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Feasibility Report for the Adequacy of Water Pollution Control Measures for a Denim Processing Unit

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Abstract: The usage of water in a textile processing unit is in big quantity and the need for the hour is to be able to recycle the water and also to discharge water in an environmentally safe and sustainable manner.

In this research the company Bellavietsa Texfab was looking for designs for their upcoming denim processing plant. So in collaboration with M/s Envichem Tech, we were able to formulate a plan for them for effective usage of their processed water.

There are various ways for processing units to treat their waste water and there are numerous chemicals and enzymes that are available in the market for this purpose.

The project was undertaken to find the right mix of chemicals and also to suggest the design of their ETP(Effluent Treatment Plant), that would help them to get their BOD (Biological Oxygen Demand) and COD (Chemical Oxygen Demand) limits under the prescribed limits of the the local pollution control authority.

As the area of operations for this particular unit is Rajasthan, a state with very less natural water resources available, the need for water conservation and recycling is an utmost priority for the upcoming unit.

1. INTRODUCTION

Usable water is is a fast depreciating natural resource. It is the need for the hour for every human being on this earth to use it efficiently. Rapid industrialization is contaminating the available water and this contamination further deteriorates the preserved water sources given to us by nature. Some of the water related facts are:

- Water covers about 71% of the earth's surface
- There is 326 million cubic miles of water on the planet
- 97% of the earth's water is found in the oceans (too salty for drinking, growing crops, and most industrial uses except cooling)
- 320 million cubic miles of water in the oceans
- 3% of the earth's water is fresh
- 2.5% of the earth's fresh water is unavailable: locked up in glaciers, polar ice caps, atmosphere, and soil; highly polluted; or lies too far under the earth's surface to be extracted at an affordable cost
- 0.5% of the earth's water is available fresh water
- If the world's water supply were only 100 liters (26 gallons), our usable water supply of fresh water would be only about 0.003 liter (one-half teaspoon)
- In actuality, that amounts to an average of 8.4 million liters (2.2 million gallons) for each person on earth

- This supply is continually collected, purified, and distributed in the natural hydrologic (water) cycle. (Source: https://www.usbr.gov/mp/arwec/water-facts-ww-water-sup.html#:~:text=0.5%25%20of%20the%20earth's%20water,for%20each%20person%20on%20earth.)

2. WATER AND EFFLUENT TREATMENT REQUIREMENT BY BELLAVISTA TEXFEB

The envirochem tech company was approached by Bellaviesta Texfeb Ltd to research and suggest a way to make their upcoming denim processing plant more water economical and to treat their waste in an environmental friendly way but also at economical cost. Due to my interest in sustainability I approached them to take me up on their research team and was accepted as an intern.

As cloth processing takes up huge volumes of water with a lot of organic and inorganic compounds that are added in water during various stages of dyeing process. The company wanted a way to use the water judiciously and also to conserve and recycle most water to make it more cost effective. The water if untreated aggravates the nature, due to settlement of the suspended substances and subsequent decomposition of the deposited sludge in anaerobic conditions. The toxic substances like sulfides and chromate affect the aquatic life; and also interfere with the biological treatment processes. The presence of sulfide makes the waste corrosive and cause a hazard to the environment if not treated properly.

For these reasons, the immediate and nuisance free removal of waste water from its source of generation, followed by treatment and disposal, is not only desirable but necessary in an industrialized society. The ultimate goal –Wastewater management-is the protection of environment in a manner commensurate with public health, economic, social and political concern.

3. DESCRIPTION OF PROCESSES THAT GENERATE WASTE EFFLUENTS:

1. **SCOURING:** Scouring is an important operation by which natural impurities and acquired impurities are being removed and to get whiteness. The following chemicals are mainly used in this process: such as caustic soda, sodium peroxide, detergents etc.

Characteristics of Scouring Effluents

Characteristics	Value
pH	10-13
Total solids mg/l	2200-3000
BOD (Biological Oxygen Demand- 5days at 20ºC) mg/l	100-400

2. DYEING AND AFTER TREATMENT: Grey Yarn (Warp) is being dyed using different mix of dyes and auxiliary chemicals. Indigo dye is mainly used for the purpose. These dyes are water insoluble. They are made soluble on treatment with reducing agents, and alkali then applied to fiber and re-oxidized to the original insoluble form. Additional chemical required for dyeing are caustic soda, sodium hydrosulphite, dispersing agents, hydrogen peroxide and acetic acid.

Characteristics of Dyeing Effluents:

Temperature	50º
pH value	10.5
Total alkalinity as CaCO3 mg/l	1600
TSS (Total Suspended Solids)	3000
TDS (Total Dissolved Solids)	2980
Chlorides	180
Permanganate Value(4hrs.)	376
COD mg/l	1100

3. DESIZING: If starch is used as sizing agent it can be desized by two methods

- Desizing by acid
- Desizingwith enzymes

If Polyvinyl Alcohol or Carboxy Methyl Cellulose is used for sizing, they are removed with a detergent/water solution as they are readily soluble in water.

Desizing effluents contain the product of hydrolysis of starch and other sizes in dissolved and colloidal forms. The pH of the effluent is usually in neutral range and it has high BOD and dissolved solids. The suspended solids (mainly of fiber) content are appreciable. PVA (Poly Vinyl Alcohol) if used for sizing, will contribute to higher COD (Chemical Oxygen Demand) values. PVA is slowly biodegradable and the 5day BOD value will be much less but the 20day BOD value is considerable.

The characteristics of waste water from desizing operation depend on the size used and method of desizing. However some of the typical values are tabulated below:

Characteristics	Results
pH	6-8
Total Solids mg/l	1600-3200
BOD (5days at 20º)	1000-1200

4. FINISHING: The finishing section imparts various finishes to the fabrics. Various types of chemicals are used for various objectives. These includes starches, dextrines, natural and synthetic waxes, synthetic resins etc. Thus the waste from the process includes the following organic and inorganic substances: starch, carboxymethyl cellulose, sodium hydroxide, detergents, peroxides, hypochlorites, dyes, dextrines, sulfides, sulphates and soaps etc. For denim chemical finishing is being done by softners (cationic/anionic).

Our team was given a task of recommending the best ways that would help the company to treat the water discharge effectively and in a cost effective way. Keeping in mind the current availibility of treatment chemicals and enzymes. We were given a desired set of targeted water discharge norms (set by the local and central government pollution governing agencies). Keeping the above in mind our team consisting of chemical engineers and experienced water treatment specialist suggested some measures as detailed below.

4. FINAL SUGGESTIONS FOR UNDERTAKING THE TREATMENT

Going through the above parameters, the treatment process was not found be too difficult to handle, as 40% of the pollution load could be reduced by Physio-chemical treatment and balance can be eliminated by secondary

biological treatment. Removal of color by single physio-chemical treatment was not deemed possible as direct dyes are used in the process, so secondary physio-chemical treatment is required.

Assuming total waste quantity would be 3 lac liters per day according to the plant capacity a treatment plant of 6 lac capacity/day should be designed taking into consideration of future expansion. The plant should be designed as per measures given below:

Below suggestions for the design of ETP (Effluent treatment plant) were given:

Characteristics	Value
pH	7-8
Total Alkalinity (as CaCO3) mg/l	215
Total Dissolved Solids	2470
Suspended Solids	380
BOD (5days at 20°) mg/l	205
COD mg/l	650
Chloride	300
Sulphate	280
Calcium	24
Magnesium	28

1. SCREENING & OIL/GREASE ARRESTING PITS: As the waste water will be highly fibrous, suitable screening arrangements at 3 to 4 points in the intake channels from coarse to fine type are to be provided.
2. EQUALISATION TANK: As the temperature of the effluent will be high due to the process system of these types of processing units. One tank of 200m³ capacity was suggested to be erected, having partition wall in between so that periodically cleaning of the tanks should not hamper the treatment process. This would also insure that any suspended fibrous/solids (if escaping the screens) should settle in the first partition and second part of the tank will remain clear of these. The waste water should overflow from 1st partition to 2nd partition. Intake channels outlet should be in both the partitions. Cascade type aeration should be provided in the first partition of the tank and the retention of 8 hrs will cool off the effluent which will smoothen the treatment process and a lot of volatile organic matter will be stripped off resulting less burden to bio reactor.
3. 1st FLASH MIXTURE: Flash mixture Size 1.5m x 1.5m x 2m to be erected with adequate mixing equipment. The coagulant and lime dosing arrangements should be made into these tanks. The retention of effluent should be 10-15 min in these tanks, as the flash mixture tank capacity is 4.5m³, and flow rate of effluent is 12.5m³ per hour.
   Fe2SO4/or Metal Complex/ or PAC (Poly Ammonium Chloride) is to be dosed into the Flash Mixture Tank along with lime to correct the pH value of the effluent. An agitator/or air pipe line is to be provided into the tank for proper mixing of coagulant with effluent to ascertain adequate reaction. Effluent retention should be for 10-15 min in this tank for adequate reaction.
4. 2nd FLASH MIXTURE: Another flash mixture of the same size as above should be erected. As the color of effluent is strong enough due to cotton dyes, the effluent from 1st Primary settling is to be taken to the 2nd Flash Mixture for dosing of above

suggested coagulant and lime for further reaction and complete removal of color from the waste.

5. ZIG-ZAG CHANNELS: Zigzag channel should be erected around the 1st Primary and 2nd Primary settling Tanks. Polyelectrolyte dozing should be done in this channel, for bonding the flocks to make these heavier for fast settling into the settling tanks.
6. PRIMARY SETTLING TANKS: Two settling tanks of size 4 x 4 x 2 should be erected having 135º cone at the bottom. The volume of these tanks are 37.5m³ each. The effluent after reaction from flash mixture and having polyelectrolyte dosed into zig-zag channels would come to these tanks. Effluent retention is more than three hours in each tank, which is sufficient for the suspended solids to settle at the bottom of the tank.
7. TERTIARY TREATMENT: Pressure sand filter and Activated carbon filter should be installed to separate the water from other effluents.
8. BIOREACTOR: 10 x 8 x 3 mtrs tank should be erected. The capacity of this tank will be by about 240m³. The retention of effluent will be about 18 hours in this tank, till the next expansion of plant capacity.

   The aeration system(Bioreactor) will be an activated sludge system (completely mixed). 40% of the sludge from secondary settling will be returned to the bio-reactor. The total BOD load will be aprox. 75 kg/day max. The requirement of diffused air will be 197m³/hr.

   A twin-lob compressor will deliver the air to 30 nos. of cup type diffusers at a pressure of 400mbar. It will be high rate aeration and food to mass ratio will be 0.6.
9. SECONDARY SETTLING: A secondary settling tank of 4mø size should be erected to capture residue effluents.
10. SLUDGE DRAIN PIT: 3 x 3 x 2 mtr tank for sludge drain should be erected. The sludge will be pumped to Filter Press for dewatering.
11. DEWATERING: 915 x 915 mm size 36 plates Filter Press should be installed for dewatering of the sludge assuming future expansion.
12. Proper storage warehouse with concrete flooring should be erected for storage of dewatered sludge cakes.

Characteristics of Treated Water:

pH	6.5-7.5
TSS	Below 100
COD	Less than 250
BOD (5 days at 20°C)	Less than 30
Oil & Grease	Less than 10
Sulphides	Less than 2 mg/l
Chromium	Less than 2 mg/l

The above treatment process will ensure that the treated water quality will be of RPCB (Rajasthan Pollution Control Board) norms. The treated water may be reused in the process and plantation in and around the plant.

The physio chemical treatment will reduce by about 40% of pollution load of the waste water and remaining load will be removed by biological treatment method later.

5. ACKNOWLEDGEMENTS

I would like to express my gratitude towards my mentor Mr. Vikas Choudhary (MD) of M/s Envirochem for guiding me and presenting me with such a valuable

learning opportunity. To be able to contribute towards the materialization of a concrete solution to pollution problems I have only studied in theory was an enlightening process. He patiently answered my every question, considered my suggestions and imparted valuable life lessons as well.

I would also like to extend my gratitude to Mr Rajix Saxena (Senior Technical Advisor) who broke down complex technical processes into simpler concepts, explained the multifarious abbreviations used and teaching me to consider all perpectives (economical, environmental and ethical) before making an decision.

Finally, I would like to thank all the advisors, experts and staff at Envirochem for their utmost kindness. It would have been impossible to name each one of you, however, all your help can never be forgotten.

6. CONCLUSION

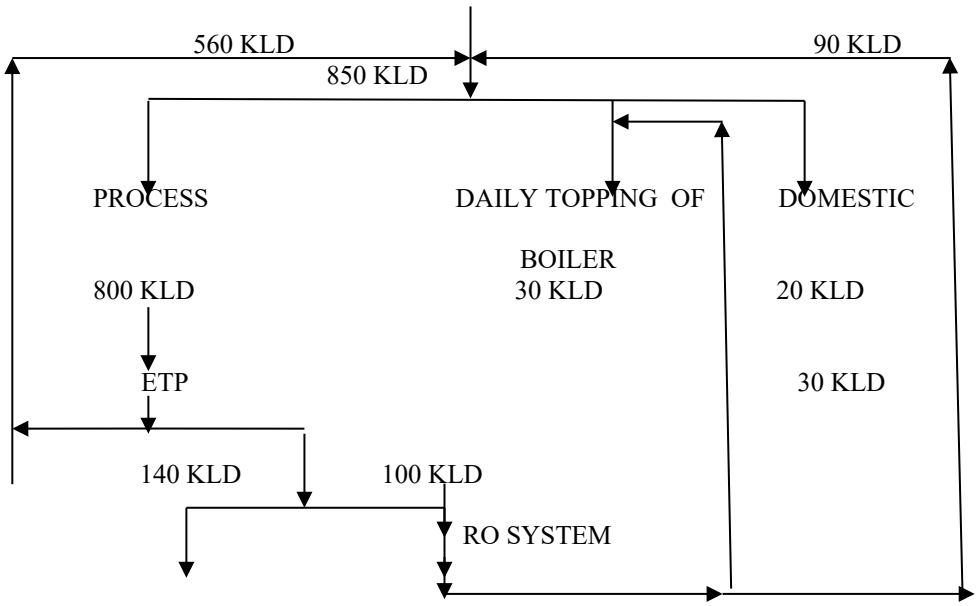
Working under Envirochem made me aware of the intricacies of treating water and waste depending on different industries. In the current research they did, they were able to formulate the plan for Bellavista Texfab for treating their water and waste so that it can be environmentally friendlier and also cost effective for them.

This research made me realize that even though the water consumption in a textile processing unit is huge, there is always a way to reuse and recyle the water if proper treatment is done. This effectively reduces the carbon footprint and also makes processes much more economical to create a win win situation for all.

The water balancing graph and ETP (Effluent treatment plant) as suggested by our team are enclosed below.

Cover photo credit: https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.nature.com%2Fnpjcleanwater%2F&psig=AOvVaw1Rsx2_CuSCuvEU1V2p2Rzy&ust=1652697479980000&source=images&cd=vfe&ved=0CAkQjRxqFwoTCMiegqqo4fcCFQAAAAAdAAAAABAE

WATER BALANCING
TOTAL REQUIREMENT OF WATER



FOR GREEN BELT (PLANTATION & IRRIGATION)
(DURING RAINYSEASON 240 KLD OF WATER FROM ETP WILL BE PASSED THRU RO SYSTEM)

Tentative 2% loss of water in process has not been considered and shown in water balancing chart above.