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Cassia alata as a Potential Coagulant in Water Treatment

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Abstract

Cassia alata or locally known as "pokok gelenggang" is a wild legume species found in Kelantan. Cassia alata based coagulant-flocculant was tested for surface water collected from the Kelantan River. The plant leaves was used to test coagulant rate and dose. The turbidity and other physico-chemicals of surface water sample were measured before and after the jar-test by using portable instruments. Turbidimeter Hanna Model 2100P was used to measure turbidity, while, portable pH meter hand-held Model C535 was used to measure pH. Meanwhile, iron and manganese were measured by using spectrophotometer model DR 2800. Total suspended solids were analyzed using method used by Michaud. The experiments were carried out with coagulant dosage of 0.5, 1.0, 1.5, 2.0, 2.5 and 3 mL/L with the intervals of 0.5 mL/L. The results have shown that Cassia alata leaves can remove turbidity up to 93.33% at the optimal dosage of 1.0 mL/L. In addition, the potential of Cassia alata leaves to remove other pollutants presence in the river water like suspended solids, ferum, manganese and pH was also identified. On the other hand, the leaves of Cassia alata can remove suspended solids by 56.4% but not other parameters.

Keywords: *Cassia alata*, coagulant, dosage, alum, flocculation.

Introduction

Clean drinking water has become scarce nowadays due to poor land use management. Surface water was polluted by sewage, industrial water discharge and run off from the land clearing, while ground water was polluted by salt water intrusion and waste dumping site. This polluted water will have to go through treatment process before it can be circulated to the consumers for domestic use including for drinking. Drinking water treatment typically includes coagulation, sedimentation, filtration and disinfection[1]. Coagulation is a critical step in water treatment processes not only because it removes particles but because it is also removing other pollutants such as heavy metals and microorganisms that are often attached to the particles[2]. The addition of certain chemicals, the most common ones being alum ($AlCl_3$), ferric-chloride ($FeCl_3$) and polyaluminiumchloride (PAC), to the water to remove suspended particles is a must in drinking water treatment process. Although the efficacy of these chemicals as coagulants is well recognized, its application is not possible in poorer areas due to high cost and low availability of these products[3].

Aluminum sulfate (alum), produces large sludge volumes[4], reacts with natural alkalinity present in the water, leading to pH reduction[5], demonstrated low coagulation efficiency in cold water[6] and health side effect. There is strong evidence linking aluminium-based coagulants to the development of neurodegenerative illnesses as senile dementia[7] and with Alzheimer's disease in human being[8]. A study published in the Journal of the British Medical Association, involved an evaluation of the geographical relationship between the aluminum content of drinking water and the prevalence of Alzheimer's over a ten year period. The study reported a 50% increase in the risk of Alzheimer's disease in areas with high concentrations of aluminum. The risk of Alzheimer was 1.5 times higher when the aluminum concentration exceeded 0.11 mg/l than in areas where the concentration was 0.01 mg/l[9].

Given the potential of natural coagulants to be part of an appropriate solution to produce potable water, a number and variety of natural resources have been examined for their coagulation properties. Several studies were carried out to identify the efficacy of *M. oleifera* spp. as natural coagulants especially by[10,11,12,13]. On the other hand, several other studies were also done to determine the antimicrobial properties in *M. oleifera* spp.[14,15]. In addition[16], studies have shown that *Opuntia* spp. reduced turbidity by 98% and the work by [17] using tannin-based coagulant have shown that total turbidity removal in the surface and municipal waste water was about 95%. None of the studies has used *Cassia alata* as a natural coagulant. The legume, *Cassia alata*, locally known as Gelenggang Besar is classified under the Class *Caesalpiniaceae* which belong to the Family *Leguminosae* and Sub-Family *Fabaceae*. The plant is also known as *Senna alata*. It is very easily raised from seed and the coarse erect shrub stands up to 3 - 4 m tall. Leaves to about 50 – 80 cm long with 8 - 14 pairs of large leaflets (the distal ones largest), up to 17 cm long, ovate oblong, obtuse,

truncate or even slightly notched at apex. The inflorescence consisting of yellow flowers, long pendunculate, erect dense oblong spike, crowded and overlapping. The pod ripening black, straight, papery in texture, winged on the angles, up to 15-20 cm long and slightly over 1 cm wide. The seeds are numerous and flat. *Cassia alata* grows aggressively in areas where there is high water table. It prefers open areas and sunlight. Often forms thickets and grown as ornamental. It is known that *Cassia alata* is widely used in India and Southeast Asia as traditional medicine[18]. Plate-1 depicts the characteristics of *Cassia alata.*

Material and Methods

Samples of *C. alata* were collected near the campus area in Pengkalan Chepa, Kelantan, Malaysia. The leaves were dried in oven for two days at 50°C. The dried leaves were then ground with a laboratory grinder. All grinded materials were passed through 0.4 mm sieve and the sieved materials were used for extraction process. Crude extract was prepared by using 1L of distilled water to 50 g of the prepared powder, mixed by a magnetic stirrer for 60 min and left to settle for 20 minutes. The crude extract of *Cassia alata* was finally filtered through 0.95 mm paper filter.

The sample that was used in this study was raw surface water that was taken at the drinking water intake in Kelar, Pasir Mas, Kelantan, Malaysia. Turbidity and pH of the raw water sample was measured using the Turbidimeter (Hanna Model 2100P) and portable pH meter (hand-held Model C535) respectively, the elements iron and manganese were determined by using a Spectrophotometer (Model DR 2800) while for suspended solids the method employed by[19] was made before jar-test was conducted. The jar-test was carried out mainly to determine the effective dosage of *C. alata* in reducing the turbidity of the sample. In addition, the effective dosage of *C. alata* in reducing other parameters namely iron, manganese and suspended solid was also determined. Jar-test was performed in four (4) cleaned Biological Oxygen Demand (BOD) bottles. To each bottle 300mL surface water sample was added and topped-up with varying concentrations of *C. alata* crude extracts; 0.5ml, 1.0ml, 2.0ml and 3.0mL. The standard procedure requires 3 min of rapid mixing (200 rpm) in the incubator shaker at 21°C followed by 30 min of slow mixing (50 rpm) for flocculation. The treated water was allowed to settle for 20 min and 100 ml of the sample was taken from the top of each BOD bottle for the determination of turbidity, pH, iron, manganese and suspended solids. The above process was repeated by replacing raw river water with distilled water as a blank. The difference in the value of pH and the concentrations of iron, manganese and suspended solids before and after treatment was used to assess the efficacy of *C. alata* in reducing these parameters in raw water. As for turbidity this was measured in the form of coagulation activity calculated by the formula:

$$\text{Coagulation activity (\%)} = \frac{Ts - Tb}{Tb} \times 100$$

where: Ts – Turbidity concentration after treatment (mg/L)
Tb – Turbidity concentration of blank (mg/L)

Plate-1
Cassia alata

Results and Discussion

Figure-1 shows leaves of *C. alata* recorded the coagulation activity of 93.33% at the dosage of 1.0 ml/L. The leaves extracts has a good potential to be used as a natural coagulant for its ability to remove turbidity.

Figure-2 shows the pH reading for river water sample decreased from 6.69 to 6.62 after being treated with the leaves extracts. The pH reading was almost similar before and after treatment. Therefore, we can suggest that *Cassia alata* leaves extract could not be use as neutralizer for drinking water.

Water in Kelantan River is noted to contain high iron content and in this study the effect of treating the surface water obtained from the river with the leaves extracts was carried out to determine as to whether the iron content could be reduced.

Figure -3 shows that water sample after being treated with the leaves extracts of up to 1.0 ml/L concentration, the iron content showed an increase of 0.7 mg/L (15.7%) from the original concentration. The *Cassia alata* leaves extract, therefore, shows no potential whatever of being used to remove iron from the river whose water source is used for drinking.

Similar tests were made for manganese and the results in Figure-4 indicate that the leaves extracts showed no promise for manganese removal as well. In fact, it showed a substantial increase (of 78.6%) from 0.123 mg/L at the start to 0.575 mg/L when the sample river water was treated with 1.0 mL/L of the extract.

A completely different picture was obtained with suspended solids as is shown in Figure-5, where after being treated with 1.0 mL/L of the leaves extracts there was a substantial reduction (56.4%) from 390 mg/L at the start to 170 mg/L. The potential for using *Cassia alata* leaves extracts to remove suspended solids in drinking water sourced from the Kelantan River shows promise.

Conclusion

The objective of this study was to study the feasibility of using the widely available legume plant *Cassia alata*, as natural coagulant to treat low turbidity surface water. The result of this study showed that the extract of *Cassia alata* leaves is able to remove turbidity of river water by up to 93.33% a level almost similar to that obtained by *Opuntia* spp.[16], which gave a reduction percentage of 95%. The ability to remove suspended solids by 56.4% is another remarkable feature. It had some effect in lowering the pH level by 1% and raised the iron and manganese concentrations by 15.7% and 78.6% respectively.

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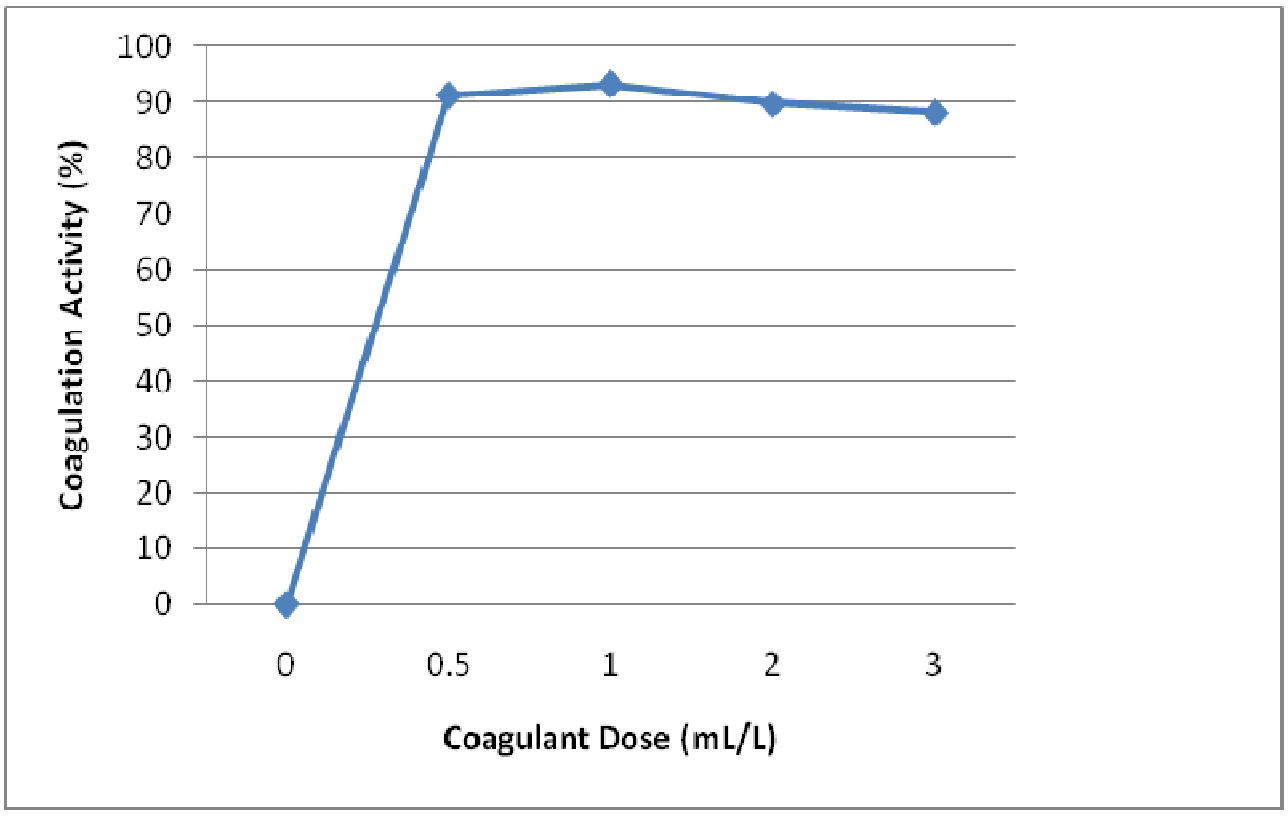

Figure-1
Coagulation activity for extracted *Cassia alata* leaves at difference dosage

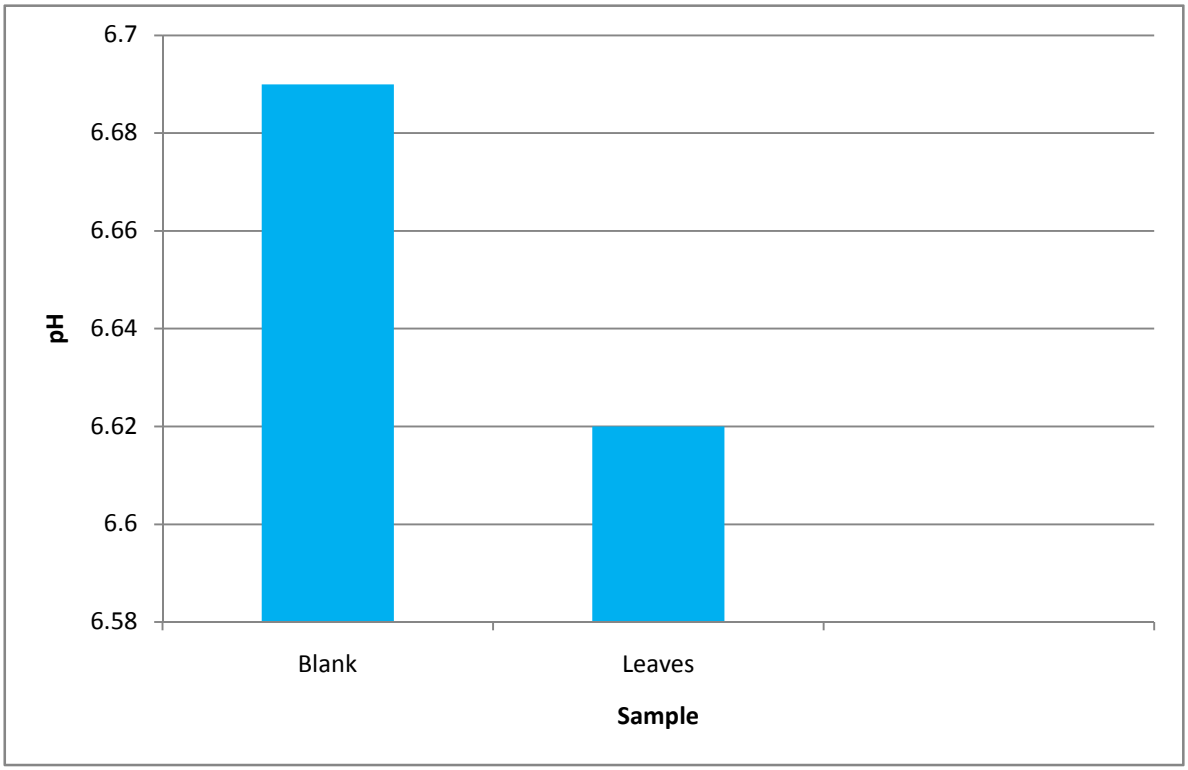

Figure-2
pH reading for blank and samples after being treated with extracted *Cassia alata* leaves

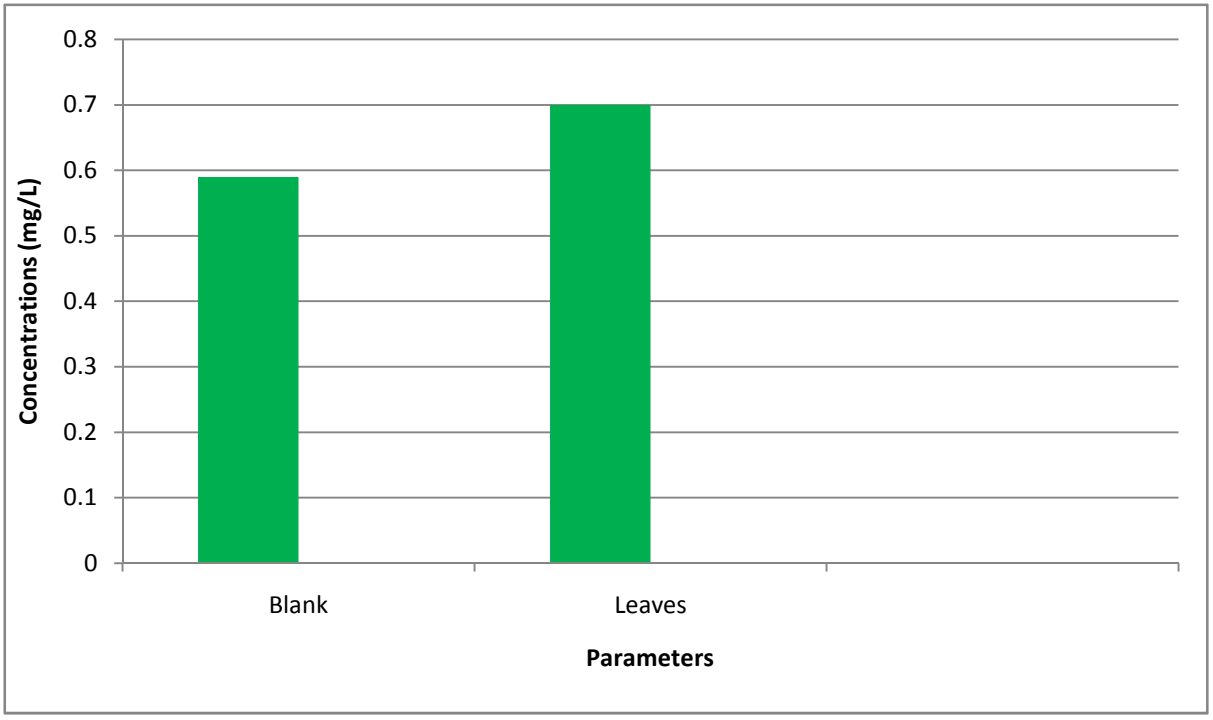

Figure-3
Ferum (Fe) concetrations for blank and samples after being treated with extracted *Cassia alata* leaves

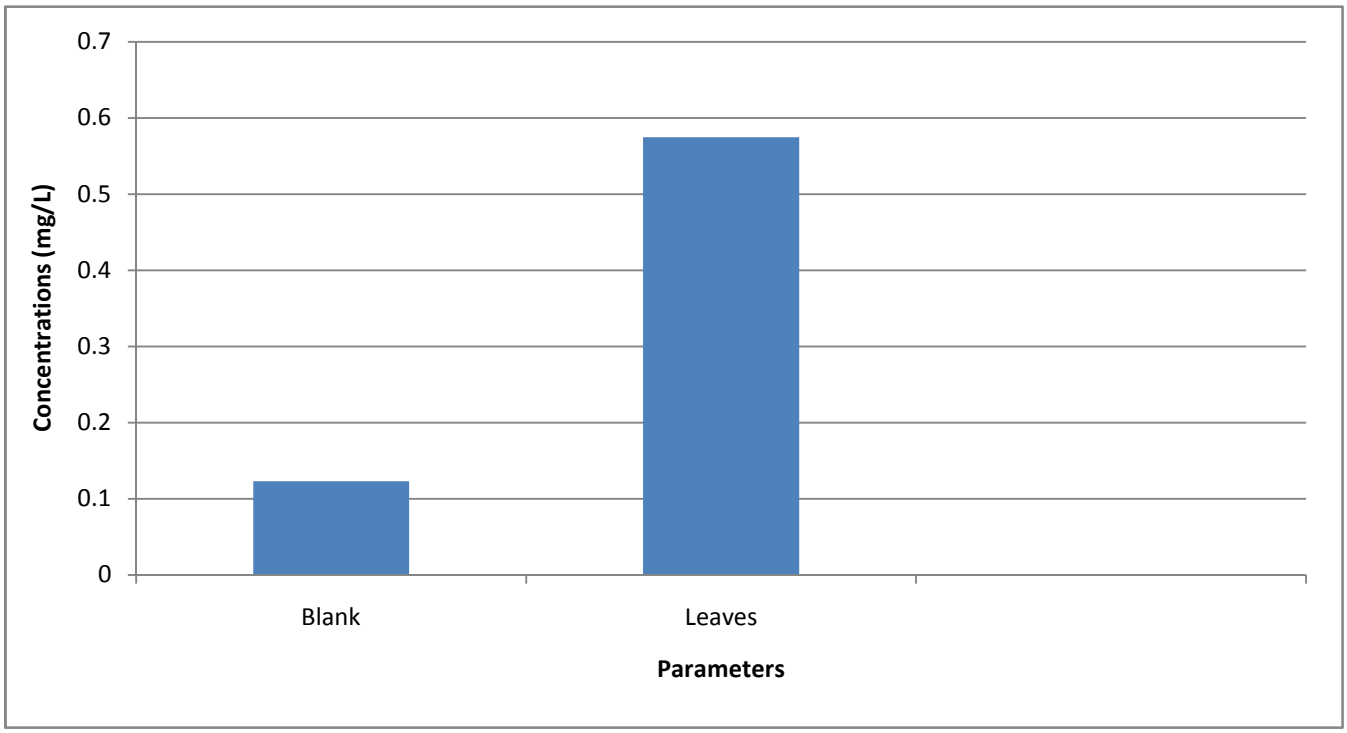

Figure-4
Manganese (Mn) concetrations for blank and samples after being treated with extracted *Cassia alata* leaves

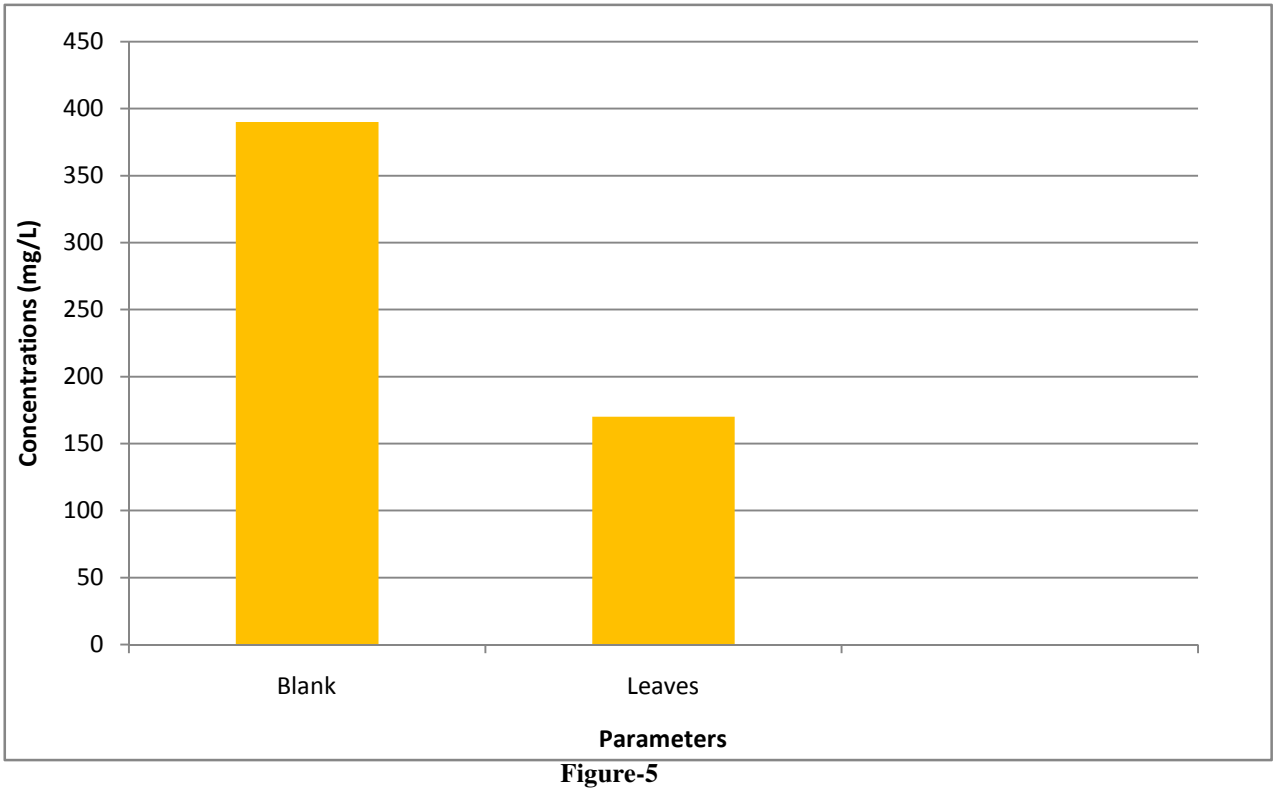

Figure-5
Suspended Solid (SS) concetrations for blank and samples after being treated with extracted *Cassia alata* leaves