

TERTIARY TREATMENT OF TEXTILE EFFLUENT USING AN INTEGRATED FILTRATION SYSTEM IN BANGLADESH: A CASE STUDY

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ABSTRACT

Dye effluent from textile industries is one of the most difficult types of wastewater to treat. There has been exhaustive research on the removal of dyes from textile wastewater by adsorption and coagulation-flocculation processes. This study examines the removal efficiency of textile dyes at the tertiary level for the effluent of Masco Industries Ltd, deploying an integrated approach by an enhanced coagulation-flocculation method using a multispectral coagulant-flocculent then, filtering the supernatant through activated filter media (AFM). The results obtained by the batch tests show that AFM has a very poor adsorbent capacity compared to traditional adsorbents used by the textile industries. Moreover, this research investigated the removal efficiency of local sand against AFM filter medium, where the local sand shows better performance in order to filter out the remaining flocs from the supernatant. The removal of flocs was achieved around 38% by the local sand (size: 0.13-0.25 mm), while around 19% was achieved by AFM grade-1 (size: 0.46-1.0 mm).

Keywords: Adsorption; coagulation-flocculation; filtration; textile wastewater

INTRODUCTION

Pollution is a great concern for a sustainable future development. Water pollution is one of the key elements of this pollution (Gupta and Suhas, 2009). Severe pollution of this water is causing serious health consequences in the neighborhood, damaging fertility of the agricultural land, killing fishes and aquatic lives (Tareq and Khan, 2009). Being a riverine country, Bangladesh is largely dependent on this surface water. Therefore, preserving the clean surface water is crucial for the safety of the population and to some extent it is a matter of global concern. Many issues are responsible for surface water pollution in Bangladesh such as the chemical processing industries like tannery, paper, food, chemical, pharmaceutical and the textile processing industry. These industries are all discharging into our river network.

In order to maintain and improve the quality of the environment through preventing industrial pollution, a paradigm change in conventional effluent treatment system of different industries is necessary. There are many conventional and modified technologies are being applied to treat the effluents coming out of various industries in Bangladesh, however, very few of them have shown to be successful until now (Ranganathan, et al., 2007). Lack of knowledge, lack of the right technology and lack of proper study of the effluent quality are one of the few major reasons behind the failure of existing effluent treatment systems. Moreover, nowadays, the wide expansion of different industries like textile, pharmaceutical and tannery are seating as a tumour in a rural area. This unplanned expansion is deteriorating the rural ecosystem. Therefore, it is a great challenge to protect the rural ecosystem in the near future from these industrial pollutions.

METHODOLOGY

Preparing synthetic wastewater with different types of textile dyes to be used in the tests was not feasible. Therefore, the effluent from the existing ETP plant of Masco Textile Industries Ltd was preferred. Eighty litres (80 L) of wastewater was collected from the outlet of the secondary clarifier of the existing effluent treatment plant at Masco. It was kept at 4°C in a cold room at the laboratory in

order to avoid biological degradation of the sample during the laboratory work. After that, the effluent sample was characterized to generate the baseline data for this study. Therefore, the following parameters were measured: Temperature, pH, Biochemical Oxygen Demand (BOD₅), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Dissolved Oxygen (DO), Total Dissolved Solids (TDS) and colour. The following flow diagram explains the entire research methodology at a glance (Fig. 1).

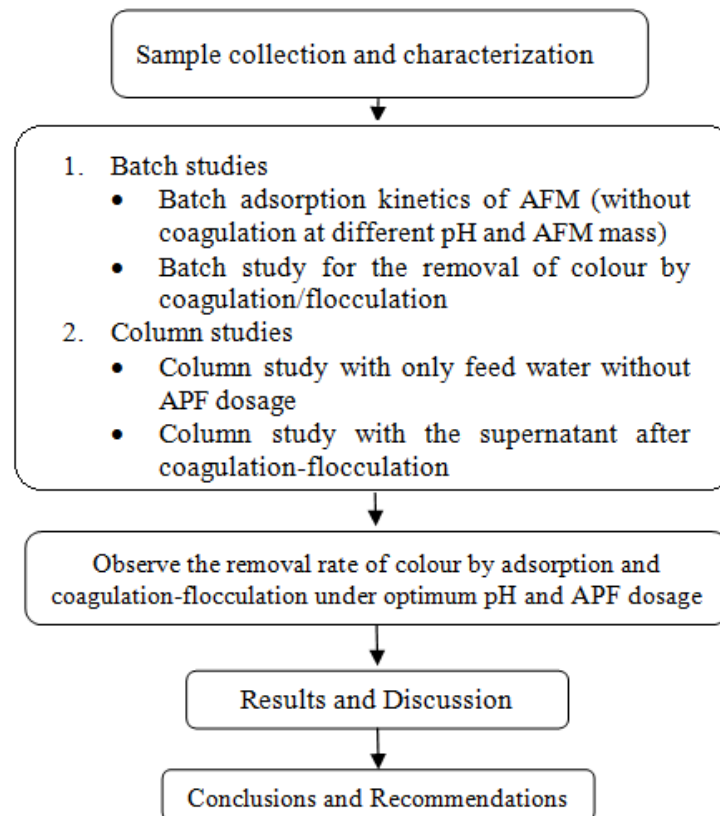


Fig. 1: Flow diagram of the research methodology

Batch Studies

Batch experiments were carried out using different masses of AFM grains and a fixed volume (100 ml) of feed water (the effluent sample collected from the outlet point of the secondary clarifier). In addition, the adsorption test was performed at a constant pH (7.81) as found in the sample (without adjusting) at a constant agitation rate (150 rpm) under ambient temperature (12 to 24.4°C). Moreover, the pH and initial colour of feed water were measured every time just before running the batch. Then the batch adsorption was observed at 24, 48 and 72 hrs. The main intention of this batch experiment was to measure the adsorption of colour compounds at a fixed pH (without adjusting pH of the feed water). Furthermore, the effect of adsorbent dosage was observed on the removal by measuring different AFM mass and equilibrium dye concentration.

Column Studies

The adsorption capacity of AFM grains was studied via the batch experiments. However, it will not be sufficient to understand the actual behaviour of the AFM, because AFM used in a pressurized tank in the real treatment system, where the pollutants, such as organic particles, heavy metals and colour compounds are expected to be removed by two mechanisms: mechanical filtration (those are formed as bigger floc by coagulation-flocculation) and electro-static adsorption. In this case, the pressure is governed by the incoming flow rate and therefore, column tests were performed in order to understand the effect of different flow rates on the removal efficiency using AFM grains. Moreover, the sample

feed water (without APF¹ dosage) and supernatant (after coagulation and flocculation with APF dosage) were used to pass through the column (Fig. 2) under two different operational conditions. Those conditions for column study are as follows:

- only feed water without applying pressure and APF dosing was used in order to observe the adsorption of colour compounds present in the feed water
- the supernatant after APF dosing and without applying pressure was used in order to observe the competitive adsorption of dyes (at the optimum coagulant dosage and pH previously found)

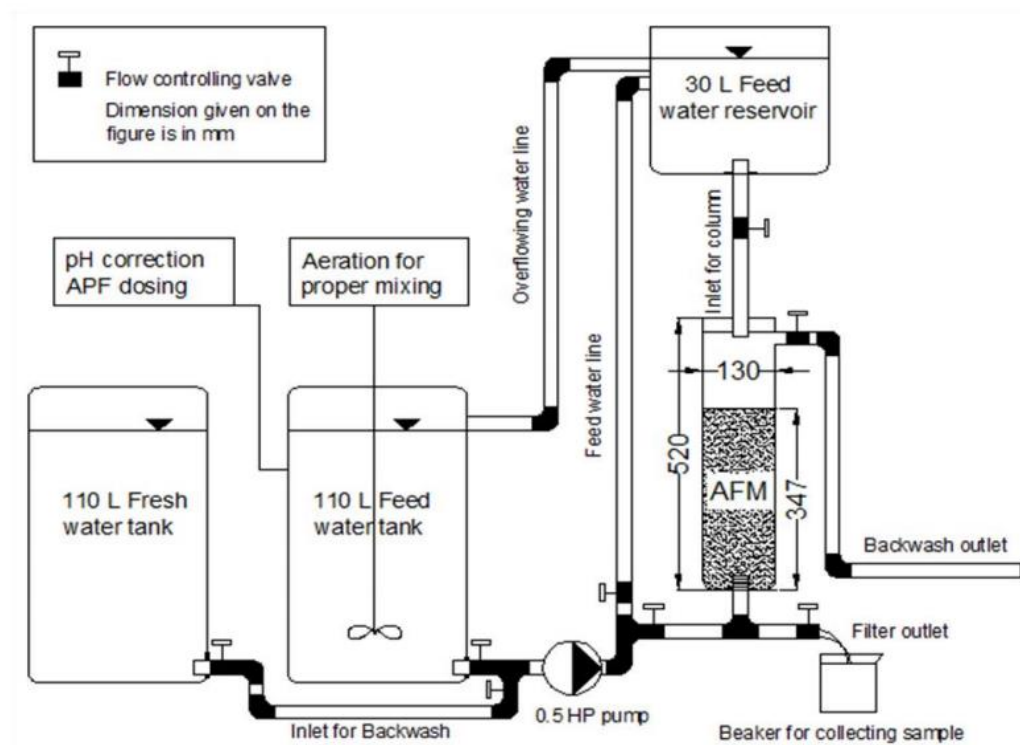


Fig. 2: Schematic of the column set-up at the laboratory

RESULTS AND DISCUSSIONS

Characteristics of the collected sample

In order to characterize the wastewater sample, the following tests had been carried out (Table 1) at the local laboratory of Biovista Bangladesh Ltd. and ICDDR,B². The main intention of this characterization of the textile wastewater was to determine the quality of the feed wastewater. As the location of the sampling point was after the secondary clarifier, BOD and COD removal was expected because the effluent was coming to the secondary clarifier after receiving biological treatment (Activated Sludge). One of the problems was the low dissolved oxygen level in the effluent. In addition, the high TDS value often went beyond the standard because the dying process involved lots of salts (Joshi and Bansal, 2004). Moreover, colour is not an issue for the Department of Environment (DoE) in Bangladesh, but for the international buyers it is a requirement to keep the colour below 150 Pt. Co. So the existing treatment plant at Masco has to solve the problem of the coloured effluent as the amount of colour compounds present in the final effluent is much higher than the discharged standard, recommended by the international buyers (Table 1).

¹ APF—All Poly Floc, a mixer of polyelectrolyte used as a flocculent which is a product of Dryden Aqua Ltd.

² ICDDR,B— International Centre for Diarrhoeal Disease Research, Bangladesh

Table 1 Characteristics of sample wastewater (sampling point: after secondary clarifier)

Date of Sampling	Temp. (°C)	BOD ₅ (ppm)	COD (ppm)	DO (ppm)	TDS (ppm)	TSS (ppm)	pH	Apparent Colour (Pt. Co.)
17/Dec/2014	31	28	96	4.1	1700	150	7.85	329
Bangladesh Standard	-	≤50	≤200	4.5-8.0	≤2100	-	6.0-9.0	-

Batch Adsorption Test for AFM

The batch adsorption test for AFM shows that the AFM filter media has no significant adsorption capacity (without APF dosing) to remove colour compounds from the textile wastewater. The removal of colour compounds was also not observed visually before and after the batch adsorption test. But the measured values differ slightly, which shows a little change before and after the batch test.

The initial colour concentration was 329 Pt.Co. in the feed water measured at site (Table 1). Before conducting the batch at the Biovista's laboratory (one day later), it was measured as 307 Pt.Co. and after the batch test (total 9 days, because the shaker machine had the maximum capacity to hold 6 bottles at a time), the colour concentration found at 282 Pt.Co. in the blank sample. Therefore, the natural degradation of dyes (including all other constituents present) in the feed water was observed at 8% as shown in the graph (Fig. 3). It clearly indicates that there is a natural degradation of colour compounds under the laboratory temperature (12-24.4 °C) though, there was no adsorbent dosed into the feed water sample.

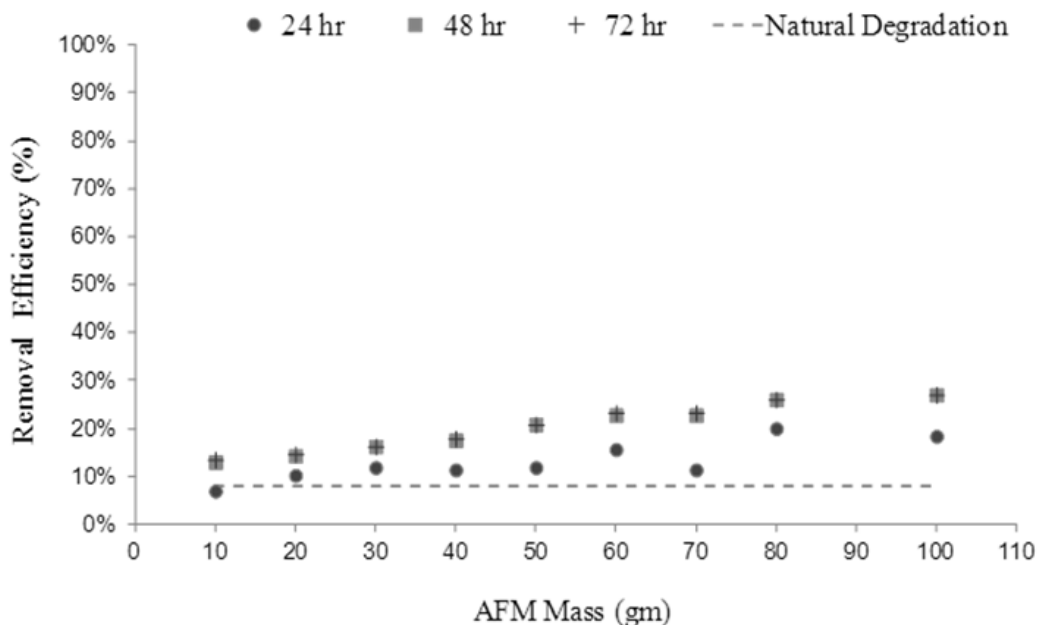


Fig. 3: Batch adsorption test for activated filter media

Column experiment with different flow rates (without coagulation-flocculation)

The column was run under three different flow rates: 120, 220 and 350 ml/min (Fig. 4). For the first two flow rates F1 and F2 were 120 and 220 ml/min, respectively. And, the removal rates for both cases were observed quite good (59%, where the initial colour was 184 Pt.Co. in the feed supernatant) but for 350ml/min, it was low (below 10%). Therefore, it is very clear that there is an effect of flow rate on the performance of the AFM filter media to remove colour. However, when comparing this above graph with Fig. 4, it can be seen that the removal of colour observed with supernatant is higher than that of with only feed water (without APF dosage). This is may be due to the very fine flocs that are remained

suspended with supernatant and are retained in the filter. However, the removal efficiency was only for the first 10 minutes of the column operation (Fig. 4), and at lower flow rates.

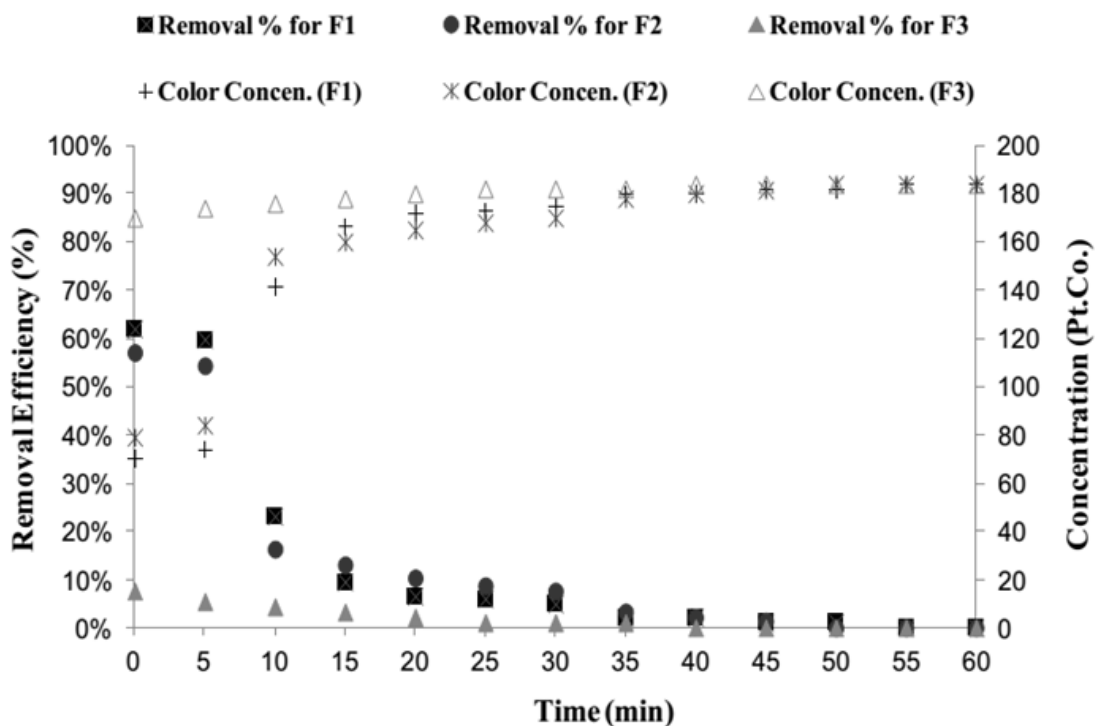


Fig. 4: Breakthrough curve for AFM with the supernatant (at different flow rates)

Column Experiment (supernatant after the coagulation-flocculation)

The initial colour was measured as 412 Pt. Co. in the feed water before coagulation (with different feed water collected at that particular day, but for the same ETP plant). After 20 hrs of retention time, the colour concentration in the supernatant was 184 Pt. Co. So, the removal rate was quite good (62%) by coagulation-flocculation process using APF as coagulant. The long retention time was needed as the floc took longer time to settle at the bottom, than for the batch test in the laboratory (4 hrs). It must be mentioned that the feed sample was different for different days; therefore, the initial colour concentration and removal efficiencies are different for each day. So, the column test was conducted at site with the feed sample that was produced daily at the existing effluent treatment plant.

Performance evaluation with alternative filter medium: AFM Vs local sand

Local sand was used for the filtration of the supernatant after coagulation-flocculation. In the Fig. 5, it can be seen that the removal of colour using sand was around 84% (from 119 to 19 Pt.Co.) at the very beginning, while it was for AFM around 86% (from 119 to 17 Pt.Co.). But, it declines very sharply within 10 minutes and reaches to 38% and 19% for sand and AFM, respectively. At the beginning, the peak was observed with more than 80%, due to the small amount of fresh water present in the filter bed. However, the fine sand (size: 0.125 to 0.25 mm) shows better removal than AFM grade-1 (size: 0.46 to 1 mm). Although, it was not possible to measure the actual pore size of the local sand at site but it seems quite smaller than 40 microns, that was known for the AFM grade-1 ([AFM specifications](#)). Only a single grade of AFM media (due to availability in the lab) was used, while two different grades of local sand were used in this column experiment. As a result, the fine sand retained finer flocs than AFM grade-1.

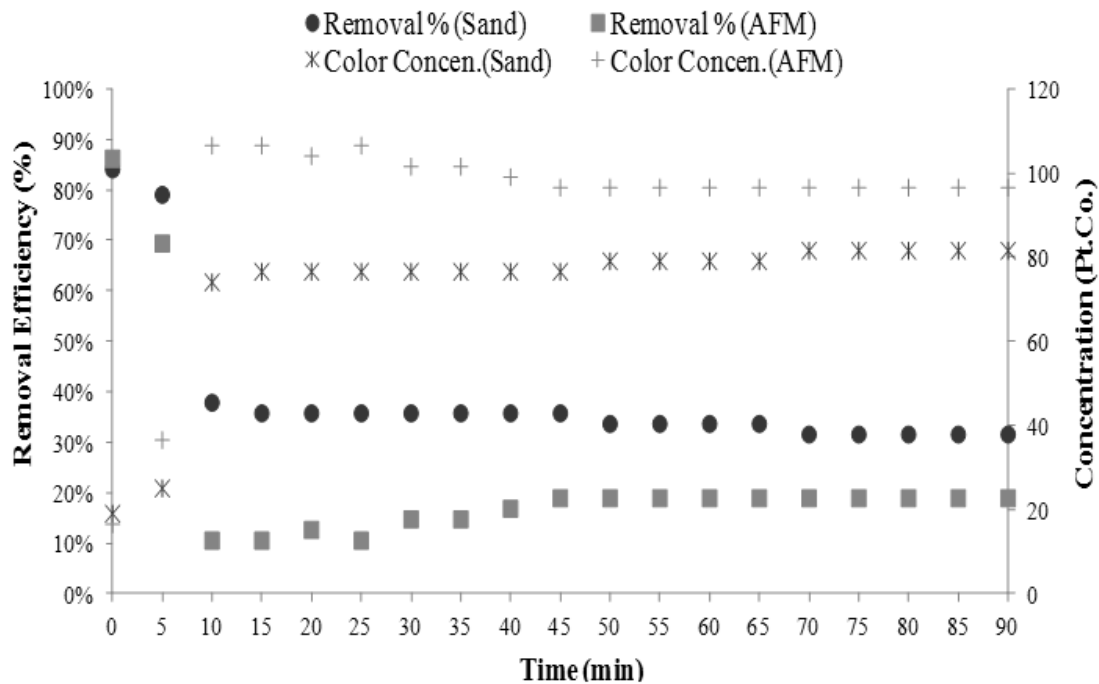


Fig. 5: Performance evaluations of the local sand and AFM as filter media

CONCLUSION

Based on the laboratory studies (both batch and column) at Masco Industries Ltd, it can be concluded that AFM system is not a suitable option as a tertiary treatment unit to remove colour from textile wastewater (after biological treatment). In addition, the AFM media has no significant adsorption capacity (with and without APF dosing). Moreover, significant result was achieved using local sand as filter media in order to remove fine flocs developed by APF flocculent at the tertiary level. But, in a long run sand might get affected due to bacteria present in the wastewater. That is why future study is essential to identify the appropriate filter media in order to polish textile wastewater at the tertiary level.

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