# PILOT PLANT STUDY FOR TREATING WHITE WATER USING ACTIVATED SLUDGE PROCESS

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## ABSTRACT

Pilot plant experiments were performed to investigate the feasibility of treating white water using activated sludge process with and without primary settler. According to the obtained results it could be indicated that the activated sludge process is very efficient as a secondary treatment method for white water. High values as 92.4% COD removal and 86% of BOD removal were observed during the course of this research.

*Keywords: White water, Pulp and paper, Activated sludge, Wastewater treatment.*

## INTRODUCTION

Paper manufacturing is an old industry. Today pulp and paper making is a highly sophisticated manufacturing process. Various gaseous, particulate, liquid, and solid wastestreams are produced with this industry.

Paper mill is a source of a liquid waste known as white water. This liquid waste is the water that drains from wet pulp as it is sequentially dried in the paper machine or pulp dryer. White water contains fibers and may contain a number of other constituents as well, depending on the additives used in the paper-forming process. Discharge of this water directly to the wastewater treatment system or to surface water would significantly increase the BOD load.

Fibers can be recovered from white water using settling tank, drum, flotation, or polydisc savealls. Fibers are returned to the stock system and subsequently reused. The clarified white water can be reused for stock dilution, grooved-roll, trim knockdown, wire knockoff, and breast roll showers (1).

Depending on the solids and organic loading of the cleaned white water, further biological treatment may be needed to improve its required quality for reusing purposes.

The activated sludge process is one of the most widely used forms of biological wastewater treatment. In the activated sludge process, the organic material in the influent wastewater is utilized by the microorganisms (biomass, activated sludge) for respiration and synthesis of new cells in the aerator. Oxygen required is supplied to maintain microorganism activity. The effluent from the aerator is purified by settling of the microbial flocs in the final settler. A portion of the concentrated settled sludge is recycled to the aerator to maintain enough microorganism amount in the system. Part of the excess sludge is regularly removed (2).

In this study pilot plant experiments were performed, aiming to investigate the feasibility of using the activated sludge process for treating white water with and without primary settling.

## MATERIALS AND METHODS

### *The Pilot Plant*

The experimental work was conducted on a pilot plant consisting of a primary settler followed by an activated sludge unit, using fresh white water from RAKTA company in Alexandria, Egypt.

The pilot plant was fabricated and located at the Sanitary Engineering Laboratory in the Faculty of Engineering, Alexandria University. The pilot plant consisted of a feed tank with a 1.7 m volume, followed by a plexiglas primary settler with a 0.64 m surface area and 0.6 m depth. The activated sludge unit consisted of three plexiglas 125 liter (each) completely mixed reactors in series followed a 0.16 m surface area and 0.5 m depth final settler. A schematic diagram of the pilot plant is shown in Figure (1).

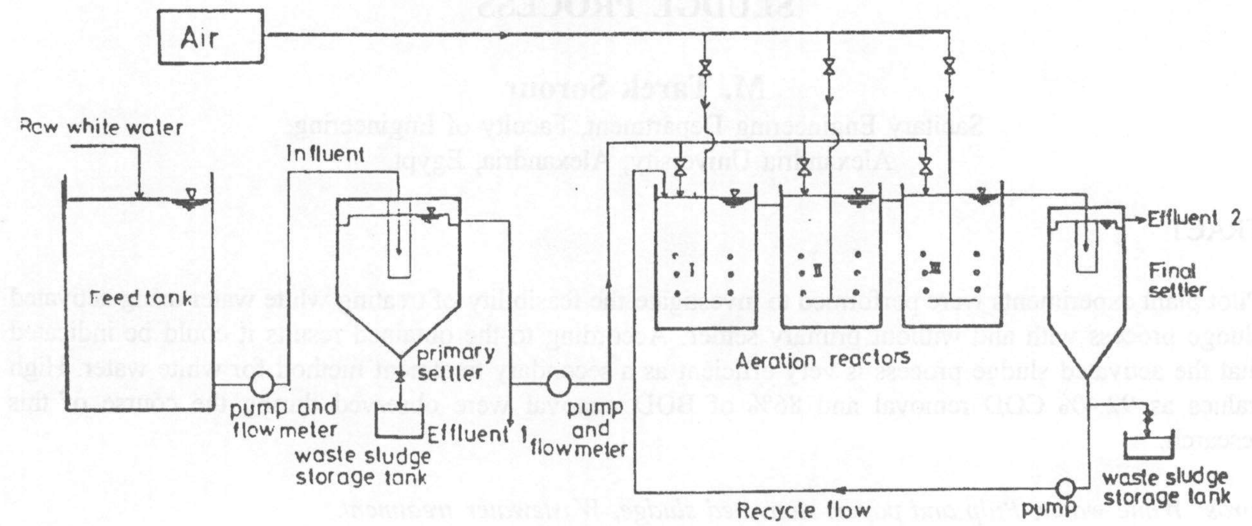

Figure 1.

The system was operated utilizing white water which was daily transported from RAKTA by a tanker. The white water was fed to the primary settler at a rate of 48 l/h, the corresponding surface overflow rate was 18 m/d, the low overflow rate offsets clarification inefficiencies resulting from the shallow tank depth, thereby rendering effluent suspended solids concentration typical of those fund in full-scale units (3).

Under normal operation the effluent from the primary settler was fed to the first reactor of the activated sludge unit at a rate of 24 l/h resulting in 15.6 hours hydraulic retention time, the sludge was recycled from the final settler to the first reactor at a rate of 12 l/h, (recycle ratio, r = 0.5). The Target solids retention time (SRT) was 10 days, and it was controlled by wasting sludge from the final settler underflow.

*Start-up Procedure*

Initially, the activated sludge seed was taken from the aeration basins of Kafer El-dawar wastewater treatment plant. The sludge seed was completely mixed and evenly distributed among the three reactors. At this stage the unit was at the projected hydraulic retention time and the target solids retention time using a 50% mixture of white water and synthetic sewage. On the tenth day the white water effluent from primary settler was used alone to feed the activated sludge. Steady state conditions were considered achieved by the constance of the measured parameters during a period equal to 1-2 times the solids retention time, it was achieved on the fourteenth day.

*Experimental Plan*

The pilot plant continuous operating program originally planned, consisted of 3 runs:

(1) Primary settler followed by the activated sludge unit with directing the primary settler effluent (effluent 1) to the first reactor at a flow rate of 24 l/h, and recycle flow rate of 12 l/h (r = 0.5).

(2) Primary settler followed by the activated sludge unit with directing the primary settler effluent (effluent 1) to the third reactor at a flow rate of 24 l/h and r = 0.5. This action modifies the activated sludge to the contact stabilization mode. For both runs influent flow rate to the primary settler was kept at 48 l/h.

(3) Activated sludge without primary settler, by directing the white water to the first reactor at a flow rate of 24 l/h, and the same recycle ratio.

After the second run the feed point was returned to the first reactor and the system was kept working under the normal operational conditions for 3 days before carrying out run 3. During the 3 runs all the other operational variables were kept constant.

### *Sampling and Analysis*

Samples were taken from influent, effluent 1, effluent 2, and the three reactors. Grab samples were taken 4 times per day for analysis, then the average of each day was calculated. Samples were analyzed for COD, BOD, suspended solids, and pH, according to Standard Methods (4).

## RESULTS AND DISCUSSION

Investigation of the effect of particular variables on the performance of an activated sludge unit requires that the system should be operated at steady state. The unit operated during this study approximately met the steady state conditions. The system was operated at a constant influent flow rate of 24 l/h, constant recycle ratio (r = 0.5), and at a constant solids retention time (10 days).

The data depicting the performance of the pilot plant for each run are presented in Table 1. The temperature of the system was found between 21-25 c . The pH also remained relatively constant in a range of 7.0 to 8.5. The DO in the reactors varied but never fall below 3.2 mg/l.

A significant variability in the properties of the influent white water could be observed in Table 1. The influent has different COD, BOD, and SS concentration from day to day. This could be expected due to the great fluctuations in production conditions in such a big paper factory (RAKTA).

Table 2, shows the average data of influent, effluent 1, and effluent 2 during the 3 runs. By examining this table it can be realized that the best COD and BOD removal percentages occurred in run 1 (92.4% and 86% respectively), this because of the primary settler role in reducing the organic load to the activated sludge, also the primary settler helps in reducing shock loading to the activated sludge unit which allows the process to perform in a steady mode.

Although the primary settler was included in run 2 (contact stabilization modification) the COD and BOD removal percentages were the lowest, this is because of the short hydraulic detention time in the biological reactor due to directing the feed point to the last reactor which results in hydraulic retention time of 5.2 h instead of 15.6 h in other both cases. However, the highest suspended solids removal percentage was obtained in run 2 because of the reduction occurred in the MLSS in reactor 3, due to directing the feed point to this reactor (dilution effect). Consequently, the solids loading to the final settler has decreased. Mixed liquor suspended solids concentrations in reactors during the 3 runs are presented in Figures (2,3, and 4) to show the effect of changing the feed point on solids concentrations in the reactors.

## CONCLUSIONS

Depending on the results of this study, it can be indicated that the activated sludge process seems to be very efficient as a secondary treatment method for white water. High values as 92.4% of COD removal and 86% of BOD removal were observed during the course of this research.

It is believed that, the primary settler can be considered as an essential part of the treatment system for white water. One on hand it plays a positive role in improving the activated sludge performance by reducing the shock organic load to the process, and on the other hand solids recovered by the primary settler could be returned to the stock and subsequently reused.

Enough hydraulic detention time in the biological reactor is also an essential factor to obtain high quality effluent.

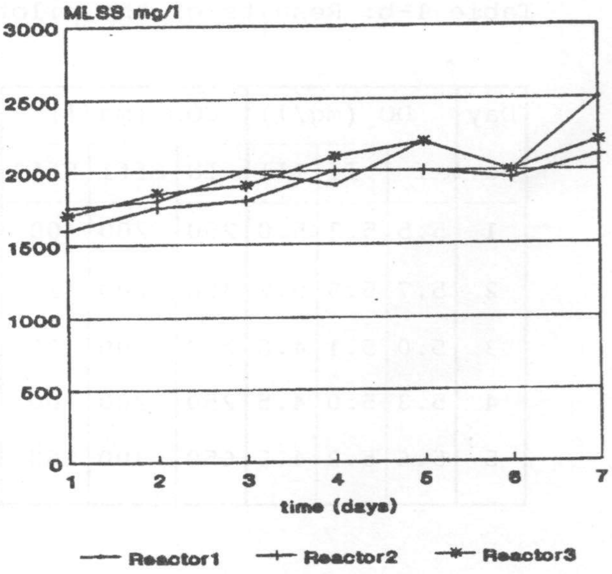

**Figure 2**. Mlss in reactors run(1).

Table 1-a results of the pilot performance (Run 1)

| Day | DO (mg/l) | | | COD (mg/l) | | | BOD (mg/l) | | | SS (mg/l) | | | pH | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | I | II | III | IN | Eff1 | Eff2 | IN | Eff1 | Eff2 | IN | Eff1 | Eff2 | IN | Eff1 | Eff |
| 1 | 4.0 | 4.5 | 4.2 | 300 | 150 | 50 | 120 | 90 | 20 | 1014 | 472 | 128 | 7.3 | 7.5 | 7.9 |
| 2 | 3.7 | 3.9 | 4.5 | 200 | 150 | 50 | 100 | 80 | 20 | 1200 | 400 | 200 | 7.1 | 7.1 | 7.3 |
| 3 | 3.2 | 4.0 | 4.0 | 300 | 150 | 50 | 100 | 20 | 20 | 1400 | 800 | 100 | 7.8 | 7.3 | 7.4 |
| 4 | 4.0 | 5.5 | 5.8 | 550 | 250 | 40 | 130 | 100 | 18 | 600 | 200 | 80 | 7.2 | 8.3 | 8.5 |
| 5 | 3.5 | 4.8 | 5.0 | 1425 | 550 | 60 | 180 | 70 | 16 | 1700 | 500 | 50 | 7.7 | 7.9 | 8.0 |
| 6 | 3.5 | 5.0 | 5.2 | 1750 | 750 | 100 | 200 | 90 | 20 | 1800 | 600 | 50 | 7.5 | 7.5 | 7.7 |
| 7 | 3.8 | 5.1 | 5.0 | 1100 | 700 | 80 | 140 | 110 | 18 | 1500 | 300 | 80 | 7.5 | 7.7 | 7.9 |

I, II, III, are reactors numbers

In is influent flow

Table 1-b: Results of the pilot performance (Run 2)

| Day | DO (mg/l) | | | COD (mg/l) | | | BOD (mg/l) | | | SS (mg/l) | | | pH | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | I | II | III | IN | Eff1 | Eff2 | IN | Eff1 | Eff2 | IN | Eff1 | Eff2 | IN | Eff1 | Eff2 |
| 1 | 5.5 | 5.3 | 5.0 | 250 | 200 | 100 | 180 | 110 | 70 | 500 | 400 | 50 | 7.3 | 7.5 | 7.2 |
| 2 | 5.7 | 5.8 | 5.2 | 350 | 200 | 110 | 220 | 130 | 70 | 900 | 300 | 50 | 7.1 | 7.6 | 7.0 |
| 3 | 5.0 | 5.1 | 4.8 | 250 | 100 | 80 | 90 | 60 | 40 | 800 | 200 | 60 | 7.3 | 7.7 | 7.1 |
| 4 | 5.3 | 5.0 | 4.5 | 250 | 200 | 100 | 110 | 90 | 53 | 1400 | 270 | 50 | 7.4 | 7.3 | 7.3 |
| 5 | 5.6 | 5.2 | 4.3 | 650 | 300 | 160 | 140 | 100 | 60 | 1250 | 300 | 40 | 7.6 | 7.3 | 7.9 |

Table 1-c: Results of the pilot performance (Run 3)

| Day | DO (mg/l) | | | COD (mg/l) | | | BOD (mg/l) | | | SS (mg/l) | | | pH | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | I | II | III | IN | Eff1 | Eff2 | IN | Eff1 | Eff2 | IN | Eff1 | Eff2 | IN | Eff1 | Eff2 |
| 1 | 5.2 | 5.5 | 5.8 | 300 | -- | 150 | 160 | -- | 20 | 1300 | -- | 130 | 7.3 | 7.4 | 7.1 |
| 2 | 5.0 | 6.0 | 5.8 | 270 | -- | 100 | 120 | -- | 25 | 1070 | -- | 100 | 7.7 | 8.3 | 8.0 |
| 3 | 4.1 | 4.7 | 5.1 | 400 | -- | 70 | 140 | -- | 20 | 850 | -- | 100 | 7.5 | 7.1 | 7.1 |
| 4 | 5.7 | 5.1 | 5.7 | 350 | -- | 50 | 110 | -- | 30 | 900 | -- | 170 | 7.2 | 7.8 | 7.6 |
| 5 | 5.3 | 5.2 | 5.5 | 300 | -- | 80 | 120 | -- | 25 | 1020 | -- | 90 | 7.6 | 7.3 | 7.9 |

Table 2. Summary of experimental conditions (average values)

| Run | Activated sludge HRT(h) | Primary Settler | Influent | | | Eff 1 | | | Eff 2 | | | Removal % | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | COD mg/l | BOD mg/l | SS mg/l | COD mg/l | BOD mg/l | SS mg/l | COD mg/l | BOD mg/l | SS ml/l | COD % | BOD % | SS % |
| 1* | 15.6 | with | 803 | 138 | 1316 | 385 | 88 | 467 | 61 | 19 | 98 | 92 | 86 | 93 |
| 2** | 5.2 | with | 350 | 148 | 970 | 200 | 98 | 294 | 110 | 59 | 50 | 69 | 60 | 75 |
| 3** | 15.6 | without | 324 | 118 | 1028 | -- | -- | -- | 90 | 24 | 118 | 72 | 80 | 89 |

* 28 samples

** 20 samples

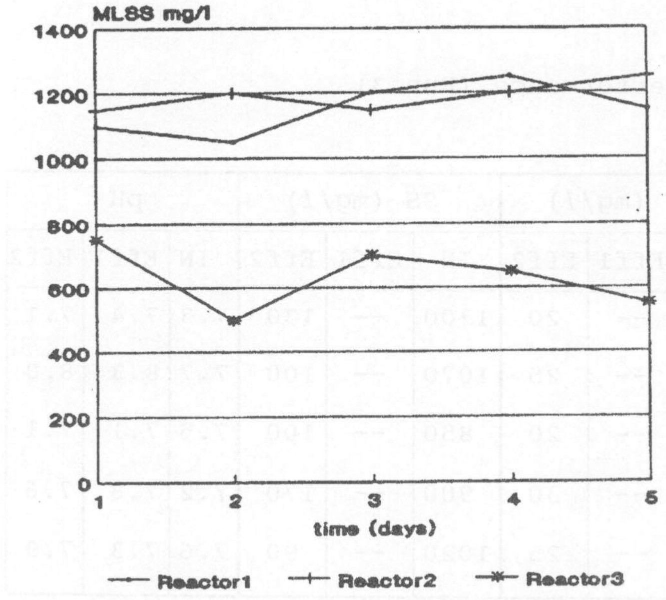

**Figure 3**. Mlss in reactors run(2).

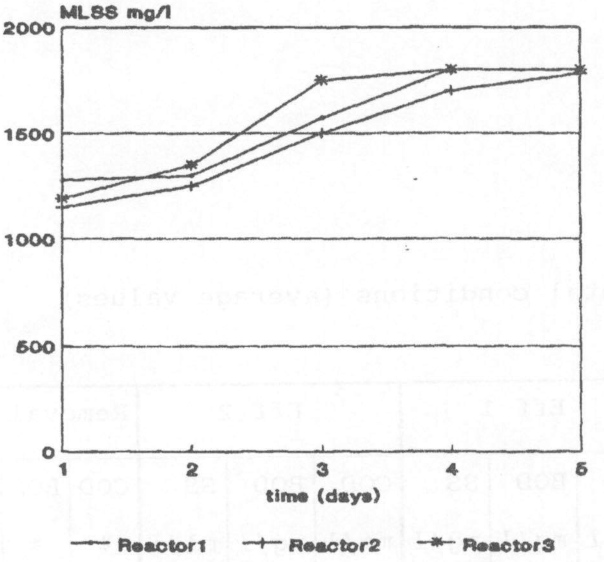

**Figure 4**. Mlss in reactors run(3).

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