# TREATMENT OF WOOL SCOURING WASTEWATER FOR GREASE REMOVAL

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*Most of the wool scouring wastewater treatment systems in Australia consist of open anaerobic and facultative ponds which require large open areas. Apart from being unsightly and emitting odours, the plants are usually located in environmentally sensitive areas thereby causing environmental problems. There is a great need to look at alternative treatment systems which are more efficient and more environmentally acceptable.*

*This study set out to investigate ways of reducing the grease content of the wastewater so that the pretreated wastewater can be fed to some high rate anaerobic digester. Various combinations of additions of coagulants, flocculants as well as using sulphuric acid for pH adjustment of the wastewater were attempted for assessing the extent of grease and COD removals. The study was also conducted at temperatures of 20 to 45°C. It was found that up to 98% of grease and 79% of COD could be removed by just using sulphuric acid at a pH of between 2 and 3 and at a temperature of 20°C. This work was first done on a batch basis.*

*The work was extended into a continuous laboratory scale mixer-settler assembly which produced comparable results to those obtained batchwise.*

## INTRODUCTION

Wool scouring is the washing of freshly sheared wool with hot water and detergent. A very stable grease-water emulsion containing some dissolved inorganic salts derived from the suint (produced from sheep sweat), as well as some insoluble material loosely classified as dirt are contained in the emulsion (McLachlan, et al, 1980a). Wool scouring plants are big consumers of water where the typical water consumption figure is 20 litres per kilogram of scoured wool (Jandakot Wool Scourers).

Most of the current wool scouring wastewater treatment systems adopted in Western Australia consist of open anaerobic and facultative lagoons which require large open spaces. Apart from being unsightly and emitting odours, the plants are usually located in environmentally sensitive areas thereby causing environmental problems which must be addressed. Thus alternative treatment systems which are both more efficient and more environmentally friendly are required.

Acid cracking, where the emulsion is dosed with an acid for cracking the emulsion, has been used, quite successfully by Harker (1970) principally for grease recovery. McCracken and Chaikin (1976) reported work on acid cracking at elevated temperatures in the presence of a flocculant that resulted in high COD and grease removals.

Solvent extraction, where an organic solvent (McLachlan, et al., (1980b), mixtures of solvents (McCracken and Chaikin, 1978a, He et al., 1989) or a combination of a solvent and a flocculant (McLachlan, 1979) had all been tested on wool scouring wastewater for grease removal. They reported successes of various degrees in a laboratory or pilot scale.

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The main objective of this study was to find a suitable method of pretreating the wool scouring wastewater for maximum removal of grease and COD so that the treated liquid effluent will be a suitable feed to some high rate anaerobic digesters such as the anaerobic fluidized bed digester or the hybrid digester (Environmental Solutions International Ltd.). A number of selected coagulants and flocculants, used individually or as a mixture together with or without pH adjustment using sulphuric acid were tested on wool scouring wastewater from Jandakot Wool Scourers. Their effects on both settling rates and grease and COD removals were studied. Batch and continuous systems were both investigated.

## EXPERIMENTAL

### Use of 500 ml Measuring Cylinders

Preliminary settling tests on the wastewater were conducted in 500 ml measuring cylinders fitted with plungers which were used for gentle mixing of the wastewater. The settling rates were measured by visually observing the movement of the liquid-slurry interface in the cylinder. Various coagulants and flocculants and at various dosages were added to the wastewater and their effects on settling were studied.

Coagulants selected for the study were alum and ferric chloride at dosages of 0.5 to 4 g/l. Flocculants tested were Alfloc 620 (nonionic), Optimer AA 184 (cationic) and Alfloc 627 (anionic) which were supplied by a local company, NALCO.

Mixing times of 1/2 to 2 minutes were used in the study. In some of the tests conducted, the grease and COD removals in the supernatant were measured by standard techniques (Adams 1990, Clesceri et al, 1989).

### Use of a Mixing Vessel

Based on the results obtained from the settling rates by the use of the measuring cylinders, a cubical 2 litre vessel fitted with a suitable impeller as recommended by Mhaisalkar, et al 1991 was designed and constructed. The vessel was made of perspex so that settling was visible. In each test, 1.6 L of wastewater was placed into the vessel which was placed into a thermostatic water bath for proper temperature control in the mixing vessel. Either a coagulant or a flocculant or a combination of both were added to the wastewater. In some tests only sulphuric acid was added when the effect of only the pH was studied. The other parameter that was also studied was temperature, ranging from 20 to 45°C. After mixing the contents in the vessel for a short period of time, it was allowed to settle into two layers. The supernatant was analysed for grease, COD, BOD, total solids and total suspended solids.

The mixing vessel was also used for continuous operation by connecting a settler of 20 L capacity downstream of the vessel. The settling times in the settler could be varied by opening selected valves located along the height of the settler for overflow of the supernatant. The bottom valve was used for continuous bleeding of the sludge formed at the bottom of the settler. A schematic diagram of the mixer settler arrangement is shown in Figure 1. To regulate the overflow into the settler, a vertical baffle was installed at the entrance to the settler. The same properties as those listed for the batch study were analysed for the supernatant and some of the sludge as well.

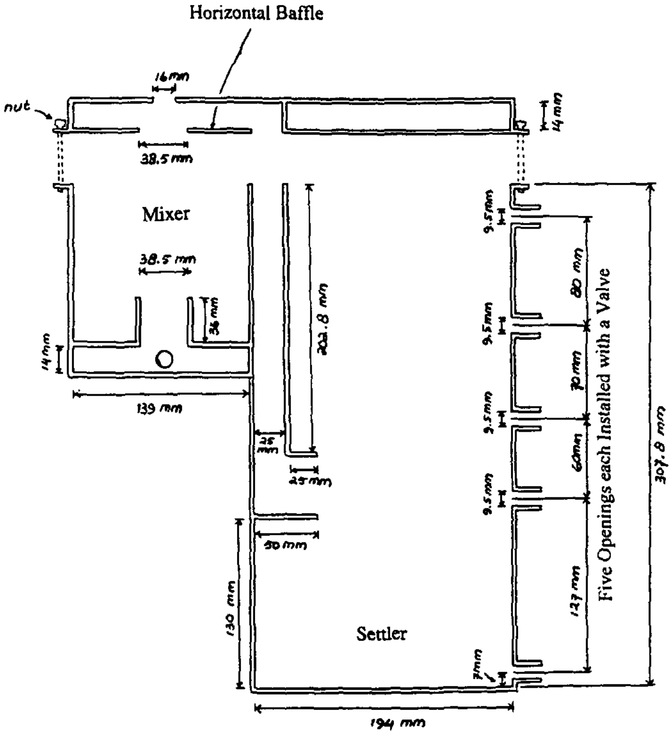


Figure 1 Set-up for the mixer settler

The effects of temperature, pH and the presence or absence of coagulants on the grease and COD removals from the wastewater were studied.

## RESULTS AND DISCUSSION

The wastewater properties discharged from the wool scouring plant varied from day to day. Thus it was always necessary to determine its properties with each batch collected from the plant. The average properties are given in Table 1 below.

Table 1 - Average Wastewater Properties at the Jandakot Wool Scouring Plant

| | |
|---|---|
| $BOD_5$ | 6,280 ± 2,520 mg/l |
| COD | 12,390 ± 3,000 mg/l |
| Grease | 8,540 ± 2,570 mg/l |
| Total Solids | 29,360 ± 13,630 (mg/l) |
| Total Suspended Solids | 19,010 ± 1,680 (mg/l) |
| pH | 7.7 ± 0.4 |
| Temperature | 44.0 ± 2.5 (°C) |

### Use of 500 ml Cylinders

The emulsion formed in the wastewater was very stable as no separation could be seen visually by leaving the wastewater over an extended period of time. Similar observations were made when either a coagulant or a flocculant was added over the whole range of dosages tested (Purwanti, 1993).

The addition of ferric chloride as the coagulant together with a nonionic flocculant at 20°C and without pH adjustment (ie, pH = 7.7) produced the highest settling rate. Generally, the fine suspended particles carry negative charges. Addition of the coagulant, which is usually positively charged, neutralized the charged particles but they themselves are still too small to settle by gravity. The further addition of a nonionic flocculant could probably cause the particles to form particle-polymer bridges so that they flocculate and settle down gravimetrically.

The effect of mixing time on the settling rate was also studied under the conditions mentioned above where a combination of $FeCl_3$ as the coagulant and a nonionic flocculant were used. Figure 2 shows that out of the three mixing times used, maximum settling rate was produced for 1 minute mixing. Higher and lower mixing times seemed to result in lower settling rates.

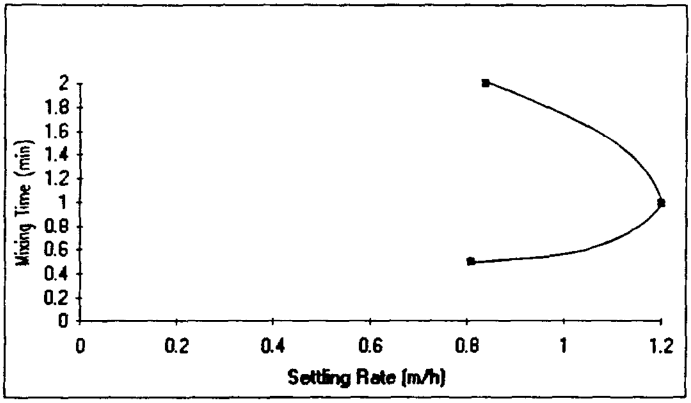


Figure 2 Variation of settling rates with mixing time (pH of 7.7, 20°C, addition of $FeCl_3$ coagulant and a nonionic flocculant)

Dosages of nonionic flocculant used were 1 - 4 ml/l. Figure 3 shows its effect on settling rates as well as its effect on grease and COD removals.

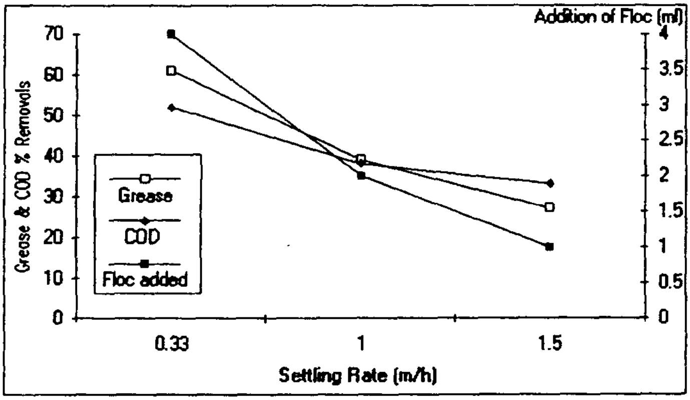


Figure 3 Effect of flocculant dosages on the settling rates, grease and COD removals in coagulated wastewater (pH of 7.7, 20°, 1 min mixing time)

It could be seen that higher flocculant dosages tended to lower the settling rate but the grease and COD removals were higher at higher flocculant dosages. It was observed that bigger flocs were produced at higher flocculant dosages but they settled slower due to its bulkiness and having a lower density. Thus higher flocculant dosages are not desirable as it will not only be costly but bulkier sludges will be produced. The bulky sludges could possibly increase sludge volumes that have to be handled and disposed of.

Use of a Mixing Vessel

Comparisons were made of settling rate results obtained by using the 500 ml cylinders and those resulting from the use of the cubical mixing vessel. They proved to be very similar (Purwanti, 1993). For instance, settling rate tests conducted in both vessels on wastewater flocculant and $FeCl_3$ and a nonionic flocculant and under similar conditions resulted in settling rates of 0.39 m/h and 0.42 m/h for the cylinder and mixing vessel respectively.

Sulphuric acid was not only used to alter the pH of the wastewater but at the same time it caused the grease and solids to crack out and settle to the bottom. The pH range studied was from 7.7 which is the original wastewater pH down to below 2. The temperature range studied was from 20 to 45°C.

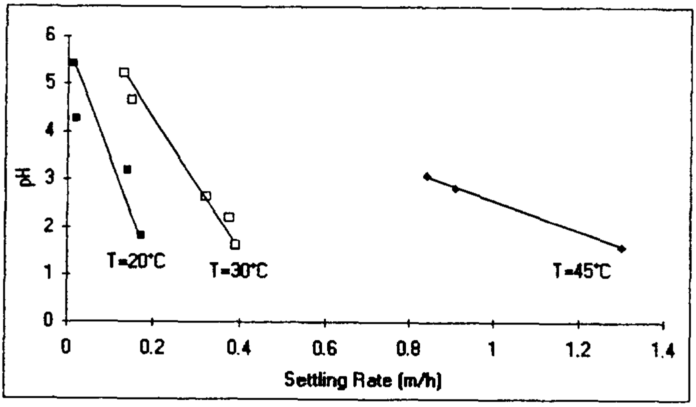


Figure 4 Effect of wastewater temperature and pH on the settling rates in the absence of additives

Figure 4 shows that higher settling rates occurred at lower pH values but at higher temperatures. These findings were for runs which were conducted in the absence of other additives. Consistent with any chemical reaction, higher temperatures resulted in higher rates of floc formation and thus higher settling rates. The cracking of the emulsion and the hydrolysis of the grease by the acid proceeded faster at lower pH values. Eilbeck and Mattock (1987) reported similar findings. However, when $FeCl_3$ and a nonionic flocculant were also added together with sulphuric acid, higher settling rates resulted (Purwanti, 1993).

Figures 5 and 6 show that grease and COD removals from the influent wastewater are both higher at lower pH's and lower temperatures. These results were obtained for runs in the absence of both coagulants and flocculants. At a pH range of 2 - 3, the grease and COD reductions were up to 98% and 79% respectively at the lower temperature of 20°C.

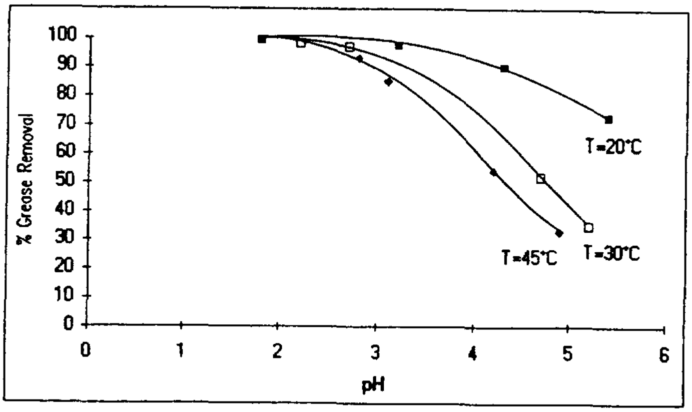


Figure 5 Effect of wastewater temperature and pH on grease removal in the absence of additives

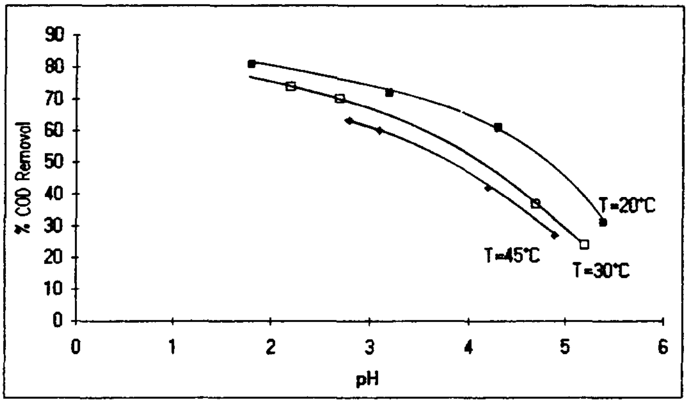


Figure 6 Effect of wastewater temperature and pH on COD removal in the absence of additives

The better pollutant removal at lower pH values is consistent with the explanation given above for the effect of pH on settling rate. At lower pH, the surface charge of the colloid formed by the emulsion was less negative as the charge of hydroxide was reduced to near neutral, thereby providing a suitable condition for coagulation to occur (Tenney and Stumm 1965, Metcalf and Eddy, 1972).

The temperature effect on grease and COD removal showed that lower temperatures, particularly 20°C, was more desirable as it produced the highest removal of pollutant (see Figures 5 and 6). These results contrasted with those of Figure 4 which showed that higher settling rates resulted at higher temperatures. Christoe (1977) mentioned that wool grease melts at around 40°C. Thus higher temperatures will tend to cause more of the grease to stay in the liquid phase and thus will result in lower grease and COD removals. It is suggested that the mixing and settling should be conducted at room temperature of about 20°C. Harker (1970), Christoe (1977) and He et al., (1989) also reported that optimum grease removal was obtained at room temperature over the range of 20 - 90°C.

In the study using a mixer settler, mixing was conducted under similar conditions adopted for the batch mixing, that is at 60 rpm for 1 minute and the supernatant overflowed directly into the settler. Steady state was assumed to be attained when the COD of subsequent samples remained the same. The grease and COD removals were found to be 98% and 75% respectively. Sludge withdrawal on the bottom had to be done intermittently so that the position of the interface was stable in the settler. Figure 7 shows the sludge or underflow properties of the settler at different pH values in the absence of any additives.

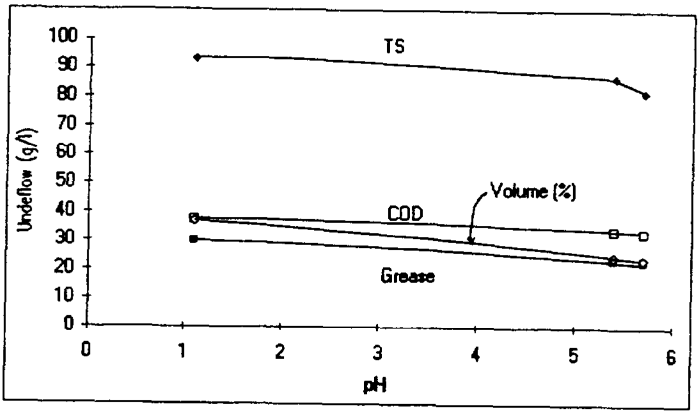


Figure 7 Effect of wastewater pH on the underflow properties in the mixer-settler (20°C, feed water properties: grease 11 g/l, COD 15.5 g/l and TS 45.8 g/l).

The total solids, grease and COD contents in the underflow did not seem to be significantly affected by changing pH. However, their volume fraction of the feed wastewater that came out in the underflow was higher at lower pH values. The grease content in the underflow was about 30 g/l and thus there is a potential for recovery of the grease from the sludge. The corresponding total solids concentration was about 92 g/l.

Figures 8 and 9 show the results obtained for grease and COD removals respectively where the results obtained from both batch and continuous operation were plotted for comparison. Only the mixing vessel was used in the batch study but in the continuous study the mixer-settler was utilized. The figures were for different pH values studied and at two temperatures (20 and 45°C). The results from the two different operating modes compared very well within experimental errors at lower pH values. Their variations seemed random and within the expected experimental errors.

Table 2 shows a summary of the quality of the pretreated wastewater from either the mixer for the batch study or from the overflow from the mixer-settler.

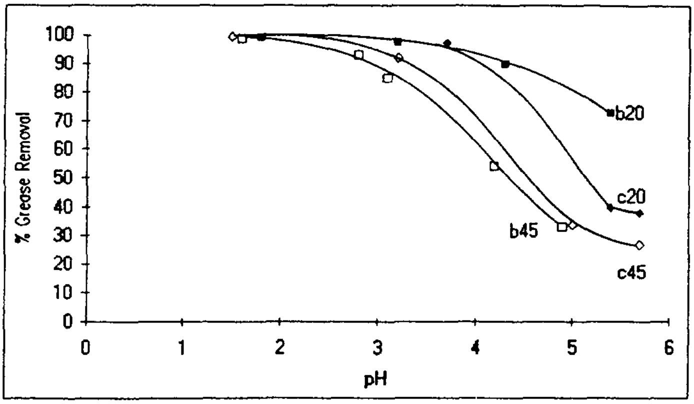


Figure 8 Comparison of grease removal between batch and continuous systems at various pH in the absence of additives

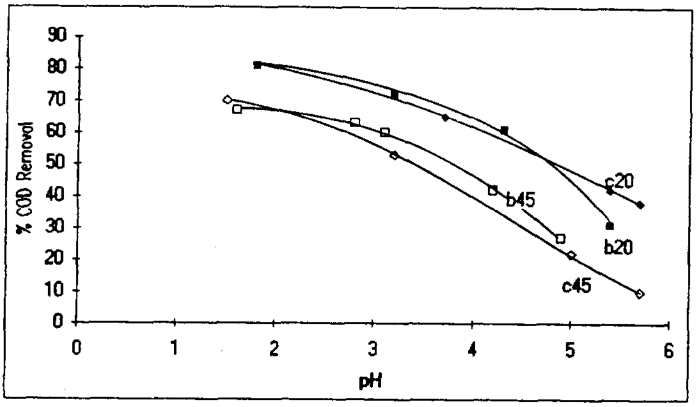


Figure 9 Comparison of COD removal between batch and continuous systems at various pH in the absence of additives

Table 2 - Quality of Wastewater After Pretreatment

| | |
|---|---|
| $BOD_5$ | 1,308 mg/l |
| COD | 3,354 mg/l |
| Grease | 85 mg/l |
| Total Solids | 13,210 (mg/l) |
| Total Suspended Solids | 1,160 (mg/l) |
| pH | 2 - 3 |
| Temperature | 20°C) |

The pretreated wastewater, with only about 85 mg/l of grease of 1,300 mg/l COD could be discharged to the sewerage system after neutralizing it with lime. Of course the surcharge for the discharge will have to be assessed. Alternatively, the preferred option would be to transfer this neutralized wastewater to an anaerobic fluidized bed digester. This latter alternative is currently the subject of one of the authors research activities. Sludge disposal after the settler is also being addressed.

## CONCLUSIONS

1. A simple laboratory mixer-settler could continuously treat wool scouring wastewater very effectively by just using sulphuric acid to bring the pH of the wastewater down to between 2 and 3. The grease and COD reductions were up to 98% and 75% respectively.

2. The best mixing and settling conditions for the mixer-settler were at 60 rpm for 1 min and about 25 minutes required for the batch settler but required 40 minutes in the case of the mixer-settler. The best temperature of operation is 20°C.

3. Higher settling rates of the sludge in the wastewater did not produce better grease and COD removals as higher settling rates were obtained at higher temperatures which did not produce better grease and COD removals than at the lower temperature of 20°C.

4. The results obtained from both the batch mixer and the continuously operated mixer-settler under similar operating conditions compared very well.

5. The addition of $FeCl_3$ coagulant to the wastewater proved detrimental to the grease and COD removals of the wastewater.

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