TREATMENT OF MUNICIPAL WASTEWATER BY USING LOCALLY AVAILABLE MATERIALS AS COAGULANTS

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ABSTRACT

Water quality remains one of the most significant environmental issues. Especially surface water contains both dissolved, suspended and colloidal particles. In wastewater treatment, coagulation has been practiced since earliest times to remove colloidal impurities and turbidity. Nowadays, there has been great attention in the improvement and implementation of natural coagulants in wastewater treatment for their least cost. In the present study, wastewater collected from different locations of municipal primary drain in Rajshahi City were tested for various physical and chemical parameters to characterize. An attempt has been taken to check how natural coagulants such as Acacia nilotica, Moringa oleifera, banana stem, banana peels and Ficus carcia can remove the TDS, TSS and turbidity from wastewater through coagulation process at its optimum conditions so that this treated water becomes suitable to safely discharge into river or directly use for irrigation. Based on the experimental results, it is found that the maximum removal of TSS, TDS and turbidity are obtained 75.65% by banana stem, 65.27% by Ficus carcia and 96.42% by banana stem respectively. Therefore, it could be concluded that further study might improve the impurities removal efficiency.

Keywords: *natural coagulants, turbidity, impurities, dissolved and suspended particles*

1. INTRODUCTION

Everyday huge quantity of wastewater is producing in municipal area and discharge without treatment of this wastewater in the natural receiving bodies creates environmental hazard. Municipal wastewater is a combination of different types of wastewaters originating from the sanitary system of commercial housing, industrial facilities and institutions, in addition to any groundwater, surface water and storm water that may be present (Al-Sarawy, et al., 2001.). The municipal wastewater usually contains numerous pathogenic microorganisms, heavy metals, toxic compounds, suspended solids, nutrients and some other organic materials (Devi, et al., 2008). It kills fish, blooms algal and increases the eutrophication and bacterial contamination (Clescerl, et al., 2001). To control the environmental and health hazards, municipal wastewater must immediately be treated appropriately before final disposal. The ultimate goal of wastewater management is the protection of the environment with public health and socio-economic concerns (Clescerl, et al., 2001). Different wastewater treatment technologies are used worldwide. Each one has its advantages and disadvantages in terms of construction costs, operational costs, energy consumption, operational complexity, effluent quality, reliability, land requirements, and environmental impact. Recently some modern technologies were reported for waste water treatment like up flow anaerobic sludge blanket (USAB) (Tawfik, et al., 2006; Axberg, et al., 1980; Camp, 1973), multi stage bubble column reactor (El-Hallwany, 2005), sequential batch reactor (SBR) (EPA, 2004), fixed film anaerobic filter (AF) (Renault, 2009), expanded granular sludge bed (EGSB), which is a modification to UASB (Heber, 1985), up flow septic tank/baffled reactor (USBR) (Yu, et al., 2010), submerged membrane hybrid system (Sahu, et al., 2009), anaerobic-anoxic-aerobic bioreactor (Kemira, 1990).

Coagulation-flocculation is one of the chemical treatment processes commonly used for water and wastewater. It has a wide range of application in water and wastewater facilities because it is efficient and simple to operate (Wang, et al., 2007; Zheng et al., 2011). The mechanism of Brownian movement in wastewater where there is a repulsion of negatively charged surfaces to form a stable dispersed suspension was reported (Bache, et al., 1999). Coagulant is a chemical used that is added to the water or wastewater to withdraw the forces that stabilizes the colloidal particles and causing the particles to suspend in the water. Once the coagulant is introduced in the water, the individual colloids must aggregate and grow bigger so that the impurities can be settled down at the bottom of the beaker and separated from the water suspension. Hence nowadays, there has been great attention in the improvement and implementation of natural coagulants in wastewater treatment (Saharudin and Nithyanandam, 2014).

Natural coagulants are mostly carbohydrates (polysaccharides) and proteins Rodiño-Arguello, et al., 2015). These natural coagulants can be formed or extracted from animal, microorganisms and also plant. Natural coagulants usage is profitable in wastewater treatment since the treatment cost is low, the steady pH levels in the treated water and because they are highly biodegradable. The application of natural coagulants is based on their traditional use in tropical, rural areas (Prodanović, et al., 2013). A prime concern of the environmental engineer today is how to lower the coagulants cost (Abdelaal, 2004). Therefore, the aim of this study is to find out the suitable natural coagulant for the treatment of wastewater.

2. METHODOLOGY

2.1 Materials Collection and Preparation

The plant based natural coagulants such as *Acacia nilotica*, Moringa oleifera, banana stem, banana peels and *Ficus carcia* were used as coagulant to avoid the drawbacks of chemical coagulation. The five coagulants used are shown in Figure 1.

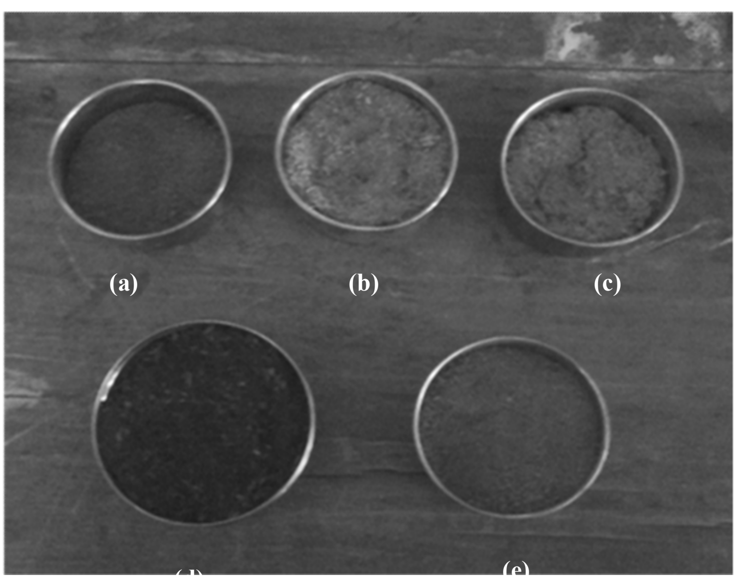


Figure 1: Natural coagulants: (a) Banana peels, (b) Banana stem, c) *Moringa oleifera*, d) *Acacia nilotica* and (e) *Ficus carcia*

2.2 Wastewater Sample Collection and Characterization

Wastewater samples were collected from five different primary drains located near Padma garden, Suvo filling station, Dorgapara, Barnali and Talaimari within Rajshahi City Corporation area. Representative wastewater samples were collected in PET bottle in sufficient quantity by following standard procedure. All the samples were brought as early as possible to the laboratory and kept in chiller below 4°C temperature to protect from the physical, chemical and biological changes. The laboratory analysis was conducted on a regular basis. The collected Wastewater samples were characterized before going for treatment. The characteristics of all samples were determined based on TDS, TSS, turbidity, pH, alkalinity and conductivity.

2.3 Experimental Instruments

The turbidity values of the wastewater sample were measured by using a turbidity meter (Turbidimeter-TN-100) from Eutech Instrument. The pH values of the wastewater samples were measured by using DZB-718 Multi-Parameter Analyzer. The conductivity values of the samples were measured by HACH conductivity meter. The bench top Jar-Tester (Model: SF6 and power 220V, 50Hz) was used for coagulation experiment (Figure 2).

Figure 2: Jar-Tester (Flooculators)

2.4 Treatment

Based on the characterization results, the worst wastewater samples were selected for treatment using different natural coagulations separately. The treatment process was divided into two parts and these are variation in coagulant doses and variation in contact time.

2.4.1 Dose Variation

Different 5 coagulants (*Ficus carcia*, banana stem, banana peels, *Acacia nilotica*, *Moringa oleifera*) were used with the same variations of doses separately as batch wise. Treatments were carried out in triplicate for each condition. Wastewater samples of 100 ml were taken in 500 ml flask. The coagulant doses were varied as 25 mg/l, 50 mg/l, 75mg/l, 100 mg/l and 125 mg/l while contact time and stirring speed were maintained of 30 minutes and 70 rpm, respectively. The flask was placed in the Jar-Tester flocculator (Model: SF6) for coagulation and flocculation. After 30 minutes, the flasks were removed from the machine and kept for sedimentation. The supernatant was tested for TDS, TSS and turbidity and percentage removal was determined.

2.4.2 Contact Time Variation

Similar to dose variation one-factor-at-a-time method was used in case of contact time variation. The contact time was varies as 10 minutes, 20 minutes, 30 minutes, 40 minutes and 50 minutes while coagulant dose was kept fixed at 75m g/l and stirring speed at 70 rpm.

3. RESULTS AND DISCUSSION

Characterization experiments were carried out for raw wastewater to determine the strength of pollutants. The highly polluted sample was selected for treatment to remove the total suspended solids, total dissolved solids and turbidity through coagulation process with locally available natural materials. The results are presented and discussed in the following sections.

3.1 Characteristics of Raw Wastewater

The collected wastewater was characterized on the based on TDS, TSS, turbidity, pH, alkalinity and conductivity. The results are presented in Table 1.

Table 1: Characteristics of raw wastewater collected from different municipal drains

Sampling location	TDS (mg/l)	TSS (mg/l)	Turbidity (NTU)	pH	Alkalinity (mg/l)	Conductivity (micro-mohoes/cm)
Padma garden	1100	100	31.00	6.08	240	2025
Suvo filling station	912	88	27.10	6.85	215	1800
Dorgapara	633	77	16.48	7.11	230	1900
Bornali	829	71	25.71	7.14	220	1950
Talaimari	740	60	22.90	7.45	225	2025

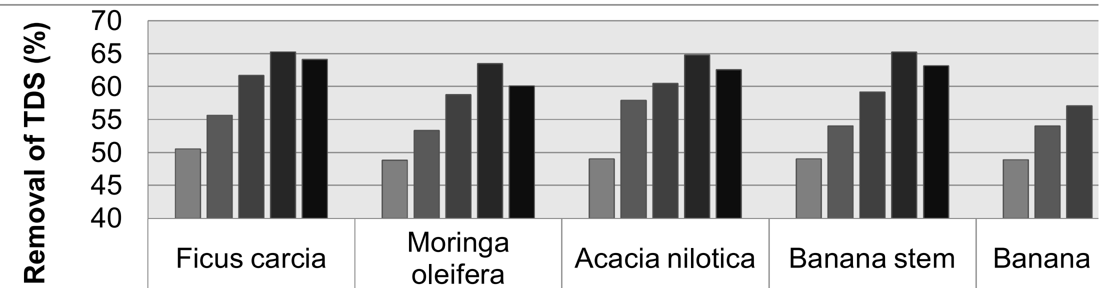
The dissolved solids, suspended solids, turbidity, pH, alkalinity and conductivity vary from 633 to 1100 mg/l, 60 to 100 mg/l, 16.48 to 31.00 NTU, 6.08 to 7.45, 215 to 240 mg/l and 1800 to 2015 micro-mohoes/cm, respectively. From the results it is revealed that the pollutants levels are varying in wide ranges from drain to drain. It might be due the source of wastewater, velocity of flow, interval of cleaning of drain, sampling location and surroundings. During the sampling it was observed that most of the cases the flow is almost laminar and solid were deposited at the bottom of the drains. Considering the all parameters, it is found that sample collected from the primary drain near the Padma garden is more polluted compared to others.

3.2 Treatment of Wastewater

The treatment was carried out to reduce the concentration of pollutants. The treatment efficiency was determined based on removal of TDS, TSS and turbidity. The effects of coagulant doses and contact time on the removal of these pollutants were examined. The performance of each natural material was also evaluated. The results are discussed in the following sections.

3.1.1 Effect of doses of coagulants

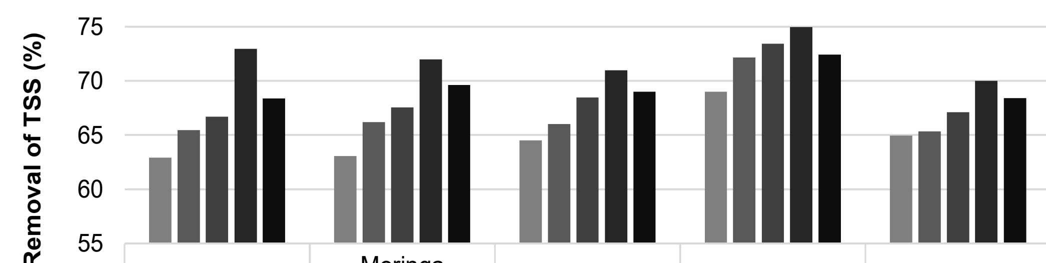
Effects of varying doses of different coagulants on TDS, TSS and turbidity are shown in Figure 3 to 5. The other parameters, contact time and stirring speed were maintained at 30 minutes and 70 rpm, respectively.



	Ficus carcia	Moringa oleifera	Acacia nilotica	Banana stem	Banana
25mg/l	51	49	49	49	49
50mg/l	56	53	58	54	54
75mg/l	62	59	60	59	57
100mg/l	65	63	65	65	64

Figure 3: Removal of TDS with variation of different coagulant doses

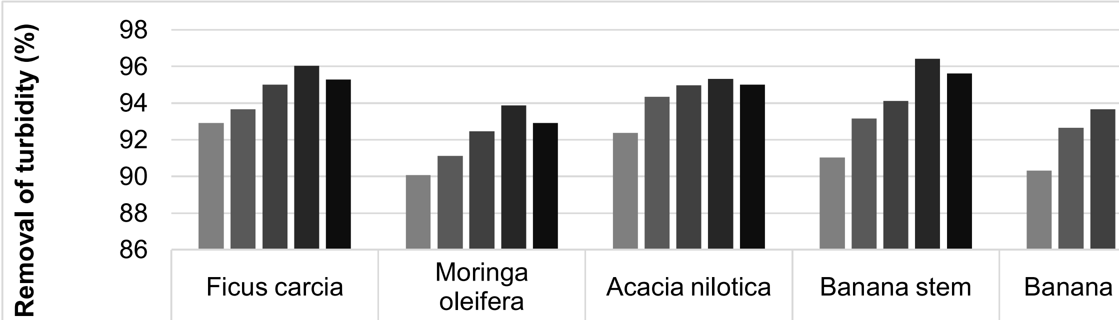
From Figure 3 it is observed that all the coagulants are capable to remove dissolved solids and removal capacity of coagulants is also almost same in every dose level. The highest removal was obtained with 100 mg/l of coagulant dose for every coagulant. The highest removal of 65% (717.97 mg/l) was achieved with *Ficus carcia*, *Acacia nilotica* and Banana stem. It can be clearly understand from the trend of dissolved solid removals that the removal is increasing with increase of coagulant doses and reached the highest at 100 mg/l of coagulant dose. However, further addition of coagulant decreased the removal which means that 100 mg/l could be the optimum dose for removal of dissolved solids from municipal wastewater.



	Ficus carcia	Moringa oleifera	Acacia nilotica	Banana stem	Banana peels
25mg/l	63	63	65	69	65
50mg/l	65	66	66	72	65
75mg/l	67	68	68	73	67
100mg/l	73	72	71	75	70
125mg/l	68	70	69	72	68

Figure 4: Removal of TSS with variation of different coagulant doses

Figure 4 shows the removal capacity of suspended solids from wastewater by different coagulants. Similar trend of removal is also observed for suspended solids in all coagulants. Total Suspended solid of the sample is reduced considerably. Here also the highest removal was achieved with 100 mg/l of coagulant dose for all cases. The highest removal of 75% (74.96 mg/l) of suspended solids was obtained with banana stem followed by 73% by *Ficus carcia*, 72% by *Moringa oleifera*, 71% *Acacia nilotica* and 70% by banana peels.



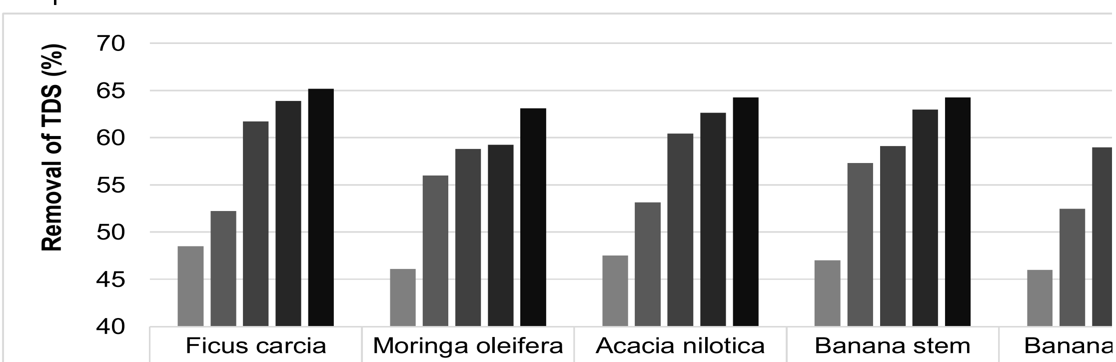
	Ficus carcia	Moringa oleifera	Acacia nilotica	Banana stem	Banana
25mg/l	92.9	90.07	92.38	91.04	90.3
50mg/l	93.67	91.13	94.34	93.17	92.6
75mg/l	95	92.45	94.98	94.12	93.6
100mg/l	96.04	93.87	95.31	96.42	94.4

Figure 5: Removal of turbidity with variation of different coagulant doses

Turbidity of the sample is reduced considerably, being highest 1.10 NTU (96.42 %) at 100 mg/l dose for banana stem coagulant and it is within maximum permissible limit. Optimum dose found is 100 mg/l following the same removal trend with variation of doses.

3.1.2 Effect of contact time

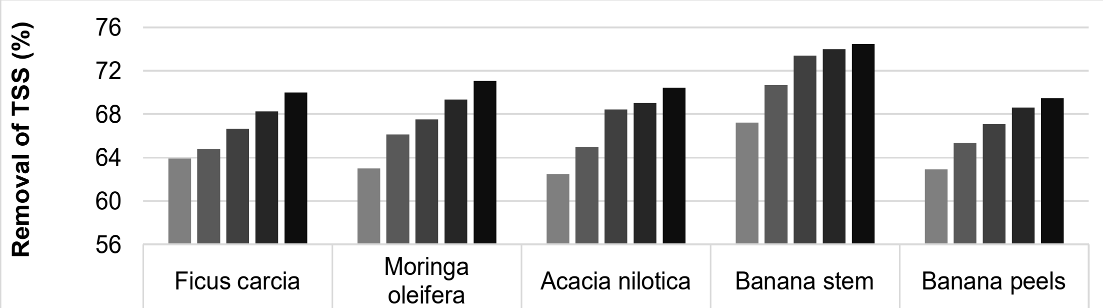
Contact time is an important parameter for coagulation process. Contact was varied from 10 minute to 50 minutes at an interval of 10 minutes. The removal of TDS, TSS and turbidity with respect to contact time with different coagulants are presented in Figure 6 to 8 where coagulant dose and stirring speed were maintained at 75 mg/l and 70 rpm, respectively as fixed parameters.



	Ficus carcia	Moringa oleifera	Acacia nilotica	Banana stem	Banana
10 min	49	46	48	47	4
20 min	52	56	53	57	5
30 min	62	59	60	59	5
40 min	64	59	63	63	6
50 min	65	63	64	64	6

Figure 6: Removal of TDS with variation of contact time for different coagulants

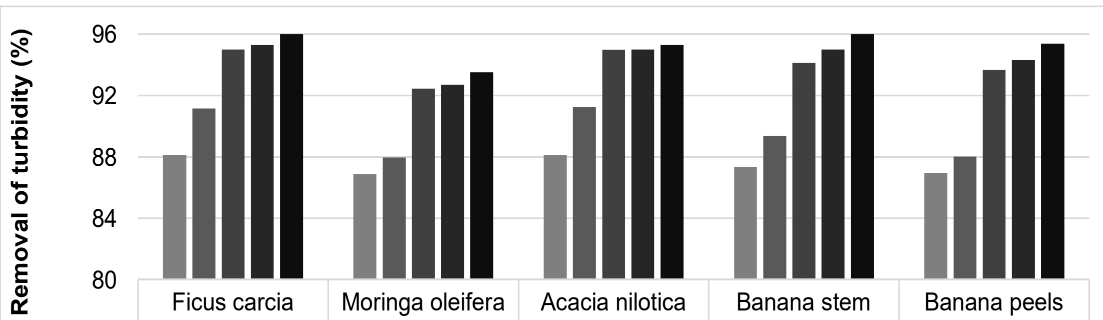
Total dissolved solid of the sample is reduced considerably, being highest 709.5 mg/l (65%) for 50 minutes for *Ficus Carcia* coagulant which is within maximum permissible limit. However, it is remarkable that the incremental rate of removal is very insignificant after 30 minutes of contact time. Therefore, it would better to consider the other parameters and interactive effect in removing dissolved solids to find out the optimum contact time.



	Ficus carcia	Moringa oleifera	Acacia nilotica	Banana stem	Banana peels
10 min	64	63	62	67	63
20 min	65	66	65	71	65
30 min	67	68	68	73	67
40 min	68	69	69	74	69
50 min	70	71	70	74	69

Figure 7: Removal of TSS with variation of contact time for different coagulants

Total Suspended solid of the sample is reduced considerably, being highest 75.68 mg/l (74%) for 50 minutes of contact time with Banana stem coagulant and it is within maximum permissible limit. Similar to dissolved solids removal suspended solids removal is also increasing with increase of time but not significant.



	Ficus carcia	Moringa oleifera	Acacia nilotica	Banana stem	Banana peels
10 min	88	87	88	87	87
20 min	91	88	91	89	88
30 min	95	92	95	94	94
40 min	95	93	95	95	94
50 min	96	94	95	96	95

Figure 8: Removal of turbidity with variation of contact time for different coagulants

From Figure 8 it can be said that effect of contact time on removal of turbidity is insignificant after 30 minutes. Turbidity from wastewater sample is reduced considerably being highest 1.24 NTU (96%) for 50 minutes for *Ficus carcia* and Banana stem coagulants. From this treatment, turbidity can be possible to reduce within maximum permissible limit and can be used for irrigation or discharging to the natural receiving bodies.

4. CONCLUSIONS

It could be concluded from the obtained results that municipal wastewater of Rajshahi City Corporation area is highly turbid (16.5 to 31 NTU) due to the presence of large amount of suspended and dissolved solids. In this study, about 65% removal of TDS, 75% removal of TSS and 96% removal of turbidity was achieved. Therefore, all five selected materials *Moringa oleifera*, *Acacia nilotica*, *Ficus Carcia*, banana stem and banana peels are found to be potential coagulants for the treatment of municipal wastewater of Rajshahi city. The optimum dose and time is obtained to be of 100 mg/l and 50 minutes for all types of materials used as coagulants for the maximum removal of TSS, TDS and turbidity.

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