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# Treatability Study for Castor Oil Unit

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**ABSTRACT: Ever increasing demand of water for domestic, irrigation and industrial use have created water crisis worldwide. Contamination of water resources from waste water (sewage and industrial effluent) has further aggravated water scarcity. End of Pipe treatment by Sewage Treatment Plant (STP) & Effluent Treatment Plant (ETP) is one of the effective tools to combat water pollution and thereby reduce water scarcity. Treatability studies are crucial to determine specific treatment and recycling technologies as well as capital and operating costs. The present paper covers treatability study for a Castor Oil production unit having capacity of 150000 MT/Year. The treatability study involves primary, secondary and tertiary treatments on a lab scale model. Based on the results of this treatability study, the design of ETP was to be suggested. Physical, chemical and biological standards are used to assess the suitability of reclaimed water for the specific application.**

**KEYWORD: Castor oil, ETP, STP**

## I. INTRODUCTION

Industrial wastewater reclamation for reuse purpose is a good practice in many countries suffering from water shortage. Wastewater reuse is based on providing reliable wastewater treatment that meet strict water quality requirement for the intended reuse application and for the protection of public health. Physical, chemical and biological standards are used to assess the suitability of reclaimed water for the specific application.

The impact of industrial discharges depends not only on their collective characteristics, such as biochemical oxygen demand (BOD) and the amount of suspended solids but also on their content of specific inorganic and organic substances. The hazardous substances pollute the surface water, the soil and the ground water becomes accumulated in food chain and therefore a special need for treatment before being discharged.

Reuse may take two forms: water conservation and recycling internally in plants and disposal to a public sewer system in which the waste is treated and later reused for irrigation. The discharge of industrial wastewater to sewage system is required through effluent standards based on local permit parameters of the country environmental law.

This study considers a new unit for Castor Oil production having capacity of 150000 MT/Year. The industry is proposing to provide an on-site ETP of capacity 250 $m^3$/ day to treat the generated effluent of the production plant and the treated effluent shall be discharged into Sea.

## II. SCOPE & METHODOLOGY

The phases of a typical treatability study include:

1. Review of effluent generation and water consumption pattern.
2. Identifying treatment and recycling goals.
3. Obtaining representative samples for testing.
4. Identify and characterize each effluent generation streams.
5. Determining analytical methods to evaluate compliance with requirements.
6. Developing the necessary testing program to determine if the goals can be met.
7. Carryout treatability study for composite stream and suggest efficient treatment scheme.

The outcome of treatability study are as below:

1. Establish treatability of the waste stream, including the overall economics of treatment and recycling.
2. Provide improved data for estimating full-scale operations and establishing capital and operating cost estimates.
3. Provide data on optimal operating conditions.
4. Allow determination of appropriate materials of construction.
5. Identify waste stream with specific issues of concern.

## III. PILOT PLANT STUDY FOR COMPOSITE STREAM

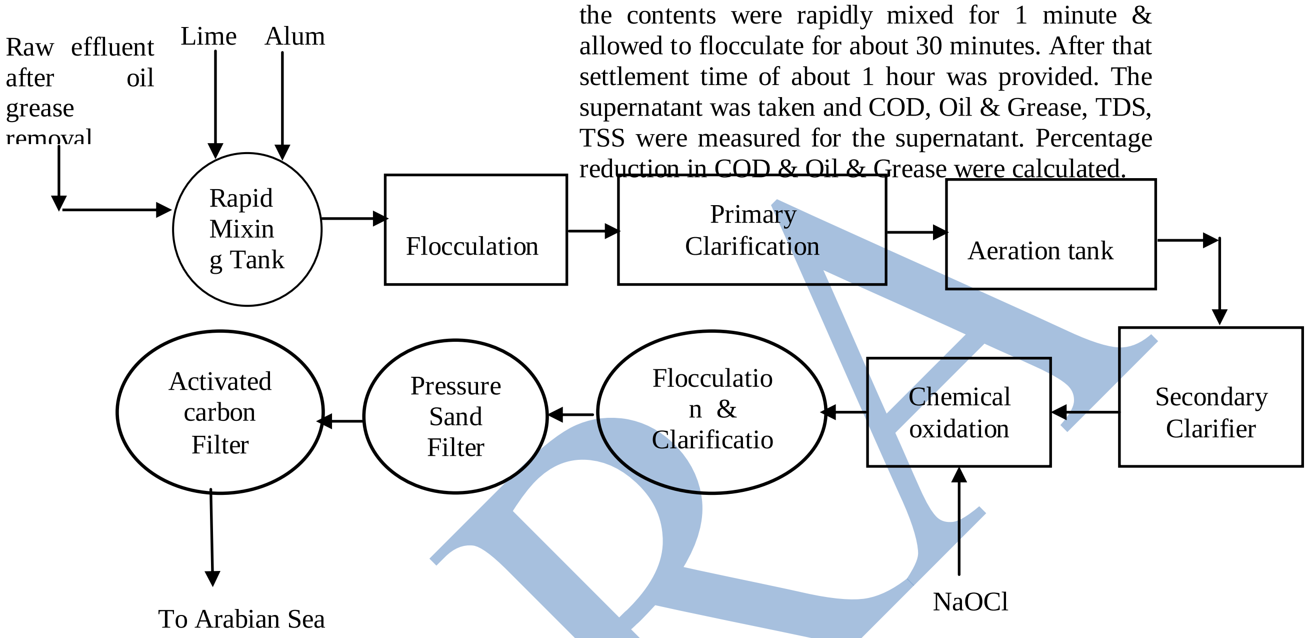
The aim of this study is to perform treatability study for the proposed ETP plant for the New unit based on the existing unit, such that final treated effluent matches the disposal norms suggested by Pollution Control Board.

The new unit already has an existing establishment for all Castor Oil derivatives; hence, individual characterization for each derivative stream has not been carried out at this stage. Therefore, the characterization and study was done for the

Composite effluent obtained from the Equalization Tank of the ETP at the existing unit.

It was further decided to run a treatability trial run on a pilot plant / lab scale model in order to get the basis for designing of the treatment plant at the new Unit. Effluent after being subjected to primary, secondary and tertiary treatment shall be discharged to drain and finally to sea. Hence, the parameters to be achieved for design and treatability study basis have been considered that of Pollution Control Board for marine disposal. The line flow diagram for the lab scale model is shown below:




Initially primary, secondary and tertiary treatments were run separately to determine optimum parameters and operating conditions for each stage of treatment separately. A sequential trial run was made on the sample from Equalization tank. This sample was then subject to primary, secondary and tertiary stage of treatment sequentially and reduction in BOD, COD, TSS and parameters determined intermittently at each stage. The final treated effluent after tertiary treatment was analysed for all parameters recommended as per Pollution Control Board norms for marine disposal of effluent.

**A. PRIMARY TREATMENT**

The purpose of study was to reduce the TSS & C.O.D. and to obtain optimum coagulant dose for the effluent collected from the Equalization Tank. The wastewater sample for primary treatment study was taken from the Equalization tank of the ETP. Initially pH of the wastewater was neutral & that is why there was no need of neutralization. Alum was used as coagulant for the reduction in TSS & COD. Optimum Alum dose and optimum pH for maximum COD reduction was determined in laboratory by performing jar test.

**B. SECONDARY TREATMENT**

Raw effluent was taken and optimum alum dose of 250 mg/lit was added at optimum pH of 8.5 & then the contents were rapidly mixed for 1 minute & allowed to flocculate for about 30 minutes. After that settlement time of about 1 hour was provided. The supernatant was taken and COD, Oil & Grease, TDS, TSS were measured for the supernatant. Percentage reduction in COD & Oil & Grease were calculated.

On the Primary treated effluent, Secondary treatment (Biological Treatment) was given. For this purpose Active Biomass, i.e. sludge from the aeration tank of the local Sewage Treatment Plant was brought to laboratory. Activated Sludge was used for acclimatization of primary treated water (ratio of biomass volume to effluent volume was about 0.25 i.e.25%). This content was aerated in the aeration tank for about 15 hours so that micro-organisms are acclimatized properly.

On the next day, the content was checked for SVI & MLSS. After every two hour of aeration period, some content was taken out of the tank & allowed to settle for 2 hours. The supernatant was checked for COD reduction. Also, volume of sludge settled in 30 minutes was observed.

Dimensions of lab scale Rectangular Aeration Unit:

- Length: 1 ft
- Width: 1 ft
- Depth: 1 ft

Volume of tank in $m^3$ = 0.028 $m^3$ = 28 lit

1. Optimization of alum dose:

2. Optimization of pH:

- pH variation is to be done using 10 % Lime Slurry

Table-1 Optimization of alum dose:

| Sr. no. | Amount of sample | Alum dose | Alum solution added | COD after treatment | % reduction in COD |
|---|---|---|---|---|---|
| | ml | mg/lit | ml | | |
| 1. | 200 ml | 50 | 1.0 | 9000 | -- |
| 2. | | 100 | 2.0 | 8050 | 10.5 |
| 3. | | 150 | 3.0 | 8000 | 11.1 |
| 4. | | 200 | 4.0 | 7050 | 21.6 |
| 5. | | 250 | 5.0 | 6390 | 29.0 |
| 6. | | 300 | 6.0 | 7000 | 22.2 |
| 7. | | 350 | 7.0 | 7500 | 16.6 |

(1 ml=10mg)for alum solution added

Table-2 Optimization of pH:

| Sr. no. | Amount of sample | Alum dose | Alum solution added | pH | COD after treatment | % reduction in COD |
|---|---|---|---|---|---|---|
| | Ml | mg/lit | ml | | | |
| 1. | 200 ml | 250 | 5.0 | 7.5 | 6380 | 29.1 |
| 2. | | | | 8.0 | 6200 | 31.1 |
| 3. | | | | 8.5 | 5922 | 34.2 |
| 4. | | | | 9.0 | 6000 | 33.3 |
| 5. | | | | 9.5 | 6020 | 33.1 |

Table-3 Effluent characteristics after primary treatment

| Sr. No. | Parameter | Unit | Before Coagulation Treatment | After Coagulation Treatment | % Reduction |
|---|---|---|---|---|---|
| 1. | pH | ---- | 7.3 | 8.5 | --- |
| 2. | COD | mg/lit | 9000 | 5900 | 34.4 |
| 3. | O&G | mg/lit | 353 | 242 | 31.4 |
| 4. | TSS | mg/lit | 12238 | 8507 | 30.5 |

Details of Air Compressor used: Specifications:

- Capacity: 2.25 cu ft.
- Working Pressure : 4 kg/cm$^2$
- Design Pressure : 4 kg/cm$^2$
- HP of motor: 0.5 HP
- RPM : 750

Air Flow Measurement Device:

- Rota meter of maximum capacity of 5 kg per hour is used.
- Air Flow rate maintained during the treatment: 2 kg/hr

Table -4 Biological treatment:

| Sr. No | Parameter | Unit | Time Period in Hours | | | |
|---|---|---|---|---|---|---|
| | | | After 2 hours of Aeration | After 4 hours of Aeration | After 6 hours of Aeration | After 8 hours of Aeration |
| 1. | pH | ---- | 8.4 | 8.5 | 8.5 | 8.8 |
| 2. | DO | mg/lit | 1.2 | 2.1 | 2.9 | 2.9 |
| 3. | BOD | mg/lit | 3078 | 2660 | 1405 | 1398 |
| 4. | COD | mg/lit | 5843 | 4500 | 2850 | 2596 |
| 7. | MLSS | mg/lit | 3216 | 3546 | 3761 | 3890 |
| 8. | SVI | ml/gm | 120 | 98 | 92 | 86 |

Table-5 Effluent characteristics after biological treatment:

| Sr. No | Parameter | Unit | Before Biological treatment | After Biological Treatment |
|---|---|---|---|---|
| 1. | pH | -- | 8.5 | 8.8 |
| 2. | BOD | mg/lit | 2925 | 1398 |
| 3. | COD | mg/lit | 5900 | 2596 |
| 4. | TDS | mg/lit | 19422 | 12874 |

Percentage Reduction in COD from the first stage after 8 hours of aeration is about 56%.

**C. Tertiary Treatment**

The effluent after secondary treatment was run for tertiary treatment. The sample was provided chemical oxidation using sodium hypochlorite, in order to bring down the COD within design load range of filters. The supernatant was then passed through pressure sand filter and activated carbon filter. The COD, TSS reduction was determined at each stage.

1. Optimization of Dose

Sample Qty (ml) : 250

Qty of Hypo (4%) (ml) : 2.0

Table -6.0 Effluent characteristics after chlorination:

| Sr. No. | Parameter | Unit | Before Chlorination | After Chlorination (1 hour Contact time) |
|---|---|---|---|---|
| 1. | pH | -- | 8.5 | 10.2 |
| 3. | COD | mg/lit | 2596 | 1288 |
| 4. | TSS | mg/lit | 6800 | 3282 |

Percentage Reduction in COD from the second stage after Chlorination is about 50.4%.

2. Optimization of Contact Time

Table -7.0 Optimization of contact time

| Sr. No. | Parameter | Unit | Contact time in hrs. | | |
|---|---|---|---|---|---|
| | | | 1 hours | 2 hours | 3 hours |
| 1. | COD | mg/lit | 1288 | 1109 | 1128 |

From the above table it is concluded that 2 hours is the optimum contact time for chlorination. % COD reduction is about 57.3 % after 2 hours.

Table -8.0 Effluent characteristics after PSF& ACF:

| S.No | Parameter | Unit | After hypo treatment | After PSF | After ACF |
|---|---|---|---|---|---|
| 1 | Ph | | 10.2 | 8.8 | 7.5 |
| 2 | COD | mg/l | 1288 | 672 | 228 |
| 3 | TSS | mg/l | 3182 | 1261 | 315 |

% COD reduction is about 47.8 % after PSF and 56.1% after ACF

**Table-9.0 Overall reduction**

| Parameters | ET I/L | PC O/L | % Redn | AT I/L | SC O/L | % Redn | HC O/L | % Redn | PCF O/L | % Redn | ACF O/L | % Redn | % Overall Redn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 7.3 | 8.5 | ----- | 8.5 | 8.8 | ----- | 10.2 | ------ | 8.8 | ------ | 7.5 | ------ | -- |
| TDS | 19514 | 19410 | 0.5 | 19410 | 12874 | 33.6 | ---- | ----- | ------ | ------ | ------ | ------ | ------ |
| TSS | 12238 | 8705 | 31.4 | 8705 | 6800 | 21.8 | 3282 | 51.7 | 1261 | 60.3 | 315 | 75 | 97.4 |
| COD | 9000 | 5900 | 34.4 | 5900 | 2596 | 56 | 1288 | 50.4 | 672 | 47.8 | 228 | 56.1 | 97.4 |
| BOD | 4478 | 3672 | 17.9 | 3672 | 1398 | 61.9 | 854 | 38.9 | 403 | 52.8 | 125 | 68.9 | 97.2 |
| O&G | 353 | 242 | 30.5 | 242 | -- | -- | -- | -- | -- | -- | -- | -- | -- |

## IV. DISCUSSION OF RESULTS:

A. Primary treatment:

- The primary treatment is effective up to 34 % for the COD reduction with the application of Alum as a coagulant & lime for pH rising.
- However more reduction in COD can be achieved with the usage of Polyelectrolyte along with Alum.
- From the economic point of view only Alum & Lime are used for Coagulation

**B. Secondary treatment**

- In the Biological Treatment we get around 56 % reduction in COD.
- The Biological treatment was done at laboratory scale using Diffused Aeration system, while in the field if we recommend Surface aerators for more reduction in COD & BOD due to better mixing & more efficient aeration.
- The initial ratio of BOD to COD in our case is around 0.5, so there is no need of addition of nutrients during the biological treatment as the waste is biodegradable & there is sufficient amount of food available to microbes during the treatment.
- Also at lab scale study aeration up to 8 hours was provided due to constraint of compressor, however on field if up to 16 hours aeration period can be provided for more reduction in COD, BOD & TSS.

**C. Chlorination Treatment:**

- About 57% reduction in COD is achieved by treatment with sodium hypochlorite solution with the contact time of 2 hours.
- On field we can go for chlorination using Chlorine gas cylinders. In that case, the safety measures are must, as chlorine is a very toxic gas.
- The main advantage of selecting NaOCl over chlorine gas is that the oxidizing agent is produced and stored in liquid form, eliminating the danger of large-scale gas leaks from high-pressure chlorine cylinders.
- Instead of Chlorination, we can go for either Peroxide treatment of the effluent or any other option of advanced oxidation of the organic pollutants. However, these options may be somewhat expensive then the traditional chlorination treatment.

**D. Tertiary Treatment:**

- Tertiary treatment using PSF and ACF was provided for final polishing of the effluent and to bring the COD within the discharge limit

## V. FINDINGS & CONCLUSION

The performance of Lab scale model for ETP at various treatment units such as, primary stage, aeration stage and tertiary stage and overall performance as observed during trial run on lab scale model is determined. The treatment performance at various stages is as under:

1. Primary Treatment:
TSS removal = 31.4 %; COD removal = 34.4 % and BOD removal = 17.9 %, O&G 30.5% of the raw effluent.

2. Activated Sludge Process:
TSS removal =43.03 %; COD removal = 25 % and BOD removal = 61.9 % of the coagulated effluent.

3. Chemical oxidation stage
TSS removal = 51.7 %; COD removal = 50.4 % and BOD removal = 38.9 % of the ASP- effluent.

4. Tertiary treatment stage (PSF+ACF)
TSS removal = 90.4 %; COD removal = 82.3 % and BOD removal = 85.4 % of the chemically treated effluent.

5. Overall Reduction of ETP:
TSS removal = 97.4 %; COD removal = 97.2 % and BOD removal = 97.2 %, of the influent concentration to ETP.

<u>Reuse of treated effluent:</u>

It is proposed that the treated wastewater shall be discharged into drain, which shall further be disposed in Sea throughout the year. Owing to the high TDS (>19000 mg/lit) expected in the treated effluent it is not feasible to reuse it either for landscaping or any other secondary use. The effluent shall be subjected to primary, secondary and tertiary treatment in order to render the outlet parameters within Pollution Control Board norms. In case of considering reuse as a option, separate study shall be undertaken to separate the high TDS stream and treat it separately.

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