APPLICATION OF NATURAL CLAYS AND POLY ALUMINIUM CHLORIDE (PAC) FOR WASTEWATER TREATMENT

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ABSTRACT
Release of wastewater into the environment due to anthropogenic industrial or commercial activities is an emerging challenge for developing countries. This study was conducted to investigate the use of two kinds of available clay coagulants namely Shendi and Singa, and their combination with Poly Aluminium Chloride (PAC) for wastewater treatment. The experiments were designed in Completely Randomized Design (CRD) in three replicates using jar test apparatus for coagulation-flocculation process. The efficiency was calculated by evaluating turbidity, COD, and colour removal. The removal efficiency for PAC and its combined use with Shendi and Singa for turbidity was 96.2%, 94.8%, and 95.7%, for COD was 70.7%, 63.2%, and 61.1% and for colour removal was 82.1%, 78.1% and 80.7% respectively. While the efficiency of sole use of Shendi and Singa for turbidity was 59.2% and 27.9%, for COD was 26.3% and 28.1% and for colour was 26.3% and 10.3% respectively.

Keywords: *Coagulation-flocculation, wastewater treatment, turbidity removal, COD reduction*

1. INTRODUCTION
In most of the big cities in Sudan, industries and agricultural schemes are established on the banks of river Nile and its tributaries. These establishments are representing the major sources of contaminants to water bodies. The discharge of most of those establishments don't receive any treatment and it goes directly to water bodies, this situation becomes more dangerous in rain season, where rainfall leaches all harmful and toxic matters from upstream to water downstream. Treating industrial sewages and wastewater is a challenge facing the country due to high cost of the chemical coagulants. However, there are many local natural materials such as Moringa and some kinds of clay soils known locally as Ruwage that are being used by local people for water treatment.
Use of clay in water and wastewater treatment has been investigated by many research studies; [1] found that addition of Bentonite to raw water performed effectively at temperature 20-37C and pH < 8. [2] used Bentonite as absorbent material for treating municipal wastewater, and they found that COD decreased to < 20mg/L. [3] reported that organic particles can be absorbed by clay minerals and therefore clays can be used for wastewater treatment. [4] investigated the effect of clay as coagulant aid with alum in industrial wastewater of paper, and they found that the combined use of clay and alum is more efficient in colour removal than using alum alone. [5]. reported that Bentonite can perform effectively at removing certain cationic components from wastewater and it can be used for treating waters containing heavy color and low turbidity. Recently [6] proved that ruwage performed efficiently at different levels of turbidity and wide range of pH (3-10).
On the other hand chemical coagulants are intensively and increasingly used at wastewater treatments plants, among which is Ploy Aluminum Chloride (PAC), which is characterized by various advantages such as working in wide range of pH and low temperatures and significant efficiency at low concentrations comparing to other conventional coagulants based on Al- or Fe(III) chlorides and sulfates [7].
The huge discharge of industrial, municipal and drainage wastewater from cities, factories and agricultural schemes in Sudan into river Nile and its tributaries with limited or no treatments in addition to the cost of the chemical coagulants are representing the main environmental challenges facing the country. To provide a possible solution, this study was conducted to investigate the effect of two clay soils as abundant natural coagulants and their combination with PAC to remove turbidity, COD, and color from wastewater, which will minimize the treatment cost.

2. MATERIALS AND METHODS

2.1. Jar Test
A conventional jar test apparatus was used in the experiments to coagulate sample of the wastewater collected from wastewater plant in shanghai by using clay soil coagulants and Poly Aluminum Chloride. The pH of the wastewater sample was adjusted at 7.2 by adding either H2SO4 or NaOH. The desired dosages of clay soil coagulants, PAC and

their combination were added to the beakers of jar test apparatus containing 100 ml of wastewater in each. The beakers were agitated at 150 rpm for 1 minute and then reduced to 40 and 20 rpm/minute for 7.5 minutes for each speed. The suspension of the samples was allowed to settle for 30 minutes. Samples of treated wastewater was taken from the mid depth of the each beaker for analyzing turbidity, COD, colour and pH. The dosage of PAC applied was 30 mg.L-1 and 400mg.L-1 for Shendi and Singa clay coagulants and for combined use, half dosage of each was applied.

2.2. Characteristics of wastewater

The collected sample of the wastewater was mixed homogeneously, and then analyzed for turbidity, COD, colour and pH. Chemical characteristics of the raw wastewater are given in Table 1.

Table 1: Characteristics of water

Parameter	Value
Turbidity	46.8 NTU
pH	7.3
Electrical conductivity (E.C)	359 µS/cm
COD	47.15 $mg.L^{-1}$
Temperature	28.6 ^oC
Colour	0.484 UV263 nm-abs (cm^{-1})

2.3. Analytical method

The COD of wastewater was calculated using HACH COD low range (3-150 mg/L), one ml from each sample was added to prepackaged low range COD vials and then heated in a COD reactor at 150 °C for 2 h. The reacted mixture in the vials was cooled to a room temperature, and the absorbance of COD solution was measured using a spectrophotometer at a wavelength of 440 nm.

Turbidity was measured by using turbidity meter (Model-2100 P, HACH, USA). The pH value was determined by using a pH meter (Model-sensION2, HACH, USA).

Colour was determined using Simadzu UV visible spectrophotometer, model-1700 (Japan), the absorbance of the samples of treated wastewater was measured in triplicate at 263 nm.

The removal efficiency of turbidity, COD and colour was calculated according to the following formula:

Removal efficiency (%)=((Ci-Cf)/Ci)*100 (1)

Where:

Ci : Initial concentration of the parameter ($mg.L^{-1}$)

Cf: final concentration of the parameter ($mg.L^{-1}$)

3. RESULTS AND DISSCUSSION

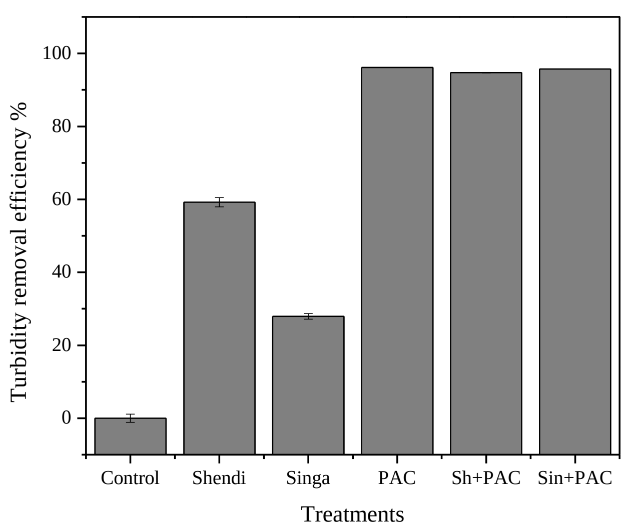

Figure 1: Effect of PAC, clay soil coagulants and their combinations on turbidity removal efficiency

The effect of PAC and soil coagulants was investigated by comparing treatments using PAC and clay coagulants individually and their combination using half dose of each. Fig1shows turbidity removal efficiency in which, PAC and the its combined use with Shendi and Singa clay coagulants performed effectively and the removal efficiency was 96.2%, 94.8%, and 95.7% to attain final turbidity 1.8 NTU , 2.5NTU , and 2 NTU for PAC, Shendi and Singa respectively, while the efficiency of single use of shendi and Singa was only 59.2% and 27.9% to attain final turbidity 19.1 NTU and 33.8 NTU respectively.

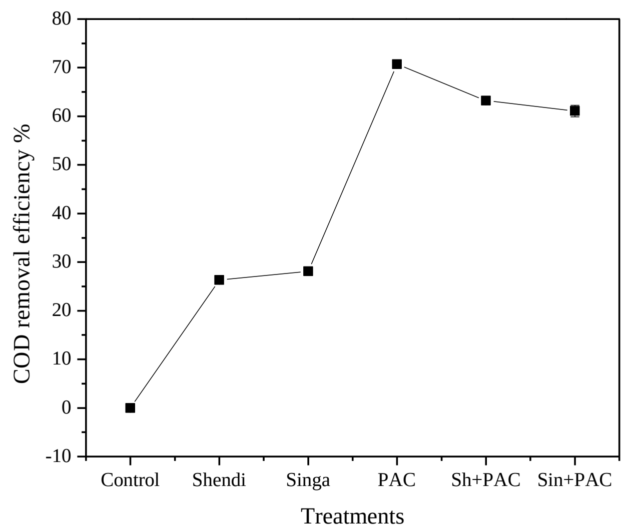

Figure 2: Removal of COD by PAC, clay soil coagulants and their combinations

Fig. 2 shows the COD removal efficiency, where, the highest removal was 70.7%, 63.2%, and 61.1% for PAC and its combined use with Shendi and Singa respectively, while the efficiency for single use of shendi and singa was 26.3% and 28.1% respectively.

The results presented in Fig. 2 showed that the quality of treated effluent of combined use of clay coagulants and PAC is quite satisfactory. These results indicated that clay coagulants could be used for treatment of such wastewaters without further treatment.

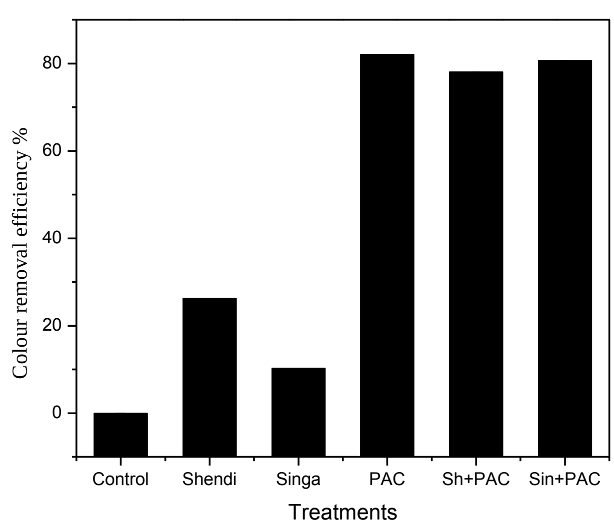

Figure3: effect of PAC, clay soil coagulants and their combinations on colour removal efficienc

Colour in water is either result of soluble chemical substances that cannot be separated by filtration or result of suspended and colloid matters that can be isolated by filtration [8]. The sources of wastewater always contain suspended materials with low density such as organic compounds that cause high rate of color in water.
The removal of the colour can be achieved by several methods including, filtration, adsorption using granulated and powder activated carbon, chemical oxidation, biological process and nanofiltration [9]. However, the coagulation and flocculation process can be used as a simple and accessible alternative method for people in developing countries.
Fig.3 shows the removal of colour from the wastewater, where PAC and its combined use with Shendi and Singa achieved maximum removal efficiency 82.1%, 78.1% and 80.7%, while the single use of Shendi and Singa was 26.3% and 10.3%. Single use of both clay coagulants have slight effect on colour removal, however, the combined use with PAC showed very effective performance similar to single use of PAC without any significant differences.

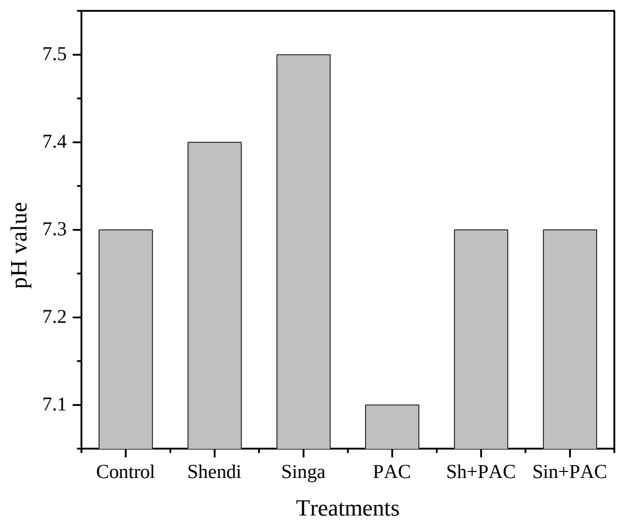

Figure 4: effect of PAC, clay soil coagulants and their combinations on the final pH of the treated wastewater

Coagulation- flocculation process is influenced by the pH value. Highly acidic coagulants may drive the pH down and consequently decrease the efficiency of the coagulation. However, clay coagulants work efficiently in wide range of pH (3-10) according to (Mohammed et al., 2013) and therefore can be used for wastewater treatment without adjusting the pH. As shown on Fig.4 the combined use of clay coagulants with PAC stabilized the pH of the treated wastewater same as the initial pH value, however, the sole use increased the pH slightly.

4. CONCLUSIONS

Sole use of clay coagulants showed limited efficiency in removal of pollutants from wastewater, whereas the combined use showed high removal efficiency comparable to that one achieved by PAC. Use of these clays as coagulants aid with PAC is beneficial and economical and can reduce the cost of the treatment considerably depending on the characteristics of the wastewaters.

5. ACKNOWLEDGEMENTS

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