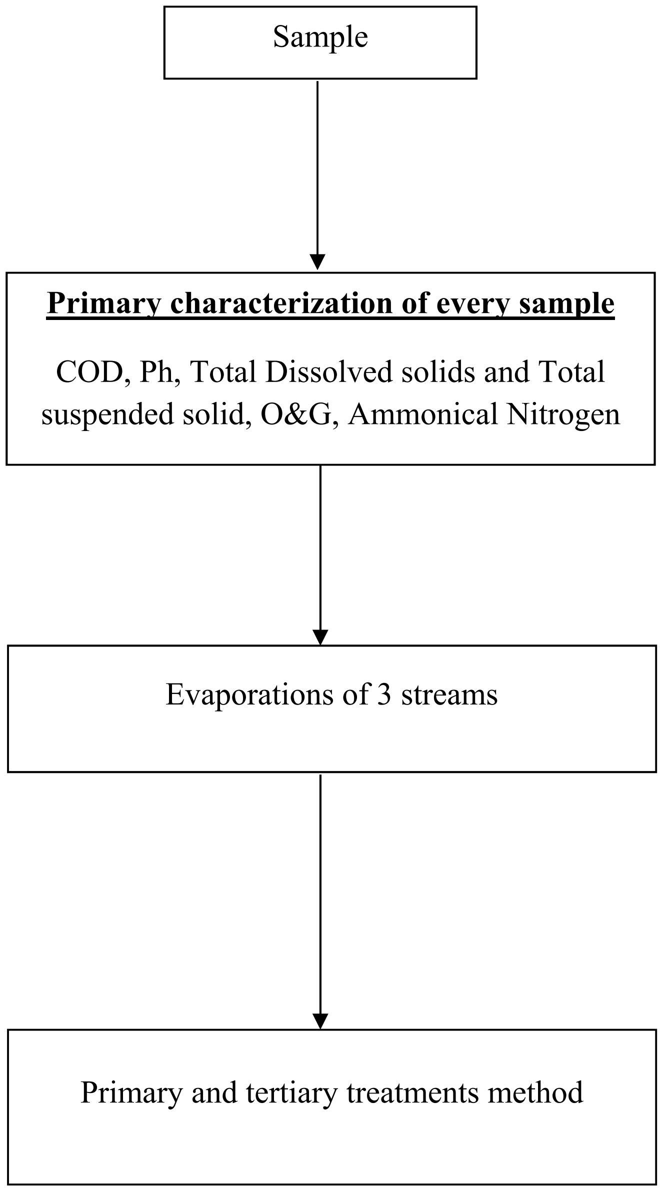
The objective of the study is to give proper treatment to wastewater so that it will help the primary effluent treatment plant to undergo necessary change for startup and give effective pollutant load as per statuary requirement of Maharashtra Pollution Control Board (MPCB).

4.2 METHODOLOGY

Methodology adopted for the study is as follows:

1) Initial treatment
2) Evaporation & Primary treatment
3) 3° treatment

FLOW CHART OF TREATMENT SCHEME



4.3 INITIAL ANALYSIS OF DIFFERENTS SAMPLE

4.3.1 STREAM BLUE

Blue stream effluent had contained high chemical oxygen demand, Reactive dyes and high solvents during   initial analysis.

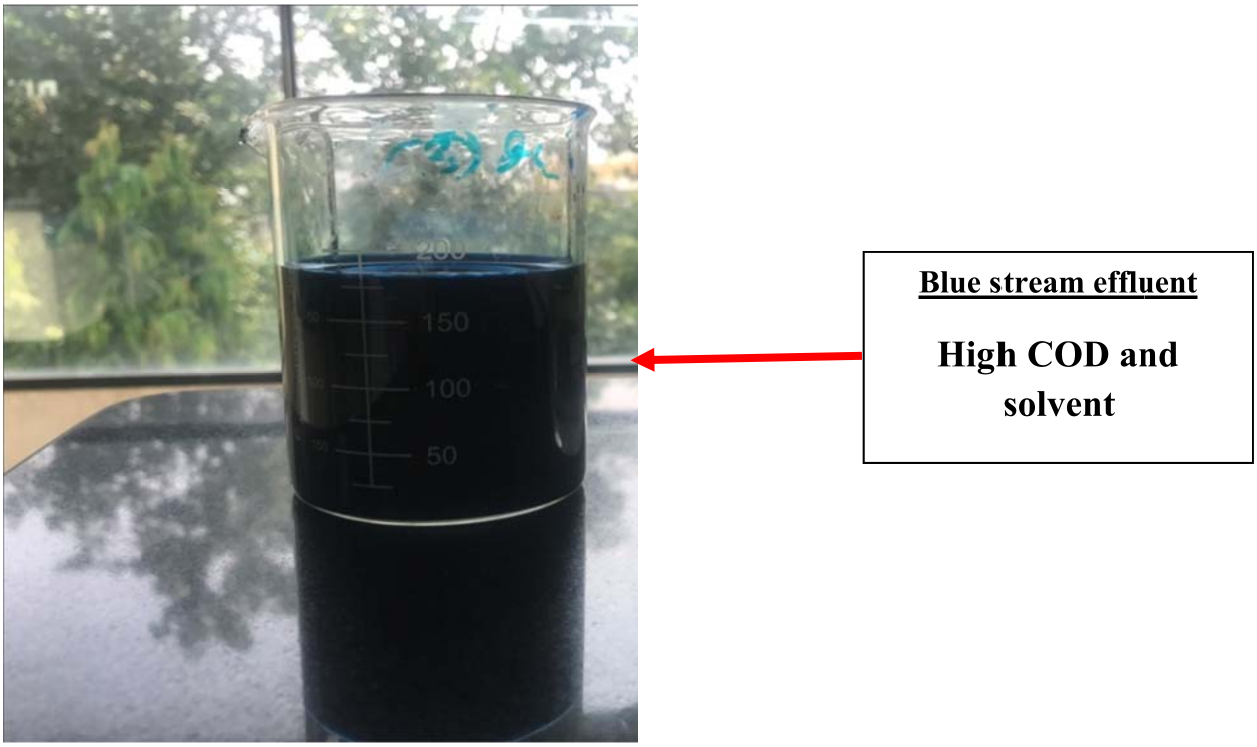


Figure 4: Stream Blue

4.3.1.1 ANALYTICAL RESULTS OF STREAM BLUE

Table 9 : Analytical results of stream blue

Sr. No.	Parameters	Unit	Results
1.	Physical Appearance	-	Dark Blue colour liquid sample with few suspended particles & strong characteristic odour.
2.	pH	-	4.6
3.	Electrical Conductivity	m ℧	116.4
4	Ammonical nitrogen	mg/L	5.6
5.	TDS(INORGANIC)	mg/L	103988
6.	TDS(ORGANIC)	mg/L	4611
7.	TSS	mg/L	3473.8
8.	Oil & Grease	mg/L	ND
9	COD	mg/L	11200

4.3.2 STREAM RED

Red stream was having high Ammonical Nitrogen and Chemical Oxygen Demand as well as a high amount of Reactive Red dyes and Solvent.

Red stream effluent

High ammonical compound and COD

Figure 5 : Stream Red

4.3.2.1 ANALYTICAL RESULTS OF STREAM RED

Table 10: Analytical results of stream red

Sr. No.	Parameters	Unit	Results
1.	Physical Appearance	-	Red colour liquid sample with few suspended particles &High Ammonia present.
2.	pH	-	3.27
3.	Electrical Conductivity	m Ʊ	92.3
4	Ammonical nitrogen	mg/L	71.68
5.	TDS(INORGANIC)	mg/L	71308
6.	TDS(ORGANIC)	mg/L	16128
7.	TSS	mg/L	2768.4
8.	Oil & Grease	mg/L	ND
9	COD	mg/L	28800

4.3.3 STREAM ORANGE

This stream contains high Chemical Oxygen Demand Reactive dyes and Solvent.

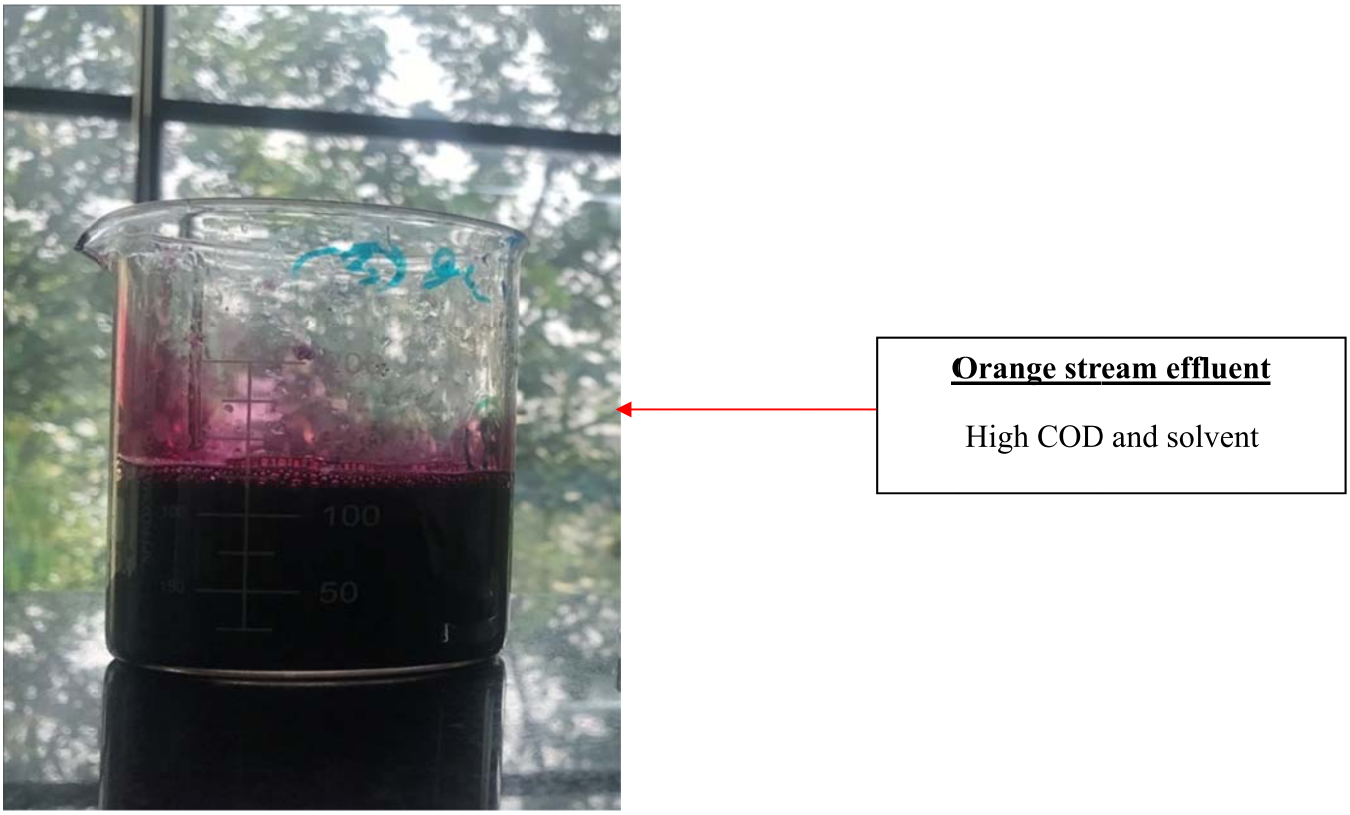


Figure 6 : Stream Orange

4.3.3.1 ANALYTICAL RESULTS OF STREAM ORANGE

Table 11: Analytical results of stream orange

Sr. No.	Parameters	Unit	Results
1.	Physical Appearance	-	Dark violet colour liquid sample with much suspended particles and high characteristic odour.
2.	pH	-	4.96
3.	Electrical Conductivity	m ℧	135.1
4	Ammonical nitrogen	mg/L	9.52
5.	TDS(INORGANIC)	mg/L	141423
6.	TDS(ORGANIC)	mg/L	16741
7.	TSS	mg/L	4878.6
8.	Oil & Grease	mg/L	ND
9	COD	mg/L	30400

4.4 TREATED WATER ANALYSIS AFTER EVAPORATION

4.4.1 EVAPORATION DETAILS

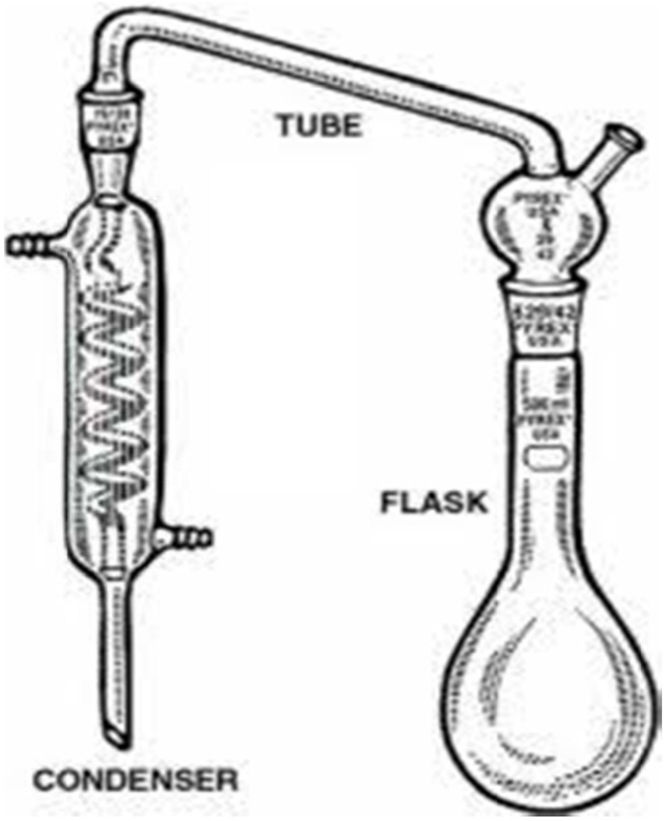
Table 12: Evaporation details

EVAPORATION DETAILS			
Sample Details	**Stream BLUE**	**Stream RED**	**Stream ORANGE**
TOTAL SAMPLE (ML)	300	300	300
CONDENSABLE (ML)	205	250	200

4.4.2 PROCEDURE:

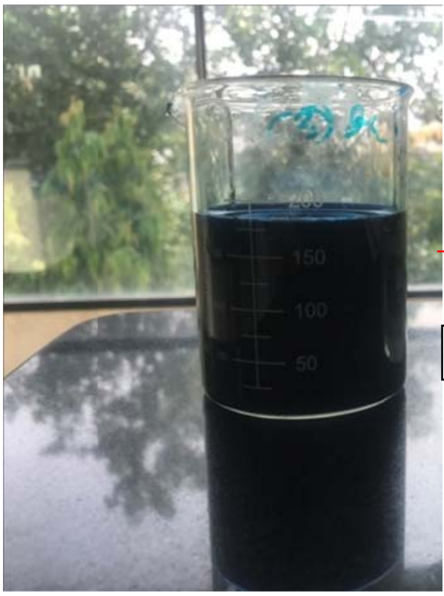
300 ml effluent Sample were taken for evaporation method in each stream in which after condensate and evaporate we got approximately 200-250 ml condensable sample which was used for further analysis i.e. primary and 3° treatment.

4.4.2.1 EVAPORATION ASSEMBLY



4.5 BLUE STREAM EFFLUENT:

300 ml effluent Sample were taken for evaporation method in each stream in which after condensate and evaporate we got approximately 205 ml condensable sample which was used for further analysis i.e. primary and 3° treatment.



Evaporation

Blue Effluent

After Evaporation sample

4.5.1 ANALYTICAL REPORT OF STREAM BLUE

Table 13: Analytical report of stream blue

Sr. No.	Parameters	Unit	Results
1.	Physical Appearance	-	Colour less liquid form in the condensable effluent.
2.	pH	-	4.1
3.	Electrical Conductivity	mS	04
4	Ammonical nitrogen	mg/L	NA
5.	TDS(INORGANIC)	mg/L	12.6
6.	TDS(ORGANIC)	mg/L	NA

7.	TSS	mg/L	195.6
8.	Oil& Grease	mg/L	NA
9	COD	mg/L	1080

4.6 RED STREAM EFFLUENT

300 ml effluent Sample were taken for evaporation method in each stream in which after condensate and evaporate we got approximately 250 ml condensable sample which was used for further analysis i.e. primary and 3° treatment.

Evaporation

Red Effluent

after Evaporation Sample

4.6.1 ANALYTICAL REPORT OF STREAM RED

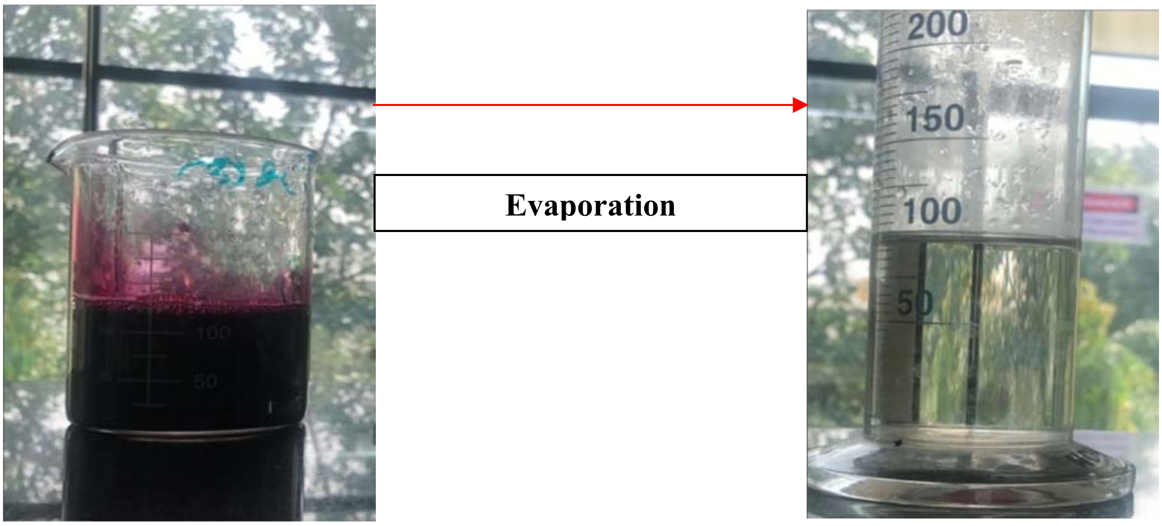
Table 14: Analytical report of stream red

Sr. No.	Parameters	Unit	Results
1.	Physical Appearance	-	Presence of red tint in the condensable effluent.
2.	pH	-	3.4
3.	Electrical Conductivity	mS	0.4
4	Ammonical nitrogen	mg/L	NA

5.	TDS(INORGANIC)	mg/L	58.6
6.	TDS(ORGANIC)	mg/L	NA
7.	TSS	mg/L	122.8
8.	Oil & Grease	mg/L	NA
9	COD	mg/L	1480

4.7 ORANGE STREAM EFFLUENT

300 ml effluent Sample were taken for evaporation method in each stream in which after condensate and evaporate we got approximately 200 ml condensable sample which was used for further analysis i.e. primary and 3° treatment.



4.7.1 ANALYTICAL REPORT OF STREAM ORANGE

Table 15: Analytical report of stream orange

Sr. No.	Parameters	Unit	Results
1.	Physical Appearance	-	Colour less liquid form in the condensable effluent.
2.	pH	-	3.11
3.	Electrical Conductivity	mS	0.5
4	Ammonical nitrogen	mg/L	NA
5.	TDS(INORGANIC)	mg/L	68.6
6.	TDS(ORGANIC)	mg/L	NA
7.	TSS	mg/L	163.6
8.	Oil & Grease	mg/L	NA
9	COD	mg/L	480

4.8 CONVENTIONAL TREATMENT OF STREAM BLUE

- 100 ml effluent sample taken (Stream BLUE 100%) in 500 ml Beaker, pH of said effluent is 4.1.
- Add 4.6 gm Lime (85% minimum Pure) for adjusting pH from 4.1 to 11**.** This step is known as Flocculation.
- Add 2.0 gm Ferrous Sulphate Hepta-hydrate for adjusting pH from 11.10 to 7.This step is known as Coagulation**.**
- Agitate the whole mixture for 10 minutes for complete Flocculation and Coagulation process.
- Measuring the sludge volume by V/V is 50/100 after 30 minutes settling.

4.8.1 TREATMENT RESULT

Table 16: Treatment Result of stream blue

Sr. No.	Parameters	Initial	After Treatment	Reduction
1	COD	1080 mg/L	240 mg/L	84%

4.8.2 CHEMICAL CONSUMPTION

Table 17: Chemical consumption of stream blue

Sr. No.	Parameters	100 ml	1 Ltr.	1 KL
1	Lime (85% minimum Pure)	4.6gm	46 gm	46 Kg
2	$FeSO_4$(AR Grade)	2.0gm	20 gm	20 Kg

4.9 CONVENTIONAL TREATMENT OF STREAM RED

- 100 ml effluent sample taken (Stream BLUE 100%) in 500 ml Beaker, pH of said effluent is 3.4.
- Add 2.8 gm Lime (85% minimum Pure) for adjusting pH from 3.4 to 11. This step is known as Flocculation.
- Add 1.3 gm Ferrous Sulphate hepta-hydrate for adjusting pH from 11 to 7. This step is known as Coagulation.
- Agitate the whole mixture for 10 minutes for complete Flocculation and Coagulation process.
- Measuring the sludge volume by V/V is 50/100 after 30 minutes settling.

4.9.1 TREATMENT RESULT

Table 18: Treatment result of stream red

Sr. No.	Parameters	Initial	After Treatment	Reduction
1	COD	1480 mg/L	800 mg/L	68%

4.9.2 CHEMICAL CONSUMPTION

Table 19: Chemical consumption of stream red

Sr. No.	Parameters	100 ml	1 Ltr.	1 KL
1	Lime (85% minimum Pure)	2.8gm	28 gm	28 Kg
2	$FeSO_4$(AR Grade)	1.3gm	13 gm	13 Kg

4.10 CONVENTIONAL TREATMENT OF STREAM ORANGE

- 100 ml effluent sample taken (Stream orange 100%) in 500 ml Beaker, pH of said effluent is 3.11.
- Add 3 gm Lime for adjusting pH from 3.11 to 11. This step is known as Flocculation.
- Add 2 gm Ferrous Sulphate Hepta-hydrate for adjusting pH from 11 to 7.00. This step is known as Coagulation.
- Agitate the whole mixture for 10 minutes for complete Flocculation and Coagulation process.
- Measuring the sludge volume by V/V is 50/100 after 30 minutes settling.

4.10.1 TREATMENT RESULT

Table 20: Treatment result of stream orange

Sr. No.	Parameters	Initial	After Treatment	Reduction
1	COD	480 mg/L	420 mg/L	12.5%

4.10.2 CHEMICAL CONSUMPTION

Table 21: Chemical consumption of stream orange

Sr. No.	Parameters	100 ml	1 Ltr.	1 KL
2	Lime (85% minimum Pure)	3gm	30 gm	30 Kg.
3	$FeSO_4$(AR Grade)	2gm	20 gm	20 Kg.

Table 22: Primary treatment(After evapouration)

SR.NO	PARAMETERS	Stream BLUE	Stream RED	Stream ORANGE
1	PH	5.83	5.51	6.22
2	Electrical Conductivity	6.1	3.9	7.4
3	COD	240	800	720

Table 23: 3°Treatment

SR.NO	PARAMETERS	Stream BLUE	Stream RED	Stream ORANGE
1	PH	6.25	5.58	5.84
2	Electrical Conductivity	5.2	3.1	5.3
3	COD	208	528	416

4.11 INTRODUCTION OF FLOCCULANTS

Flocculation is used to describe the action of polymeric material which forms bridge between individual particles. Bridging occurs when segments of a polymer chain adsorb on different particles and help the particles agglomerate into larger particles. Flocculants have charged groups with a charge that counterbalances the charge of the particles. Flocculants adsorb on the particles and cause destabilization by bridging or charge neutralization. Certain designate chemicals are used to improve the formation of larger flocs. Flocculants are generally used of high molar mass and are even highly water-soluble.

Flocculants used are:

1. Nonionic flocculant
2. Anionic flocculant
3. Cationic flocculant
4. Chitosan 1 - Low molecular weight
5. Chitosan 2 - High molecular weight
6. Biodegradable starch based anionic flocculant

7. Biodegradable starch based cationic flocculant

4.11.1 FLOCCULATION MECHANISM

The stability of the suspension depends upon the number, size, density and surface properties of the solid particles (internal or dispersed phase) and on the density of the external phase or dispersion medium. In aqueous suspensions, the particle surface has an electrical (usually negative) charge, which, for example, in mineral solids originates from the dissociation of protons from surface hydroxyl groups belonging to silicate groups (e.g.Ca^{2+} or Mg^{2+}) are present in the surrounding water, they accumulate on the surface of the suspended particles, forming an ionic double layer. The excess negative charge layer is called Zeta Potential which increases the columbic repulsion between the particles and becomes stronger and the suspension is more stable.Now here we are using Starch Based Flocculant (SBF) by preparing 1 N solution and allowing it to settle.

The following rate processes to be considered in flocculation:

a. Adsorption of polymer molecules on the particles
b. Re-arrangement (or re-conformation) of adsorbed chains
c. Collisions between destabilized particles to form aggregates (flocs)
d. Break-up of flocs

4.11.2 RESULTS AFTER FLOCCULATION IN BLUE STREAM:

Table 24: COD results of stream blue

Sr. No.	Chemicals	COD After Treatment
1.	Lime – $FeSO_4$ -SBF	10036
2.	Lime – $FeSO_4$– Poly Electrolyte-SBF	9884
3.	NaOH – $FeSO_4$ - SBF	9794
4.	NaOH – $FeCl_3$ –SBF	11008
5.	NaOH – PAC – Poly Electrolyte – SBF	9920

4.11.3 RESULTS AFTER FLOCCULATION IN RED STREAM:

Table 25: COD results of stream red

Sr. No.	Chemicals	COD After Treatment
1.	Lime – $FeSO_4$ -SBF	25176
2.	Lime – $FeSO_4$– Poly Electrolyte - SBF	27904
3.	NaOH – $FeSO_4$ -SBF	21480
4.	NaOH – $FeCl_3$ - SBF	27323
5.	NaOH – PAC – Poly Electrolyte -SBF	26208

4.11.4 RESULTS AFTER FLOCCULATION IN ORANGE STREAM:

Table 26: COD results of stream orange

Sr. No.	Chemicals	COD After Treatment
1.	Lime – $FeSO_4$ -SBF	26560
2.	Lime – $FeSO_4$– Ploy Electrolyte -SBF	28982
3.	NaOH – $FeSO_4$-SBF	29244
4.	NaOH – $FeCl_3$-SBF	27282
5.	NaOH – PAC – Poly Electrolyte-SBF	29045

CHAPTER 5 CHITOSAN

Chitin is a natural polymer derived mainly from two aquatic crustaceans, shrimp and crabs. The most important derivative of chitin is chitosan obtained by partial de acetylation of chitin under alkaline environment or enzymatic hydrolysis.(15) Chitin polymers consist of N-acetyl glucosamine (GlcNAc) and glucosamine (GlcN) units, which contain amino (-NH2) groups. The process of de-acetylation influences the amount of the amino groups along the glucosamine structure. When liquefied, the amino groups on the glucosamine units will protonate, resulting in increased solubility and positive charge (cationic property). The positive charge is a critical property for a coagulant, as a coagulant with high positive charge density in water at or near neutral pH, results in efficient removal of negatively charged turbidity and microbes, more so than a coagulant of lower positive charge density or negative charge [16].

Chitosan is a linear chained polysaccharide composed of randomly distributed β-(1→4)-linked D-glucosamine (deacetylated unit) and N-acetyl-D-glucosamine (acetylated unit). It is made by treating the chitin shells of shrimp and different shell-fish with an antacid substance, similar to sodium hydroxide [12]. It works as biosorptive powder with the industrial effluent. The utilization of biopolymers with adsorbents is because of its effectiveness, biodegradability and economic viability.Today a few techniques were created with the point of expelling these contaminations, for example, chemical precipitation, ion exchange, adsorption, membrane filtration, electrochemical etc., which are effective in treating effluent limitations with more.

Chitosan is taking out from crustacean shell waste, produced by fishery and sea food industry. Crab shell waste is pollutant with noteworthy health hazards. The most common method used for its disposal is burning, which becomes environmentally costly, due to its low burning capacity. In such a consequence, transformation of crab shell waste to chitosan, a commercially useful product with many of uses, could work as an effective mode of shell remediation and more importantly enable waste water treatment [13]

The shell fish production produces about 60,000 tons of wastes per year [13]. The disposal of such massive amount of waste has become a serious environmental concern. Although these wastes are biodegradable but the rate of degradation of a large amount of waste generated per processing operation is moderately slow. The most viable way out to this issue is recycling of the crustacean shells generated and extraction of commercially viable polysaccharide such as chitosan.

Most normal colloids in water, for example, clays, silts, bacteria, viruses, protozoans, etc., having a negative charge over the pH range of natural waters, around pH 5–9. Together, these chemical properties create chitosan a unique and effective biopolymer for inter-particle bridging, aggregation of floc particles and precipitation [14].

Chitosan is a non-toxic linear high molecular weight cationic polymer exhibiting a range of uses. It has a variety of uses in cosmetics, biomedical engineering, agriculture, nutrition and many other fields. Chitosan-based materials have also been mentioned as potentially eco-friendly coagulants and flocculants for water and wastewater treatment because of their natural biological characteristics and biodegradability [15].

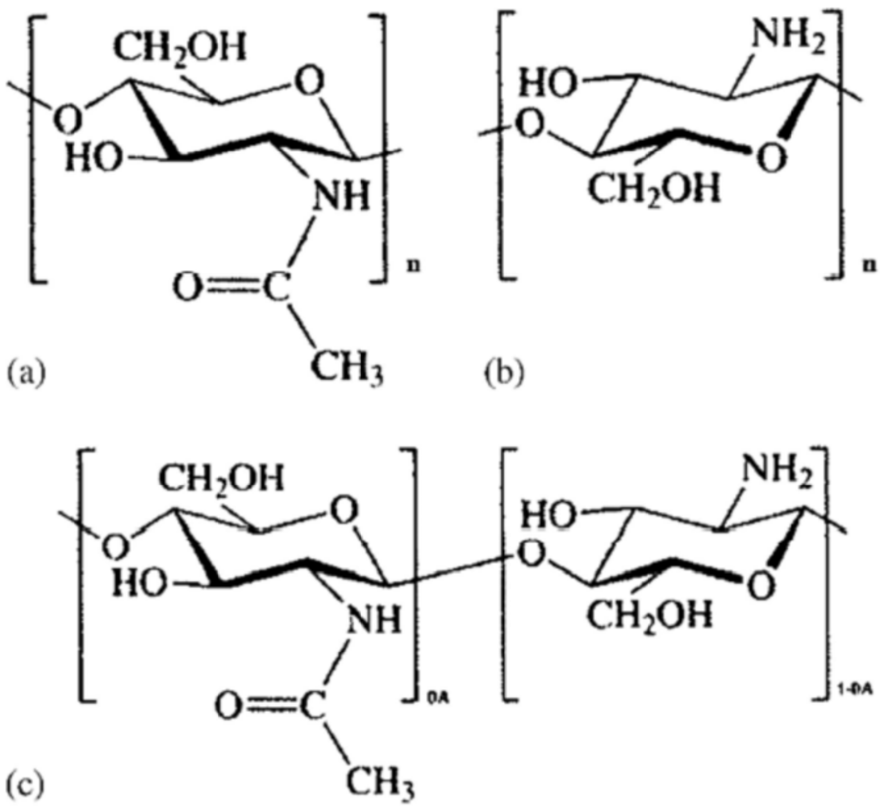


Figure 7:Chemical structure of chitin (a) Poly(N-acetyl-β-D-glucosamine) and (b) Poly(D-glucosamine) (c) Partially acetylated chitosan, a copolymer characterized by average amount of acetylation[14]

5.1 PROPERTIES OF CHITIN AND CHITOSAN

The vast majority of the normally happening polysaccharides e.g., cellulose, alginic corrosive, agar, dextrin, pectin, caragenas, and agarose are regular and acidic in nature, while chitin and chitosan are cases of fundamental polysaccharides. Their properties incorporate solvency in different media, arrangement, thickness, polyelectrolyte conduct, polyoxysalt development, capacity to shape films, metal chelation, optical, and basic attributes. In spite of the fact that the b(1→4)- anhydroglucosidic obligation of chitin is likewise present in cellulose the trademark properties of chitin &chitosan are not shared by cellulose. Chitin is particularly hydrophobic and is insoluble in water and most natural solvents [14].

5.2 CHITOSAN AND ITS CHEMICAL PROPERTIES

The chemical properties of chitosan are thus mentioned below:

- Molecular Formula: $C_{56}H_{103}N_9O_{39}$
- Viscosity Range: 5-600 mPa.s
- Molecular Weight: 1525 g/mol
- Linear polyamine
- Presence of amino groups rective by nature
- Presence of reactive hydroxyl groups
- The transition metal ions are chelated

5.3 CHITOSAN AND ITS BIOLOGICAL PROPERTIES

The biological properties of chitosan are thus mentioned below:

- Biocompatible
- Natural polymer
- Safe and non-toxic
- Biodegradable to normal body constituents
- Fixes mammalian and the microbial cells quickly, Accelerated reformation on the connective gum tissue.
- Quickens the development of osteoblast in charge of bone arrangement.

5.4 APPLICATIONS OF CHITIN AND CHITOSAN

Chitosan and its Industrial Applications

Because of its physical and substance properties, chitosan is being utilized as a part of broadly extraordinary items and applications, extending from pharmaceutical and restorative items to water treatment and plant assurance. In various applications, diverse properties of chitosan are required. These properties change with, e.g., level of acetylation upto atomic weight [18].

Cosmetic Industry

Generally organic acids are used as good solvent medium for cosmetic applications. A natural amino polysaccharide, chitosan can be placed in the category of hydrocolloids.

Wastewater Engineering

Chitosan is in polycationic nature and because of its polycationic nature it can be used as an agent for floc formation. It can also be utilized as chelating material and heavy metals removal. According to various literature survey it is described that the removal of colour from the dye and intermediate industry effluents using chitosan as an adsorbent. Large amounts of world production of chitosan from chitin and derivatives are utilized in wastewater treatment.

Chitosan molecules agglomerate the particles which are highly anionic materials in wastewater to form precipitates hence flocs are formed, thus it also used as flocculent for recovery of rare and expensive material. Chitosan is completely effective with synthetic resins so as to capture the heavy metals ions from the process water. Chitosan has is proactively used to extract or remove plutonium ions containing water, and water containing methyl-mercury acetate, a massive pollutant of water from the industries which have acetaldehyde production. Utilization of combination of chitosan/chitin was found to expel arsenic from polluted potable water. Chitosan has also been discovered in the successful removal of petroleum from the process water of petroleum industry [18].

Pulp & Paper Industry

As chitin and chitosan are eco-friendly they can strengthen recycled paper and increase the eco-friendliness of packaging and other products. Chitosan is already involved in the production of paper because chitosan molecules greatly resemble those of cellulose the main constituent of plant walls. It also cuts down the cost of chemical additives and increases its economic viability [18].

Textile Industry

Chitin and its various derivatives have been created and used as an antistatic as well as soil repellent agents to the materials. In material industry, chitin is utilized as a part of printing and completing arrangements, while the chitosan can expel colours from colour handling effluents.

Food Processing

Utilization of chitosan in nourishment industry is outstanding in light of the fact that it isn't lethal for the creatures who are warm-blooded. Microcrystalline chitin (MCC) indicates great emulsifying nature, prevalent thickening as well as gelling specialist for settling substances. It is additionally utilized as a dietary fiber in prepared substances. The utilization of MCC tackled a portion of the issues, for example, flavour, shading, and timeframe of realistic usability, postured by different wellsprings of fiber.

Agriculture

The treated seeds of wheat which were treated by chitin are found to have developed quickening and development improving impacts. Additives of chitin are used to prepare blends/soil brought about noteworthy lessening in root hitch worm invasions and concealment of contagious pathogens.

Photography

In colouring photography, chitosan is utilized as a settling specialist for the corrosive colours in gelatin as to furthermore goes about as a guide to enhance dissemination, an imperative advance in creating photos.

Biomedical Applications of Chitosan

Chitosan is used as a membrane in this new technology that is artificial kidney design which is helpful to the patients who undergo a kidney failure. It is used as a membrane because of its high membrane permeability and increased tensile strength.

World Health Organization (WHO) declared that 1.1 billion individuals need access to an enhanced drinking water supply, 88% of the 4 billion yearly instances of diarrheal sickness are credited to risky water and deficient sanitation and cleanliness, and 1.8 million individuals bite the dust from diarrhoeal maladies every year. The adsorption procedure has too gotten much consideration and has turned out to be one of the more famous strategies for the expulsion of substantial metal particles and microbial contaminants from water, as a result of its aggressive what's more, successful process. Various adsorbents have been announced for the evacuation of harmful metal particles, for example, chitin, Chitosan, cellulose and Guarana, which are not just ecofriendly what's more, financially savvy but on the other hand are viable in the remediation of normal effluents display in wastewater [19].

Bangladesh is the seventh biggest exporter of shrimp and prawn to the world. So wealth of prawns shell is high and have generally minimal effort. A considerable measure of shell is squandered amid handling activities furthermore, these shells being bioaccumulation cause natural contamination. The reason for this investigation is to assess the adequacy of chitosan for enhancing the nature of drinking water by expulsion of substantial metal substance and other physicochemical parameters. We can embrace such eco-friendly adsorbents and financially feasible treatment process rather than regular strategies which is monetarily practical and easy to understand [20].

Mohammadtaghi Vakili et al. chitosan is a plentifully accessible minimal effort bio-polymer for dye expulsion that can be acquired from regular assets. As compared with other business adsorbents, it has gotten a considerable measure of focus because of its particular properties, for example, cationicity, high adsorption limit, macromolecular structure, abundance and low cost [21]. Coagulation/flocculation process is a standout amongst the most productive strategies that are broadly utilized for colour expulsion from mechanical wastewater as it is effective and easy to work.The expulsion of toxins by the guide of coagulation is a promising process, yet the utilization of traditional coagulants may not be so commendable as a result of the concoction costs. Under these conditions, utilizing muck created from water treatment plants (WTPs) might be positive [22].

Chitin is the most inexhaustible regular amino polysaccharide and is evaluated to be delivered every year nearly as much as cellulose. It has happened to awesome intrigue as an underutilized asset, as well as another useful material of high potential in different fields, and late advance in chitin science is very essential [23]. The effectiveness of chitosan as an adsorbent for the treatment of wastewater from the egg handling industry was tested in this research. Parameters influencing the emanating treatment process, for example, pH, chitosan measurement, settling time and chemical oxygen demand(COD) on the decrease level of turbidity, COD and biochemical oxygen demand were contemplated [24].

Yusmaniar et al. has shown a deep insight on the guarantee of the safeguarding of water assets from the transfer of wastewater of printing ink industry, the administration of Indonesia has set effluent quality standards for the wastewater released from the industries. So as to satisfy emanating quality principles, the wastewater of printing industry must be dealt with by physic-substance or natural handling or a blend of physic-substance natural wastewater which is needy their attributes. At the point when wastewater contains high suspended solids and low disintegrated natural focus, this wastewater is sufficient treated by physic-substance process with the treated wastewater satisfying the effluent quality standard. Be that as it may, when the wastewater contains high broken down natural and low suspended strong substance, this waste water needs organic treatment process all together satisfy the gushing quality standard [25].

CHAPTER 6: EXPERIMENTAL WORK WITH CHITOSAN

6.1 OBJECTIVES

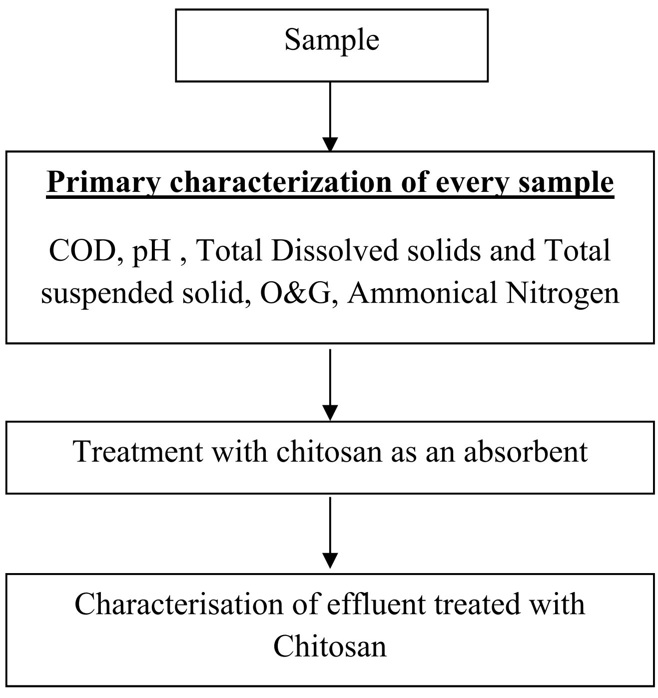
The objective of the study is to give proper treatment to wastewater so that it will help the primary effluent treatment plant to undergo necessary change for startup and give effective pollutant load as per statuary requirement of Maharashtra Pollution Control Board (MPCB). Henceforth we have used chitosan in liquid form as well as powdered form as an absorbent for colour reduction, decreasing COD, decreasing TDS & TSS. The experimental work in laboratory is done by different methods and following different literature survey.

6.2 METHODOLOGY

Methodology adopted for the study is as follows:

1) Initial characterisation of streams
2) Treatment with Chitosan
3) Final characterisation of treated effluent

FLOW CHART OF TREATMENT SCHEME



6.3 INITIAL ANALYSIS OF DIFFERENT STREAMS

6.3.1 STREAM BLUE

Blue stream effluent had contained high chemical oxygen demand, reactive dyes and high solvents during initial analysis.

6.3.1.1 ANALYTICAL RESULTS OF STREAM BLUE

Table 27 : Results of stream blue

Sr. No.	Parameters	Unit	Results
1.	Physical Appearance	-	Dark Blue colour liquid sample with few suspended particles & strong characteristic odour.
2.	pH	-	4.6
3.	Electrical Conductivity	m Ʊ	116.4
4	Ammonical nitrogen	mg/L	5.6
5.	TDS(INORGANIC)	mg/L	103988
6.	TDS(ORGANIC)	mg/L	4611
7.	TSS	mg/L	3473.8
8.	Oil & Grease	mg/L	ND
9	COD	mg/L	11200

6.3.2 STREAM RED

Red stream were having high ammonical nitrogen and chemical oxygen demand, reactive dyes and solvents.

6.3.2.1 ANALYTICAL RESULTS OF STREAM RED

Table 28: Results of stream red

Sr. No.	Parameters	Unit	Results
1.	Physical Appearance	-	Red colour liquid sample with few suspended particles & high ammonical nitrogen present.
2.	pH	-	3.27
3.	Electrical Conductivity	m ℧	92.3
4	Ammonical nitrogen	mg/L	71.68
5.	TDS(INORGANIC)	mg/L	71308
6.	TDS(ORGANIC)	mg/L	16128
7.	TSS	mg/L	2768.4
8.	Oil & Grease	mg/L	ND
9	COD	mg/L	28800

6.3.3 STREAM ORANGE

This stream contains high chemical oxygen demand reactive dyes and solvent.

6.3.3.1 ANALYTICAL RESULTS OF STREAM ORANGE

Table 29 : Results of stream orange

Sr. No.	Parameters	Unit	Results
1.	Physical Appearance	-	Dark violet colour liquid sample with much suspended particles and high characteristic odour.
2.	pH	-	4.96
3.	Electrical Conductivity	m ℧	135.1
4	Ammonical nitrogen	mg/L	9.52
5.	TDS(INORGANIC)	mg/L	141423
6.	TDS(ORGANIC)	mg/L	16741
7.	TSS	mg/L	4878.6
8.	Oil & Grease	mg/L	ND
9	COD	mg/L	30400

6.4 TREATMENT OF EFFLUENT STREAMS WITH CHITOSAN

The treatment of all the three effluent streams is carried out using chitosan in a form of different solutions and the results were thus obtained at the end of each experiment.

6.4.1 TREATMENT OF STREAM BLUE

- 100 ml effluent sample taken (Stream BLUE 100%) in 500 ml Beaker, pH of said effluent is 4.1.
- Chitosan solution of 1 N was prepared and kept it for settling for 24 hours and then taken for the usage in experiments.
- Now the dosing is done drop by drop with the help of pippete and kept on the magnetic stirrer at 520 rpm for 5 – 6 hours.
- Then the solution is taken after 6 hours and then allow it to settle for 10 minutes**.**
- Take the sample for characterisation of the effluent.

6.4.1.1 TREATMENT RESULT

Table 30 : Treatment result of stream blue

Sr. No.	Parameters	Initial	After Treatment	Reduction
1	COD	11200	10182	9%

6.4.2 TREATMENT OF STREAM RED

- 100 ml effluent sample taken (Stream RED 100%) in 500 ml Beaker, pH of said effluent is 3.4.
- Chitosan solution of 1 N was prepared and kept it for settling for 24 hours and then taken for the usage in experiments.
- Now the dosing is done drop by drop with the help of pippete and kept on the magnetic stirrer at 520 rpm for 5 – 6 hours.
- Then the solution is taken after 6 hours and than allow it to settle for 10 minutes.
- Take the sample for characterisation of the effluent.

6.4.2.1 TREATMENT RESULT

Table 31 : Treatment Result of stream red

Sr. No.	Parameters	Initial	After Treatment	Reduction
1	COD	28800	26108	9.5%

6.4.3 TREATMENT OF STREAM ORANGE

- 100 ml effluent sample taken (Stream ORANGE 100%) in 500 ml Beaker, pH of said effluent is 4.1.
- Chitosan solution of 1 N was prepared and kept it for settling for 24 hours and then taken for the usage in experiments.
- Now the dosing is done drop by drop with the help of pippete and kept on the magnetic stirrer at 520 rpm for 5 – 6 hours.
- Then the solution is taken after 6 hours and then allow it to settle for 10 minutes.
- Take the sample for characterisation of the effluent.

6.4.3.1 TREATMENT RESULT

Table 32 : Treatment result of stream orange

Sr. No.	Parameters	Initial	After Treatment	Reduction
1	COD	30400	28556	6.5%

6.5 TREAMENT OF EFFLUENT USING CHITOSAN IN SOLID FORM

Chitosan is used in the solid form for the sequence of experiments in the below series. Henceforth it works more effectively in its solid for as it is an bio-absorptive powder.

6.5.1 TREATMENT RESULT FOR BLUE STREAM

Table 33 : Chitosan treatment results of stream blue

Sr. No.	Combination of Distilled Water & Effluent	Dosing Of Chitosan	Initial COD	Final COD
1.	25 ml D.W + 25 ml E.T	0.15 g	7600	4560
2.	50 ml D.W + 25 ml E.T	0.15g	6400	3920
3.	75 ml D.W + 25 ml E.T	0.15g	5200	3360
4.	100 ml D.W + 25 ml E.T	0.15g	2800	2080
5.	125 ml D.W + 25 ml E.T	0.15g	2400	1840
6.	25 ml D.W + 25 ml E.T	0.20g	7600	4400
7.	50 ml D.W + 25 ml E.T	0.20g	6400	3760
8.	75 ml D.W + 25 ml E.T	0.20g	5200	3200
9.	100 ml D.W + 25 ml E.T	0.20g	2800	1920
10.	125 ml D.W + 25 ml E.T	0.20g	2400	1680
11.	25 ml D.W + 25 ml E.T	0.25g	7600	4320
12.	50 ml D.W + 25 ml E.T	0.25g	6400	3680
13.	75 ml D.W + 25 ml E.T	0.25g	5200	3120
14.	100 ml D.W + 25 ml E.T	0.25g	2800	1840
15.	125 ml D.W + 25 ml E.T	0.25g	2400	1600

Here in the above table,

D.W= Distilled Water

E.T= Effluent

6.5.2 TREAMENT RESULT FOR RED STREAM

Table 34 : Chitosan treatment results of stream red

Sr. No.	Combination of Distilled Water & Effluent	Dosing Of Chitosan	Initial COD	Final COD
1.	25 ml D.W + 25 ml E.T	0.15 g	7600	3400
2.	50 ml D.W + 25 ml E.T	0.15g	6400	2680
3.	75 ml D.W + 25 ml E.T	0.15g	5200	2320
4.	100 ml D.W + 25 ml E.T	0.15g	2800	1600
5.	125 ml D.W + 25 ml E.T	0.15g	2400	1320
6.	25 ml D.W + 25 ml E.T	0.20g	7600	3320
7.	50 ml D.W + 25 ml E.T	0.20g	6400	2600
8.	75 ml D.W + 25 ml E.T	0.20g	5200	2240
9.	100 ml D.W + 25 ml E.T	0.20g	2800	1520
10.	125 ml D.W + 25 ml E.T	0.20g	2400	1240
11.	25 ml D.W + 25 ml E.T	0.25g	7600	3280
12.	50 ml D.W + 25 ml E.T	0.25g	6400	2560
13.	75 ml D.W + 25 ml E.T	0.25g	5200	2200
14.	100 ml D.W + 25 ml E.T	0.25g	2800	1480
15.	125 ml D.W + 25 ml E.T	0.25g	2400	1200

Here in the above table,

D.W= Distilled Water

E.T= Effluent

6.5.3 TREATMENT RESULT FOR ORANGE STREAM

Table 35 : Chitosan treatment results of stream orange

Sr. No.	Combination of Distilled Water & Effluent	Dosing Of Chitosan	Initial COD	Final COD
1.	25 ml D.W + 25 ml E.T	0.15 g	18400	11200
2.	50 ml D.W + 25 ml E.T	0.15g	13600	8800
3.	75 ml D.W + 25 ml E.T	0.15g	5200	3200
4.	100 ml D.W + 25 ml E.T	0.15g	2800	2400
5.	125 ml D.W + 25 ml E.T	0.15g	2400	1600
6.	25 ml D.W + 25 ml E.T	0.20g	18400	10400
7.	50 ml D.W + 25 ml E.T	0.20g	13600	8000
8.	75 ml D.W + 25 ml E.T	0.20g	5200	2400
9.	100 ml D.W + 25 ml E.T	0.20g	2800	1600
10.	125 ml D.W + 25 ml E.T	0.20g	2400	800
11.	25 ml D.W + 25 ml E.T	0.25g	18400	10000
12.	50 ml D.W + 25 ml E.T	0.25g	13600	7600
13.	75 ml D.W + 25 ml E.T	0.25g	5200	2000
14.	100 ml D.W + 25 ml E.T	0.25g	2800	2400
15.	125 ml D.W + 25 ml E.T	0.25g	2400	1200

Here in the above table,

D.W= Distilled Water

E.T= Effluent

6.6 EFFECT OF HIGH MOLECULAR WEIGHT CHITOSAN ON DIFFERENT EFFLUENT STREAMS

The treatment of all the three effluent streams is carried out using chitosan in a form of different solutions and the results were thus obtained at the end of each experiment.

6.6.1 CHITOSAN TREATMENT OF BLUE EFFLUENT STREAM

- 100 ml effluent sample taken (50 ml distilled water + 50 ml effluent) in 500 ml Beaker, pH of said effluent is 4.1.
- Chitosan was pre-weighed by 0.25 grams and then added grain by grain to the effluent solution with the help of a spatula.
- Now it is kept on the magnetic stirrer at 520 rpm for 5 – 6 hours.
- Then the solution is taken after 6 hours and then allows it to settle for 10 minutes.
- Now with the help of funnel and tripod the effluent is filtered with the help of whatman filter paper.
- Take the sample for characterisation of the effluent.

6.6.1.1 CHITOSAN TREATMENT RESULT

Table 36 : Treatment result of stream blue

Sr. No.	Parameters	Initial	After Treatment	Reduction
1	COD	8000	5600	30%

6.6.1.2 CHARCOL TREATMENT OF TREATED EFFLUENT

- Now the chitosan treated sample is again taken in a beaker and then followed by tertiary treatment.
- Now 0.15 grams of activated charcoal powder is added to the previously treated effluent.
- Now it is kept on the magnetic stirrer at 400 rpm for 2 hours.
- Then the solution is taken after 6 hours and then allow it to settle for 10 minutes.
- Now with the help of funnel and tripod the effluent is filtered with the help of whatman filter paper.

- Take the sample for characterisation of the effluent.

6.6.1.3 CHARCOL TREATMENT RESULT

Table 37 : Charcoal treatment result of stream blue

Sr. No.	Parameters	Initial	After Treatment	Reduction
1	COD	5600	2560	54.3%

6.6.1.4 SPECTROPHOTOMETER ANALYSIS RESUTLS OF BLUE STREAM

Table 38 : Spectrophotometer analysis report of stream blue

Wavelength	Optical Density		
	Initial	After Chitosan Treatment	After Charcoal Treatment
200	3.7	3.891	3.7
300	3.7	3.7	0.147
400	0.636	0.164	0.001
500	2.045	1.192	0
600	0.91	0.319	0
700	0.36	0.013	0
800	0.016	0	0
900	0	0	0
1000	0	0	0
1100	0	0	0

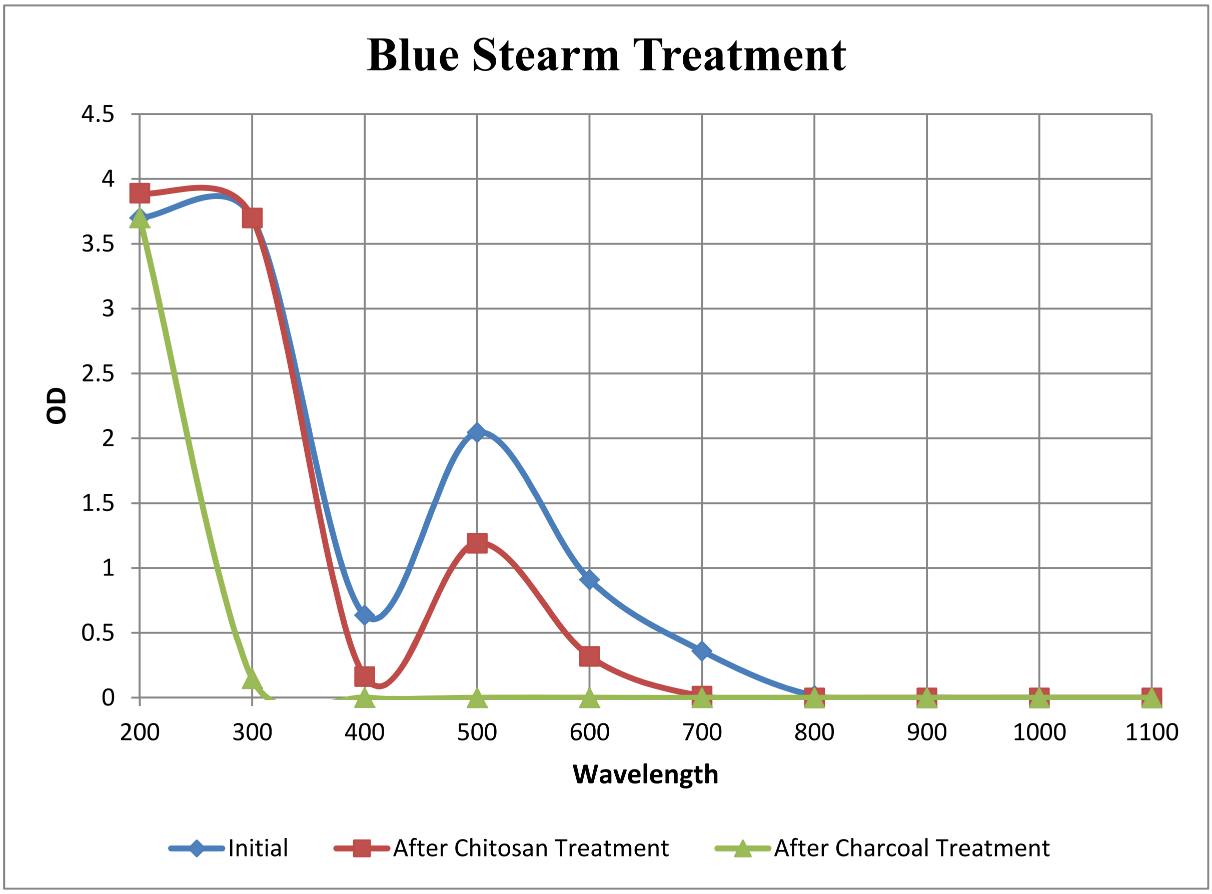


Figure 8: Spectrophotometric results for blue stream treatment

6.6.2 CHITOSAN TREATMENT OF RED EFFLUENT STREAM

- 100 ml effluent sample taken (50 ml distilled water + 50 ml effluent) in 500 ml Beaker, pH of said effluent is 4.1.
- Chitosan was pre-weighed by 0.25 grams and then added grain by grain to the effluent solution with the help of a spatula.
- Now it is kept on the magnetic stirrer at 520 rpm for 5 – 6 hours.
- Then the solution is taken after 6 hours and then allows it to settle for 10 minutes.
- Now with the help of funnel and tripod the effluent is filtered with the help of whatman filter paper.
- Take the sample for characterisation of the effluent.

6.6.2.1 CHITOSAN TREATMENT RESULT

Table 39 : Treatment result of stream red

Sr. No.	Parameters	Initial	After Treatment	Reduction
1	COD	12000	6800	43.3%

6.6.2.2 CHARCOL TREATMENT OF TREATED EFFLUENT

- Now the chitosan treated sample is again taken in a beaker and then followed by tertiary treatment.
- Now 0.15 grams of activated charcoal powder is added to the previously treated effluent.
- Now it is kept on the magnetic stirrer at 400 rpm for 2 hours.
- Then the solution is taken after 6 hours and then allow it to settle for 10 minutes.
- Now with the help of funnel and tripod the effluent is filtered with the help of whatman filter paper.
- Take the sample for characterisation of the effluent.

6.6.2.3 CHARCOL TREATMENT RESULT

Table 40 : Charcoal treatment result of stream red

Sr. No.	Parameters	Initial	After Treatment	Reduction
1	COD	6800	2080	69.4%

6.6.2.4 SPECTROPHOTOMETER ANALYSIS RESUTLS OF RED STREAM

Table 41 : Spectrophotometer analysis report of stream red

Wavelength	Optical Density		
	Initial	After Chitosan Treatment	After Charcoal Treatment
200	4	4	4
300	4	4	4
400	0.962	0.705	0.356
500	0.345	0.246	0.12
600	1.81	1.088	0.076
700	2.13	1.039	0.042
800	0.625	0.131	0.037
900	0.146	0.072	0
1000	0.006	0	0
1100	0	0	0

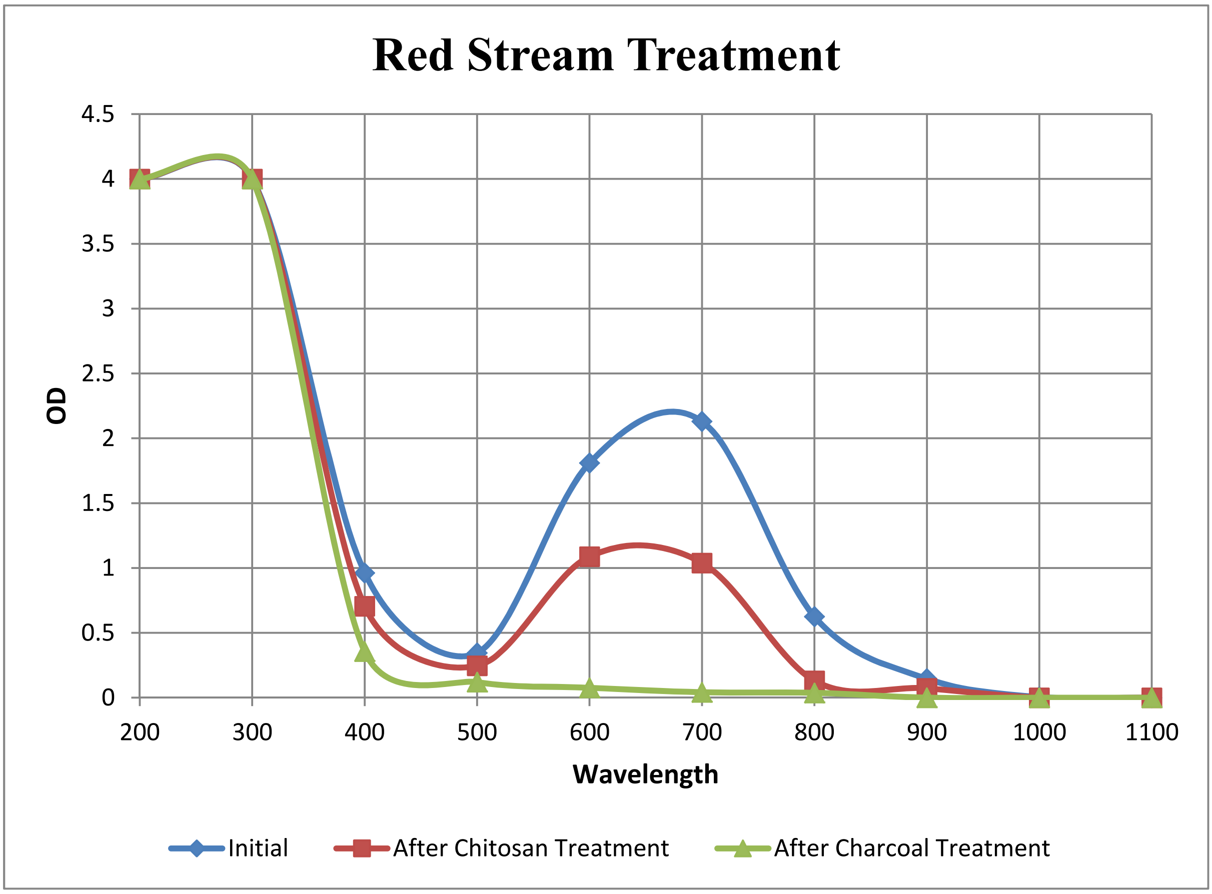


Figure 9: Spectrophotometric results for Red stream treatment

6.6.3 CHITOSAN TREATMENT OF ORANGE EFFLUENT STREAM

- 100 ml effluent sample taken (50 ml distilled water + 50 ml effluent) in 500 ml beaker, pH of said effluent is 4.1.
- Chitosan was pre-weighed by 0.25 grams and then added grain by grain to the effluent solution with the help of a spatula.
- Now it is kept on the magnetic stirrer at 520 rpm for 5 – 6 hours.
- Then the solution is taken after 6 hours and then allows it to settle for 10 minutes.
- Now with the help of funnel and tripod the effluent is filtered with the help of whatman filter paper.
- Take the sample for characterisation of the effluent.

6.6.2.1 CHITOSAN TREATMENT RESULT

Table 42 : Treatment result of stream orange

Sr. No.	Parameters	Initial	After Treatment	Reduction
1	COD	13600	6800	50%

6.6.2.2 CHARCOL TREATMENT OF TREATED EFFLUENT

- Now the chitosan treated sample is again taken in a beaker and then followed by tertiary treatment.
- Now 0.15 grams of activated charcoal powder is added to the previously treated effluent.
- Now it is kept on the magnetic stirrer at 400 rpm for 2 hours.
- Then the solution is taken after 6 hours and then allow it to settle for 10 minutes.
- Now with the help of funnel and tripod the effluent is filtered with the help of whatman filter paper.
- Take the sample for characterisation of the effluent.

6.6.2.3 CHARCOL TREATMENT RESULT

Table 43 : Charcoal treatment result of stream orange

Sr. No.	Parameters	Initial	After Treatment	Reduction
1	COD	6800	2400	35.2%

6.6.2.4 SPECTROPHOTOMETER ANALYSIS RESUTLS OF ORANGE STREAM

Table 44 : Spectrophotometer analysis report of stream orange

Wavelength	Optical Density		
	Initial	After Chitosan Treatment	After Charcoal Treatment
200	4	4	2.493
300	4	4	1.45
400	1.684	0.545	0.351
500	1.43	0.89	0.23
600	2.24	1.23	0.156
700	0.76	0.201	0.086
800	0.54	0.216	0.011
900	0.33	0.02	0
1000	0.035	0.021	0
1100	0.046	0.015	0

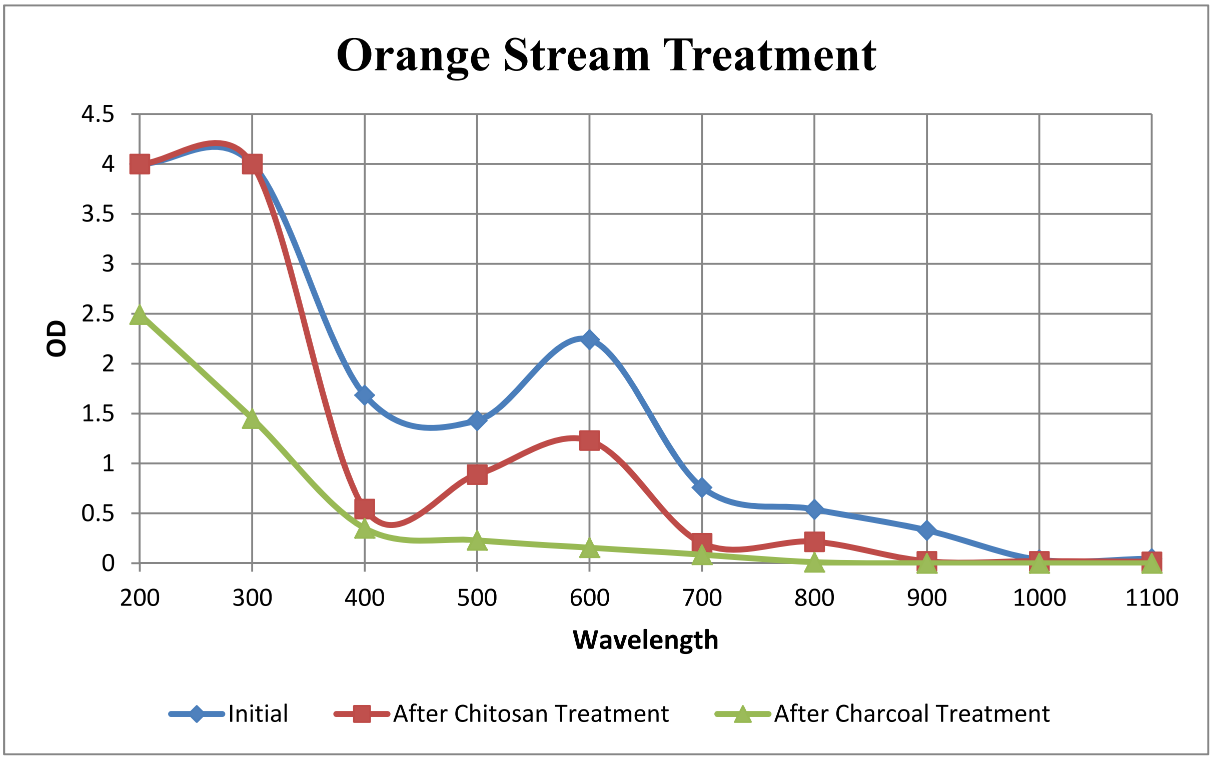


Figure 10: Spectrophotometric results for Orange stream treatment

6.7 CONCLUSION

- Chitosan used in the form of solution (1 N, 2 N, etc.) does not work efficiently.
- Chitosan when used in its powdered form can prove to have efficient results.
- Chitosan with more molecular weight can be even used to even absorb colour as the colour is too much high in the effluent.
- If the chitosan powder is dosed at proper optimum conditions than can achieve the best of the results.

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