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AN ASSESSMENT OF THE QUALITY AND TREATMENT OF DETERGENT WASTEWATER

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ABSTRACT

Removal efficiency of organic load from a detergent wastewater by a bench scale physical-chemical treatment is reported. The results of the wastewater characterisation showed that the concentrations of the organic matter were very high, expressed as COD, ranging from 2400-26,400 mg/l, while the biodegradable portion was very low, since the BOD/COD ratio was low. These values indicate that organic compounds are not easily subjected to biological treatment. In addition, methylene blue active substances appeared in high concentrations as well as sulphates and ammonia.

The experiments for the treatment of the wastewater were performed using various chemicals such as lime, alum and polyelectrolyte. The use of lime gave a 26% average COD removal, while by using alum a slightly lower removal was achieved, 23%. The use of lime (pH=9-10) in combination with alum led to a 41% COD reduction. Similar removal was achieved by using alum (pH=5-6) in combination with lime, 43%. Finally, the addition of polyelectrolyte in the systems of lime and alum did not improve total removal of organic matter giving reductions of 46% and 48%, respectively. © 1997 IAWQ. Published by Elsevier Science Ltd

KEYWORDS

Coagulation; detergent wastewater; organic load; physical-chemical treatment; precipitation.

INTRODUCTION

The main sources of wastewater produced in plants manufacturing toiletries and detergents are the washing processes. The polluting load of this wastewater is, mainly, due to the residual product in the reactor which has to be washed away in order to use the same facility for the manufacture of other products. The extreme diversity of raw materials and production schemes employed by the industries is reflected in the variety and complexity of this type of wastewater. As a result, the industries pose problems in assessing effluent characteristics and subsequently defining pollution control technologies.

The high and varied polluting load of the detergent wastewater can cause significant environmental problems (Cain, 1977; Hon-nami and Hanya, 1980; Larson *et al.*, 1989; Quiroga *et al.*, 1989; Rapaport and Eckhoff, 1990; Ferrer and Morenio, 1991; Lewis, 1991; McAvoy *et al.*, 1993). Prior to its disposal in the environment an efficient treatment process must be applied. Due to its complexity, detergent wastewater is

very difficulty to treat. In the literature, limited data have been reported on the removal of polluting loads from this type of wastewater (Hashim *et al.*, 1985; Adachi *et al.*, 1990).

This study is a part of an extensive research project referring to detergent wastewater treatment. For this particular work a chemical method was applied in order to reduce the organic matter concentration of the wastewater. This can be achieved by the destabilization of colloids which can be brought about by processes such as precipitation, coagulation and flocculation.

EXPERIMENTAL PROCEDURE

The treatment of detergent wastewater samples by coagulation-flocculation and precipitation was examined systematically using a jar test apparatus. Wastewater samples were taken during a six month period from a local plant manufacturing toiletries and detergents. The samples were properly preserved and kept refrigerated during experimentation. Chemical characterization was performed by determining the following parameters: pH, colour, total, dissolved and suspended solids, methylene blue active substances (MBAS), BOD, COD, SO_4^-, and NH_4^+ (Standard Methods, 1990).

For its treatment the experimental procedures followed are given next.

The optimum lime [$Ca(OH)_2$] dose was established by a series of experiments using different wastewater samples with initial pH ranging from 9-10. The lime and the wastewater were vigorously mixed for one minute, followed by slow mixing for thirty minutes at a speed of 15-20 rpm and then allowed to settle for thirty minutes. Samples of the clarified wastewater were taken and analysed for the effectiveness of the method for COD removal.

Similar tests were performed using alum [$Al_2(SO_4)_3.18H_2O$]. In particular, different wastewater samples with initial pH in the range of 5-6 were treated by alum and its optimum dose was established.

After determining the optimum conditions of lime and alum, the effectiveness of the method concerning COD reduction was examined by using lime or alum on their own, lime and alum together and, finally, lime, alum and polyelectrolyte together.

Table 1. Values of the wastewater characteristics

Parameters	Value (Range)
pH	2.7-11.6
Colour	1000-18500
Total Solids (T.S.)	2400-17600
Dissolved Solids (D.S.)	903-17075
Suspended Solids (S.S.)	30-3600
COD	2400-26700
BOD	250-6300
MBAS	180-6900
SO_4^{2-}	275-5200
NH_4^+	25-316

- All units in mg/l except pH and colour

RESULTS AND DISCUSSION

The results of the wastewater characterization are shown in Table 1. The pH values of the wastewater showed very high fluctuations ranging from 2.7-11.6, and the colour units were in the range of 1000-18,500. Solids, expressed as total, dissolved and suspended solids were in high concentrations, 2400-17,600 mg/l, 903-17,075 mg/l and 30-3600 mg/l, respectively.

The organic load concentrations were very high since the COD ranged from 2400-26,700 mg/l, while its biodegradable portion was very low since the BOD was in the range of 250-6300 mg/l. These values indicate that organic compounds are not easily subjected to biological treatment. In addition, methylene blue active substances (MBAS) appeared in quite high concentrations ranging from 180-6900 mg/l. Finally, sulphate concentrations ranged from 275-5200 mg/l, while ammonia concentrations did not exceed 316 mg/l.

The experimental results show that the concentrations of the various parameters ranged over wide limits. This is due to the fact that the industry produces several cleaning agents and each of them is produced by a different process. As a result the wastewater quality, which depends on the production process applied, varies significantly.

As mentioned above, in this study, experiments were performed using various chemicals such as lime, alum and polyelectrolyte, in order to examine their ability to remove the organic compounds from the wastewater. The bench scale experiments which were carried out gave the results as shown in Figures 1-5.

Having found the optimum pH values, 9-10, at which precipitation can occur with lime, a series of experiments were performed in order to find the optimum lime dose, expressing the results as a COD percentage removal. The results are presented in Figure 1, where the curves correspond to four wastewater samples with initial COD ranging from 5600-19,980 mg/l. As, can be seen, the pattern followed is similar for the wastewater samples examined and an average COD removal of around 26% can be achieved using a dose of 1500 mg/l of lime.

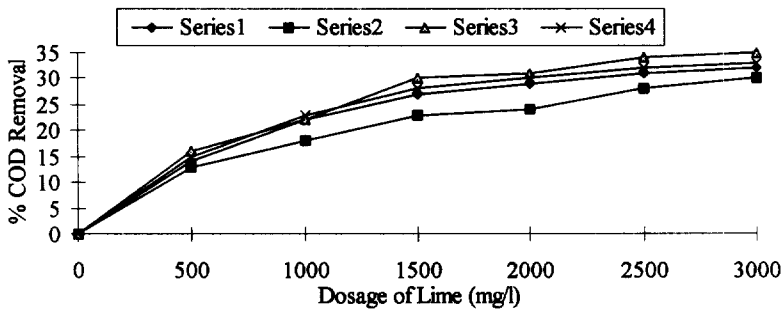

Figure 1. COD removal using lime; pH=9-10.

Similar to lime, jar tests were carried out using alum. Having found the optimum pH values, 5-6, a similar series of experiments were performed in order to find the optimum alum dose. The results which are shown in Figure 2 indicate that the alum dose for the maximum COD removal, about 23%, is 2000 mg/l.

After determining the optimum conditions for wastewater treatment by using lime or alum, their combinations with other chemicals were carried out in order to find the most efficient treatment system. In particular, as shown in Figure 3, the use of 1500 mg/l of lime for the treatment of four different wastewater samples (initial COD concentrations from 5300-10,060 mg/l) gave COD removal ranging from 19-29%. Its combination with 1500 mg/l of alum improved COD removal up to 18%, leading to total COD removal of 33-47%. The addition of 6 mg/l of polyelectrolyte in this treatment system helps towards the COD removal

only by a low percentage, about 5%. As a result, the combination of lime, alum and polyelectrolyte gave total COD removal in the range of 39-52%.

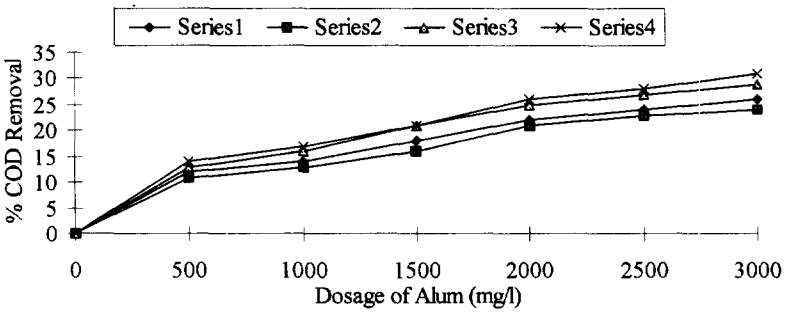

Figure 2. COD removal using alum; pH=5-6.

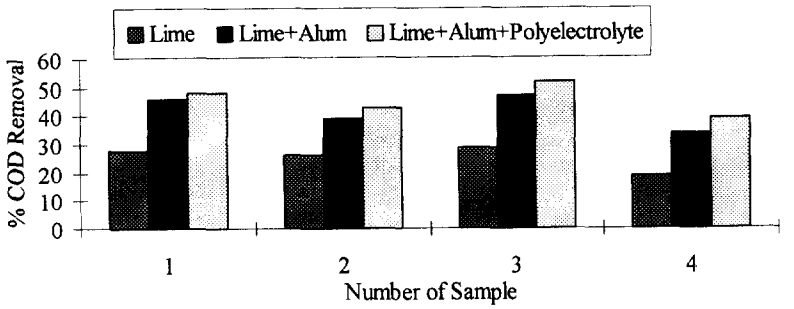

Figure 3. COD removal using lime system.

Figure 4 presents the results of the treatment of the same wastewater samples using alum on its own, and in combination with lime and polyelectrolyte. By using 2000 mg/l of alum, COD removal ranging from 18-26% was achieved. The addition of 1500 mg/l of lime improved the COD reduction by up to 22%, giving a total COD removal ranging from 39-48%. Finally, by adding 6 mg/l of polyelectrolyte in this treatment system the improvement of COD removal did not exceed 6% and the total COD reduction was in the range of 45-52%.

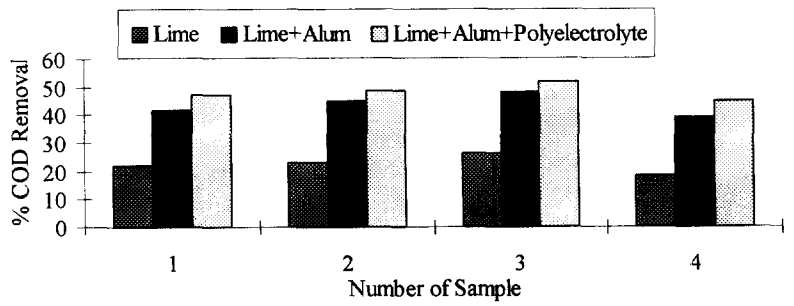

Figure 4. COD removal using alum system.

Comparing the experimental results, it is shown that the combination of lime and alum leads to significant removal of organic compounds from the wastewater. As shown in Figure 5, by using lime (initial pH=9-10) with alum an average COD removal of 41% was achieved, while similar removal, 43%, was obtained by using alum (initial pH=5-6) with lime. Furthermore, the addition of polyelectrolyte in these treatment

systems did not improve the organic load removal significantly since the additional COD reduction gave total average COD removals of 46% and 48%, respectively.

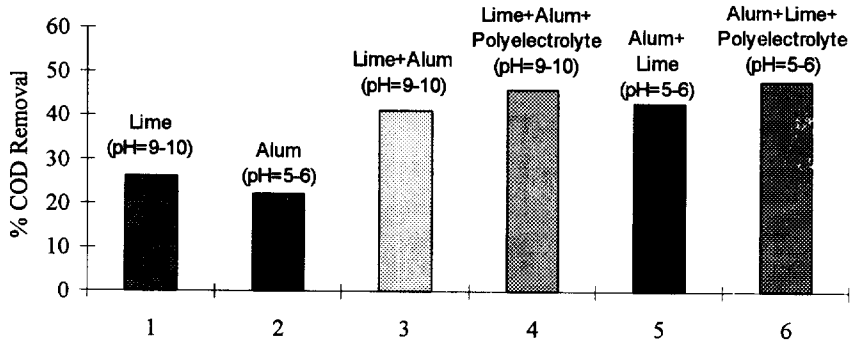

Figure 5. Average COD removal.

CONCLUSIONS

The wastewater examined under this study contained very high and varied organic loads of which the main portion was not biodegradable. Therefore biological treatment will not be applicable by itself. The treatment employed, using lime or alum gave a COD removal of up to 26% and 23%, respectively. The combination of lime and alum led to a significant COD removal up to 43%, while the addition of polyelectrolyte in this treatment system did not improve the results significantly, giving an additional COD removal up to 6%.

In conclusion, the total COD removal achieved is quite satisfactory, taking into account the fact that the initial organic load concentrations were too high. Despite this, the treatment based on the addition of chemicals did not give the required wastewater quality for its disposal in the main sewage system for municipal waste. The polluting load can be significantly reduced by adjusting the production process and reducing the number of changes of products for a given reactor.

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