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# Judicious Use of Coagulants in Primary Treatment of Combined Effluent of Starch and Liquid Glucose Industries and a Tentative Design of an Effluent Treatment Plant

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A treatability study was carried out on a combined effluent of starch and liquid glucose industries using different chemicals for primary treatment so as to make the effluent more amenable to secondary treatment and subsequently reduce the energy consumption. The doses of laboratory scale investigation were implemented at plant level to assess the accuracy of test. Chemicals like alum, lime, ferric chloride and ferrous sulphate were utilized in various doses ranging from 300 mg/L to 600 mg/L. The maximum suspended solids and organic removal efficiencies were found to be 45–60% and 40–50% respectively. The object of this investigation was achieved by the successful trials of the results of treatability study at the field. A tentative flow diagram of effluent treatment plant is evolved which should serve as a guideline for designing a new plant based on this type of combined effluent. This paper also highlights the characteristics of combined effluent and detailed results of the study.

**Key Words: Primary, Treatment, Effluent, Starch, Glucose, Industries, Effluent treatment plant.**

## INTRODUCTION

Industries and human beings in persistent interaction with environment willingly and unwillingly excrete the pollutants in water bodies resulting in various adverse impacts on flora and fauna, mankind and aquatic life. The Government of India, after realising the importance of environment for the sustainable life, has made obligatory, through Central Pollution Control Board, the installation of an effluent treatment plant (ETP) for every industry generating liquid-waste. The State Pollution Control Boards ensure the continuous and satisfactory operation of ETPs to meet the prescribed norms.

The combined effluent of starch and liquid glucose industries is having tremendous potential of suspended solids, COD, BOD and TDS. However, proper treatment makes this effluent fit for on-land irrigation substituting the partial need of fresh water.

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## EXPERIMENTAL

Effluents were collected in 2.5 L plastic containers, previously rinsed thrice with the effluent being collected. Grabs and time composite samples were collected and transported to the laboratory within the shortest frame of time. Grab samples were collected at suitable intervals and analysed separately for documenting the extent frequency and duration of variations in composition of effluent. The time composite samples of 24 h period were collected for observing average concentrations that are used in calculating the loading or the effciency of an ETP. The samples of effluent were collected from the overflow of the equalisation tank of an ETP.

The characteristics of combined effluent sand their analysis carried out as per standard methods[1]. Some of the parameters like pH and temperature were measured at the site.

### Treatiability study

The effluent samples, after thorough analysis, were subjected to jar tests. The samples were taken in one litre beakers and chemicals in a designed dose were added to them. The paddles of jar testing equipment were immersed in the beakers. In the beginning the rpm of paddles was kept at 100 for 1 min, followed by 40 rpm for 20–25 min. The synergetic effect of rapid and slow mixing resulted in the formation of flocs. The flocs were allowed to settle down for 1 h and a clear supernatant was taken out for analysis to ascertain the percentage removal mainly for suspended solids and COD. Different chemicals like alum, ferric chloride and ferrous sulphate were used in combination with lime for the chemical treatment of effluent. Solutions were prepared in distilled water. pH was adjusted by NaOH or HCl solution. For ferrous sulphate, the optimum pH was found 9 and therefore lime dosing was necessary in order to adjust the pH at 9. For alum, the effective flocculation was found in the belt of 6 and 8.5 and therefore it became necessary to adjust the pH of effluent as the pH of combined effluent was around 4.5. In case of lime, the resultant pH of 9 to 11 could be obtained after the trials with different doses of lime. This was necessary when lime was solely tried as a coagulant.

The chemicals, *viz*., alum, ferric chloride and ferrous sulphate were dosed at the potential of 300, 400, 500 and 600 mg/L, while lime dosing was adjusted based on the required pH.

## RESULTS AND DISCUSSION

**Effluent characteristics:** Effluent samples were analysed for knowing the pollution potential of the effluent with respect to different major pollution parameters. Table-1 reveals the average values of different parameters for grab and composite samples.

It is obvious from the perusal of Table-1 that the removal of SS, COD and BOD (27°C, 3d) by chemical treatment can save good chunk of electricity and space in the secondary treatment. It is also ostensible from the ratio of BOD and COD (BOD : COD) that the effluent is highly biodegradable and very much amenable to biological treatment in secondary treatment units.

TABLE-1
CHARACTERISTICS OF COMBINED EFFLUENT OF STARCH AND GLUCOSE INDUSTRIES*

| Sr. No. | Parameter | Grab samples results | Composite sample results |
|---|---|---|---|
| 1 | pH | 4.8 | 5.5 |
| 2 | Suspended solids (SS) | 2400 | 2200 |
| 3 | Total dissolved solids (TDS) | 12600 | 11800 |
| 4 | Total solids (TS) | 15000 | 14200 |
| 5 | Total volatile solids (TVS) | 10600 | 10200 |
| 6 | COD | 11689 | 12680 |
| 7 | BOD (27°C, 3d) | 7598 | 8876 |
| 8 | Dissolved oxygen (DO) | Nil | Nil |
| 9 | Sulphates | 2600 | 2300 |
| 10 | Chlorides | 2000 | 2100 |
| 11 | Oil and grease | 6 | 10 |
| 12 | Alkalinity (as $CaCO_3$) | 1881 | 1861 |
| 13 | Hardness (as $CaCO_3$) | 1660 | 1640 |

All results are in mg/L, except pH.
* Weighted average results based on three consecutive samplings.

Table-2 divulges the characteristics of effluent after treatment with different chemicals cited above. It is clear from Table-3 that the combined effluent of starch and liquid glucose industries can successfully be treated through chemical treatment as the maximum SS and COD removal were observed to be 60 and 50% respectively.

Table-3 reveals the different units and volume required for a 600 $m^3/d$ of combined effluent of starch and glucose industries having the characteristics as given in Table-1.

## Conclusion

The laboratory treatability investigation has brought with the three chemicals, *viz.*, lime, alum and ferric chloride for the effective treatment of effluent. However, combinations of lime and alum are preferred to other chemicals due to less sludge production and better reduction of SS and organic loading. Based on this study, a flow-sheet with an option of UASB biodigester as shown in Fig. 1 has been evolved for chemical treatment followed by biological treatment. An ETP has been designed based on the characteristics of effluent and the treatability results of laboratory analiysis. The ETP is designed based on the 600 $m^3/d$ effluent[2–4].

TABLE-2
CHARACTERISTICS OF COMBINED EFFLUENT AFTER TREATABILITY STUDIES.

| Parameter | Alum | | | | Ferric chloride | | | | Ferric sulphate | | | | Lime at pH | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 300 | 400 | 500 | 600 | 300 | 400 | 500 | 600 | 300 | 400 | 500 | 600 | 9.0 | 10.0 | 10.0 | 11.0 |
| pH | 4.9 | 4.7 | 4.1 | 3.8 | 5.2 | 3.9 | 3.4 | 3.0 | 6.2 | 5.9 | 5.1 | 4.8 | 8.8 | 9.8 | 10.4 | 10.8 |
| SS | 1408 (36) | 709 (48) | 1386 (37) | 1430 (35) | 1650 (25) | 1210 (45) | 1100 (50) | 836 (58) | 1870 (15) | 1760 (20) | 1826 (17) | 1980 (10) | 1496 (32) | 1100 (50) | 880 (60) | 1584 (28) |
| TDS | 9600 | 9862 | 9587 | 9460 | 10961 | 11076 | 11100 | 10896 | 12660 | 12480 | 12876 | 12992 | 12324 | 12406 | 12809 | 12762 |
| TS | 11008 | 10571 | 10973 | 10890 | 12611 | 12286 | 12200 | 11732 | 14530 | 14240 | 14702 | 14972 | 13820 | 13506 | 13689 | 14346 |
| TVS | 4080 | 4260 | 4162 | 4219 | 4590 | 4531 | 4683 | 4602 | 6900 | 7601 | 6200 | 6480 | 7650 | 7701 | 7406 | 7006 |
| COD | 6974 (45) | 6086 (52) | 6594 (48) | 7735 (39) | 8622 (92) | 7608 (40) | 7228 (43) | 9003 (29) | 10398 (18) | 9510 (25) | 8622 (32) | 9003 (29) | 7862 (38) | 7354 (42) | 6469 (49) | 8622 (32) |
| Chlorides | 1260 | 1278 | 1230 | 1066 | 2169 | 2296 | 2306 | 2496 | 1218 | 1367 | 1280 | 1196 | 1969 | 1469 | 1880 | 2162 |
| Alkalinity (as $CaCO_3$) | 967 | 962 | 893 | 940 | 1209 | 1316 | 1176 | 1109 | 1271 | 1207 | 1236 | 1230 | 1930 | 1960 | 1972 | 1980 |
| Hardness (as $CaCO_3$) | 1670 | 1699 | 1682 | 1679 | 1638 | 1639 | 1642 | 1645 | 1760 | 1711 | 1690 | 1745 | 1690 | 1743 | 1669 | 1680 |
| Volume of sludge, ml/L | 6.2 | 13.8 | 8.9 | 7.0 | 17.0 | 21.0 | 28.0 | 32.0 | 10.0 | 14.0 | 16.8 | 22.4 | 28.0 | 32.0 | 35.0 | 30.0 |

All results are in mg/L, except pH.
Figures in parentheses indicate % removal.
Treatability studies carried out on composite samples.

TABLE-3
DIFFERENT UNITS OF TENTATIVE ETP WITH VOLUME DIAMETER, HP REQUIRED FOR 600 $m^3$/d EFFLUENT

SCHEME-I

| Sr. No. | Name of unit | Nos | Requirements |
|---|---|---|---|
| 1 | Equalization tank | 1 | V = 75 $m^3$ |
| 2 | Neutralization tank | 1 | V = 13 $m^3$ |
| 3 | Clariflocculator | 1 | V = 75 $m^3$, $\phi$ = 5.5 m |
| 4 | Anaerobic lagoon | 2 | V = 15000 $m^3$ |
| 5 | $1^{st}$ stage aeration tank | 1 | V = 300 $m^3$, HP = 15, F/M = 0.5 |
| 6 | $1^{st}$ stage secondary clarifier | 1 | V = 100 $m^3$, $\phi$ = 7.5 m |
| 7 | $2^{nd}$ stage aeration tank | 1 | V = 500 $m^3$, HP = 11, F/M = 0.12 |
| 8 | $2^{nd}$ stage secondary clarifier | 1 | V = 100 $m^3$, $\phi$ = 7.5 m |
| 9 | Sludge drying beds | 6 | V = 50 $m^3$ each |

SCHEME-II

| Sr. No. | Name of unit | Nos. | Requirements |
|---|---|---|---|
| 1 | Equalization tank | 1 | V = 75 $m^3$ |
| 2 | Neutralization tank (during start-up of digester) | 1 | V = 13 $m^3$ |
| 3 | Clariflocculator | 1 | V = 75 $m^3$, $\phi$ = 5.5 m |
| 4 | Buffer tank | 1 | V = 100 $m^3$ |
| 5 | UASB digestor | 1 | V = 1100 $m^3$ |
| 6 | $1^{st}$ stage aeration tank | 1 | V = 252 $m^3$, HP = 13, F/M = 0.5 |
| 7 | $1^{st}$ stage secondary clarifier | 1 | V = 100 $m^3$, $\phi$ = 7.5 m |
| 8 | $2^{nd}$ stage aeration tank | 1 | V = 450 $m^3$, HP = 10, F/M = 0.12 |
| 9 | $2^{nd}$ stage secondary clarifier | 1 | V = 100 $m^3$, $\phi$ = 7.5 m |
| 10 | Sludge drying beds | 6 | V = 50 $m^3$ each |

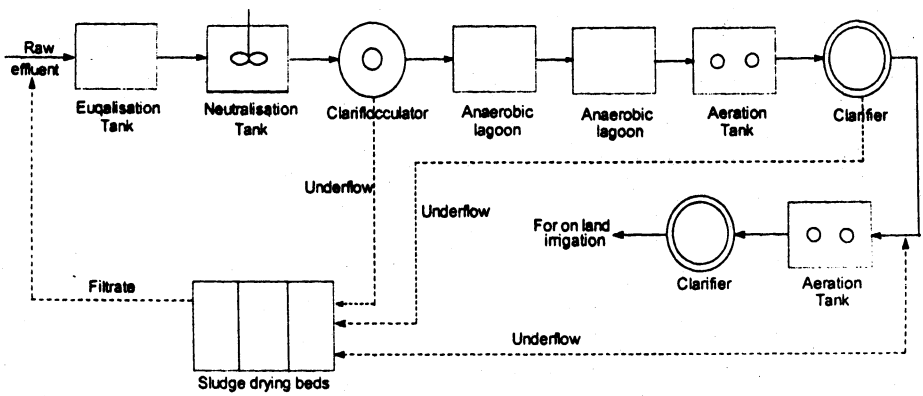


Fig. 1. Tentative flowsheet of ETP for combined effluent of starch and glucose.

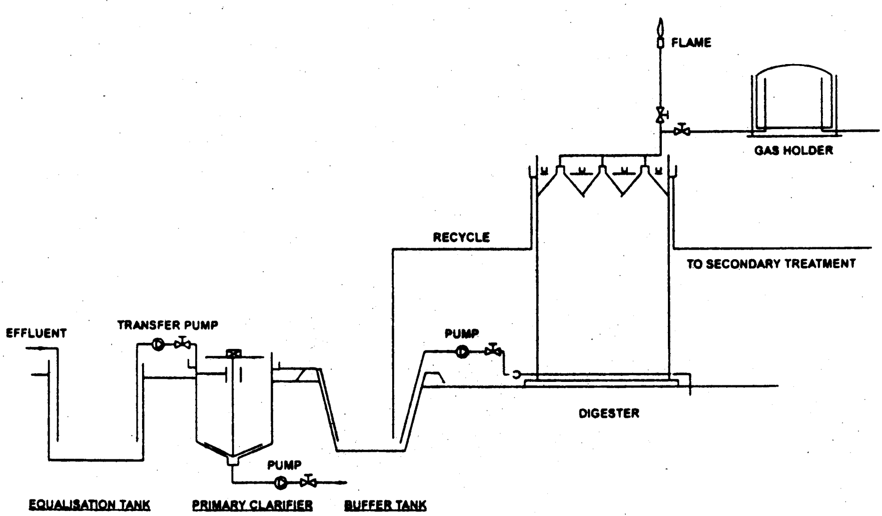


Fig. 2. Tentative flowsheet of ETP for combined effluent of starch and glucose.

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