Characterization and physicochemical treatment of wastewater from rubber processing factory

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Wastewater collected from rubber processing factory was characterized for their pollution characteristic. Results of the analysis show that the total solids, TS, suspended solid, SS and dissolve solid, DS, were 1528.5, 1078.5 and 450 mg/l respectively, the turbidity was 702 FTU. These values are high when compared to Federal Environmental Protection Agency (FEPA) effluent discharge standard for industrial wastewater. The dissolved oxygen content was 4.72 mg/l, the biochemical oxygen demand (BOD) and Chemical oxygen demand (COD) were 2610.18 and 3142 mg/l respectively. The total bacterial count was $6.0 \times 10^8/100 \text{ ml}$. These results show that the wastewater has high pollution potentials and so need to be treated before discharged to the environment. The values for ammonia, Nitrate and Phosphate were 1.49, 1.36, 1.32 mg/l respectively. Heavy metals contents were within FEPA effluent discharge standard for industrial wastewater. The ratio of COD to BOD was 1.2:1, meaning that, the extent of biodegradation of the wastewater from this factory is less than 50%. This shows that biological treatment may not be suitable for its treatment. It conductivity is 320 Scm$^{-1}$ suggesting that the wastewater contain ions and so physicochemical method of coagulation and flocculation may be a good alternative for the treatment of this wastewater. Physicochemical treatment of this wastewater yielded substantial reduction in the solid concentration, BOD and COD, nitrate, phosphorus, and bacteria counts and so the treated effluent could be discharged safely into the environment without the fear of pollution.

**Keywords:** Wastewater, rubber processing factory, pollution, physicochemical treatment, effluent discharge standard, environment.

INTRODUCTION

Industries are major sources of pollution in all environments. Based on the type of industry, various levels of pollutants can be discharged into the environment directly or indirectly through public sewer lines. Wastewater from industries includes employees’ sanitary waste, process wastes from manufacturing, washwaters and relatively uncontaminated water from heating and cooling operations (Emongor et al., 2005).

Wastewater is an unavoidable by-product of rubber processing: whatever processing procedures are used for preparing products from latex, there will always be an aqueous liquid as a by-product. About 60 percent of the latex exuded by a rubber tree is water. Like any other natural plant product, it contains a variety of substances as well as the commercially important constituent, in this case rubber hydrocarbon. Also present are proteins, minerals, non-rubber hydrocarbons and carbohydrates. In even the most efficient commercial extraction process, the effluent water from a rubber factory will contain some of each of these materials, together with any chemicals that might have been added to make the process economically more efficient. If the wastewater is put straight into surface waters – wells, streams, lakes or even the sea – without any treatment, it will inevitably pollute that water.

The increasing global concern on the environment demands that wastes should be properly managed in order to minimize and possibly eliminate their potential harm to public health and the environment.

In this work wastewater from rubber processing factory...
was characterized using some parameters of interest and treated using four different coagulants/flocculants namely; alum, iron (III) chloride, lime and polyacrylamide partially hydrolysed with soda. The essence of this treatment was to assess the extent to which these chemicals can effect changes to the wastewater in question so as to ensure proper and safety discharge to the environment.

MATERIALS AND METHODS

Sample collection

The wastewater was collected from the discharge unit of the rubber processing sewage system with a Jerry can which has been thoroughly washed and rinsed with water. The wastewater sample used for DO and BOD determinations were collected directly into dark DO bottles and were added some drops of manganous sulphate solution to fix the dissolve oxygen. After collection it was stored at room temperature.

Methods of analysis

All samples were analyzed as described in the Standard Methods for the Examination of Water and Wastewater and Standard Methods for water and effluent analysis (APHA, 1995; Ademoroti, 1996a). Where analysis was not immediately possible, they were preserved to inhibit biodegradation.

All the reagents used for the analysis were of analytical grade and obtained from BDH Chemicals Limited Poole England.

Jar test experiment (coagulation studies)

For coagulation studies, jar tests were conducted. The objective of the jar test was to determine the optimum dose and the pH value at which a coagulant should be introduced to the wastewater (Asia and Ademoroti, 2002; Asia and Oladoja, 2003). Stock solution of alum, iron (III) chloride, hydrated lime and polyacrylamide partially hydrolysed with soda used as coagulants were prepared fresh at the time of the test.

Determination of the optimum dosage of coagulant needed for wastewater treatment

Four sets of wastewater samples were coagulated each with 100, 200, 300, 400, 500, 600, 700, 800, 900, and 1000, mg/l commercial alum, Al₂(SO₄)₃.14H₂O, iron (III) chloride, FeCl₃, lime, Ca(OH)₂ and polyacrylamide partially hydrolysed with soda, (-CH₂CH-COONa⁺) in a mixer as shown in Figure 1.

Sand-bed filtration was carried out using Teflon to trap the suspended solids. The liquor was analysed for COD, and percentage COD reductions were calculated. The highest point on a plot of % COD reductions versus coagulant dosage gave the optimum coagulants doses for the coagulants.

Chemical treatment procedure

Four sets of wastewater samples were treated each with the optimum doses of alum (Figure 3), iron (III) chloride (Figure 4), lime (Figure 5) and polyacrylamide. A Teflon cloth placed on a sand bed was used as the filter medium (Figure 2). The wastewater were analysed for any chemical changes and disinfected with chlorine.

RESULTS AND DISCUSSION

Results

As shown in Table 1.

Discussion

The effluent has a pH value of 8.1, which makes it alkaline. The high turbidity of 702 FTU shows that the colloidal matter in the wastewater was high and by implication, the wastewater contains high solids concentration. The total solids and the total dissolved solids were 1528.5 and 450 mg/l respectively. These values are within FEPA standard for effluent discharge to surface waters in Nigeria. The suspended solid of 1078.5 mg/l is higher than 30 mg/l FEPA standard (FEPA, 1988). The effect of these high values for solids could lead to difficulty in disposal. The dissolved oxygen (DO) of 4.7 is relatively low. A healthy body of water should have a DO of at least 5.2
Figure 2. Sand-bed filtration unit.

Figure 3. Alum treatment of rubber processing waste water.

Figure 4. Iron (III) chloride treatment of rubber processing wastewater.

Figure 5. Lime treatment of rubber processing wastewater.
mg/l (Ademoroti, 1996b). The value of Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were rather high, this mean that the wastewater has high pollution potentials and therefore should be treated before discharge into the environment. The result also shows that the ratio of COD: BOD of 1.20:1. This indicates that the extent of biodegradation of the wastewater from this factory is less than 50%. It has been found that organic matters have about 50-90 percent substrate biodegradation if the COD: BOD ratio ranges between 2 and 3.5 (Quano et al., 1978). The wastewater therefore may not be effectively treated by biological methods. A conductivity of 320 Scm$^{-1}$ indicates that the wastewater contains ions, this suggests that physicochemical method (PCM) of coagulation and flocculation may be used to treat this wastewater.

Nitrate-Nitrogen level is low compared to FEPA standard and the Ammonium-Nitrogen content of 1.49 mg/l is higher than FEPA standard of 0.5 mg/l for industrial wastewaters. If this wastewater containing high concentration of ammonium-Nitrogen is discharged to environment, depletion of receiving water body oxygen resources may set in as the ammonia is oxidized to Nitrate by some group of bacteria. This can then promote plant and algae growth, thus leading to eutrophication of the water body. The presence of nitrate in water used to prepare food for little babies may lead to blue-baby syndrome in infant. Also, if high level of Ammonia is discharged to water bodies, it could lead to death of some aquatic organisms living in the water. The level of phosphate is 1.32mg/l, this is within FEPA standard.

Heavy metals result shows that the value of Fe, Mn, Cu, Zn, Ni, Cr, V and Pb were 1.85, 0.42, 0.003, 0.02, 0.002, 0.001, 0.021, 0.211 mg/l respectively. These values are within FEPA standard for industrial wastewater.

Effect of PCM on treatment

Treatment of the wastewater by physicochemical method yielded good results. Although, the solids concentration increase by about 5 – 26%. These solids were almost completely removed after filtration; this is shown in Figure 7, Oxygen Demand Characteristics. The results of the BODs and CODs depicted in Figure 8 show that physicochemical method may be used to achieve a considerable reduction in BOD and COD. The percentage BOD and COD reduction achieved were in the range of 91 - 97% and 89 - 97% before treatment with powdered activated
Figure 6. Polyelectrolyte treatment of rubber processing wastewater.

Figure 7. Results of solids content before and after treatment with the optimum doses of coagulants/flocculants.

Figure 8. Results of BOD and COD before and after treatment with optimum doses of coagulants/flocculants.

carbon (PAC) and 98 - 98.9% BOD and 97 – 99% COD reduction after treatment with PAC. (Results are shown in Figure 8). Polyelectrolyte, an organic polymer proves more effective and therefore, a better chemical for BOD and COD reduction than any of these inorganic chemicals employed in this study (Figure 6).
**Figure 9.** Results of nitrogens concentration before and after treatment with optimum doses of coagulants/flocculants.

**Figure 10.** Results of phosphorus concentration before and after treatment with optimum doses of coagulants/flocculants.

**Figure 11.** Results of total bacteria counts (TBC) before and after treatment with optimum doses of coagulants/flocculants.
Nitrogens

The results of nitrogens concentration of physicochemically treated wastewater is depicted in Figure 9. From the results, the total Kjeldahl nitrogen (TKN), ammonia nitrogen \((\text{NH}_3-N)\) and nitrate nitrogen \((\text{NO}_3-N)\) were found to reduce for the wastewater treated. Reductions were more in wastewater treated with lime.

Phosphorus concentration

The results of phosphorus concentrations shown in Figure 10 reveal that about 90 - 93 percent phosphorus removal from the wastewater was achieved. Therefore, if wastewater is to be discharged to water bodies, physicochemical method will be a preferred alternative, as it ensures nutrient (nitrate and phosphate) removal before discharged. This method therefore, minimized the fear of eutrophication of water bodies caused by nitrate and phosphates.

Bacteria reduction

The physicochemical method ensures maximum level of bacteria kill before filtration. Sand bed filtration (shown in Figure 2) was employed to ensure proper removal of solids and other undesirable materials using teflon as the filter medium. The effluent was passed over a column packed with Powdered Activated Carbon (PAC). PAC is known to adsorb detergents of alkyl benzene sulphonate base, phenol, and phenolic compounds, organic toxicants and odourant; hence the processed liquid would not contain most of these substances after treatment (Ademoroti, 1982; Ademoroti, 1994). The final effluents were further treated with calcium oxochlorate (I) until residual chlorine was between 0.2 – 0.7 mg/l (Figure 11) (Henry and Gary, 1987). All bacteria remaining in the processed liquid were killed off at this stage. The pH of the effluents was corrected to neutral using lime or HCl as the case may be.

Conclusion

The results of characterization of this water effluent show that the water has high pollution potentials and so need to be treated before disposal. However, biological method was not found to be suitable as the COD:BOD ratio is less than 2. Physicochemical treatment of the wastewater yielded good solid reduction after filtration, high BOD and COD reduction, High nitrate and phosphate reduction, thus preventing eutrophication due to these undesirable nutrients and also maximum bacteria kill. The wastewater could therefore be discharged safely without the fear of pollution.

REFERENCES