VOL. 3, NO. 12, December 2013 ISSN 2225-7217
ARPN Journal of Science and Technology

http://www.ejournalofscience.org

Effect of Guar Gum (Cyamopsis Tetragonolobus) Powdered as Natural Coagulant Aid with Alum on Drinking Water Treatment

[1] Omer R.M., [2] El Hassan B.M., [3] Hassan E.A., [4] Sabahelkhier M.K.

[1] Department of Gums Chemistry and Processing Section, Gum Arabic Research Center, University of Kordfan, SUDAN
[2] Departments of Chemical Engineering, Faculty of Engineering, University of Khartoum, SUDAN
[3] Chemistry Section, Science College, University of Sudan, SUDAN
[4] Departments of Biochemistry and Molecular Biology, Faculty of Science and Technology, Al Neelain University, SUDAN

ABSTRACT

This study was carried out to determine the effectiveness of guar gum as a coagulant aid with alum on treatment of Blue Nile water (drinking water) in Khartoum State during the flood period (July – October 2007). The results showed that the highest efficiency for guar gum as a coagulant aid with alum especially at the mixture ratio of 1:1 (Guar: Alum mixture) at 30 min. sedimentation time, decrease the turbidity from 12050.0 NTU to 3.8 NTU in comparison with 192.0 NTU when using 120 mg/l alum alone, with their corresponding efficiencies 99.97% and 98.41% reduction of turbidity under similar conditions. Guar gum at different concentrations as coagulant aids it did not alter the physicochemical properties of water. The pH values ranged from 6.95 to 7.35 which is within the recommended range 6.5 – 8.5. Furthermore, overall operating costs can be significantly lowered when using guar gum as a natural coagulant aid with alum as well as reducing the health hazards.

Keywords: *Guar gum, coagulant aid, alum, drinking water treatment.*

1. INTRODUCTION

Water is used for several purposes by humans, purity of water is very important since it has a direct effect on health. The conventional method of water purification using poly aluminum chloride (PAC) and aluminum sulphate (alum) as imported chemicals makes treated water expensive in most developing countries. The high level of alum in the brain is a risk factor for Alzheimer disease (1).The advisability of introducing aluminum into environment by continuous use of aluminum sulphate as a coagulant in water treatment (2), besides production of large sludge volumes (3). There is also the problem of reaction of alum with natural alkalinity present in water leading to a reduction of pH (4), in addition to its low efficiency in coagulation of cold water (5). A significant economic factor is that many developing countries can hardly afford the high costs of imported chemicals for drinking water treatment, but. an alternative is used of natural locally available coagulants (plant origin) for coagulation. It is desirable that other cost effective and more environmentally acceptable natural coagulant aid to be developed to reduce the alum dose. The aim of this study is effect guar gum as natural coagulant aid with alum as primary coagulant in treatment of drinking water on the physicochemical characteristics of water such as turbidity and total suspended solids, total dissolved solid and electric conductivity, pH and alkalinity.

2. MATERIALS AND METHODS

2.1 Materials

The raw water was obtained from the Blue Nile (a surface source), Khartoum State, Sudan. It was collected during the flooding season(July – October 2007), samples were kept in polyethylene tank until testing was conducted.

The guar gum is of the fine grade class, supplied by the Sudanese Guar Company Ltd, season 2005, from Singa City, Sinner State, Sudan. The coagulant alum was obtained from Laboratory Technical Administration, Khartoum University.

2.2 Experimental Design

It was done as follows: Guar gum was added to the first set of jars containing one litre of raw water, Alum was added to the second set of jars containing one litre of raw water. Guar gum mixed with alum at different ratios 1:1, 1:2 and 2:1 was added to third, fourth and fifth set of jars containing each one litre of raw water. Where the dose designed for each jars was carefully pipetted (6). The each jar contents stirred at 120 rpm for 2 minutes for disperse the coagulant throughout each container, then the stirring speed was reduced to 35 rpm for 10 minutes, then the mixer was turned off, and the containers were allowed to settle for 30 minutes, then the final turbidity was measured in each jars. The supernatant was then analyzed to measure the total suspended solids (TSS) The jar test experiment was repeated at the same conditions, but the containers were left to settle for 1 hour, then the turbidity was tested.

2.3 Methods

2.3.1 Preparation of coagulant solution G and A

Preparation of guar solution (G) as 0.1% w/v and Alum solution (A) as 1.0% w/v To test the hypothesis, the first step was determined the turbidity and TSS of each coagulant G and A, an additional series of jar tests were conducted for each coagulant ratios (1:1, 2:1 and 2:1).

2.3.2 Physicochemical Analysis of Water

Turbidity and Total Suspended Solids (TSS) were measured according to method described (7). While pH and alkalinity were measured according to (8)

3. STATISTICAL ANALYSIS

Analysis of samples was carried out in replicate and then averaged. Data were analyzed according to procedure described (9).

4. RESULTS AND DISCUSSION

4.1 Turbidity and Total Suspended Solids

Fig.1 indicated that the maximum value of turbidity (12050.0 NTU) obtained in July and minimum value of turbidity (1166.0 NTU obtained in October. The flooding during this period is most likely to be the reason behind such highly turbid waters. In addition the effect of flooding in July was prominent (10). This may be due to the high collision probabilities of the colloids for high turbidities 12050.0 NTU in July.

Fig 2 - 5 show that the in July the lower level of turbidity 3.8 and 4.2 NTU was produced at the ratio 1:1 and 1:2 at 30 and 60 min. sedimentation time, respectively, compared with turbidity of 192.0 NTU when using alum alone (120 mg/l). The values of turbidity which were obtained at ratio 1:1 and 1:2 are within the recommended (11). The results showed that in October the turbidity of water when using 120 mg/l of guar gum alone was reduced from 1166.0 NTU to 570.0 NTU, when guar gum was used as coagulant aid with alum at ratio of 1:2, the turbidity decreased to 8.0 NTU. The effectiveness of guar gum as a coagulant aid with alum may be attributed to the number of electrical charges along the molecular chain of guar gum carbon atoms, which linked with the suspension particles resulting in increasing of floc size (12).

Fig 6- 9 were indicated that total suspended solids was 5 and 4 mg /l for ratio 1; 1 AND 1; 2, respectively, compared with 241 mg/l when using alum alone as chemical coagulant. Statistical analysis (ANOVA) showed the highest significant difference ($p \leq 0.001$) in turbidity and total suspended solids after allowing for the effect of differences of sedimentation time (30 and 60 min.) among the different levels of coagulants ratios during July to October 2007, but there are insignificant differences ($p \leq 0.137$) in turbidity at ratio 1:1 and 1:2, it gave 3.4 and 3.3 NTU, respectively.

4.2 Efficiency of Coagulant

Fig 10 was indicated that the turbidity of water at ratio 1:2 in mixture G: A at 30 and 60 minutes sedimentation time had reduced by 99.78% during September, but Fig.11 and 11were Indicated that the efficiency of mixture G: A at ratio 1:2 was decreased as the turbidity decreased, then it reached the highest efficiency of 99.97 % with turbidity of 12050.0 NTU in July, while the lower efficiency of 99.33 % was obtained at turbidity 1166.0 NTU in October. Fig.12 shown that the inversely proportional between efficiency of coagulant and turbidity level may be attributed to the highly turbid water in July, because of the high collision probabilities between positively charged coagulant ions and the negatively charged colloidal particles causing turbidity, so the probability of floc growth was greater than in October (10).

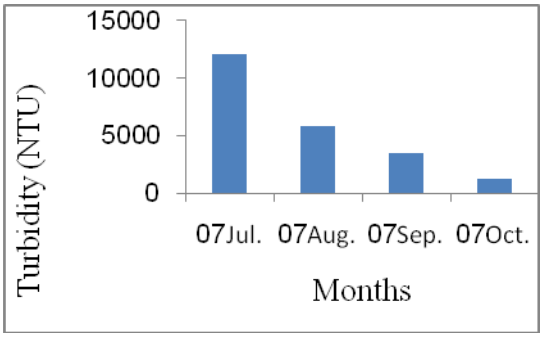

Fig 1: Turbidity of the Blue Nile raw water during July – October2007

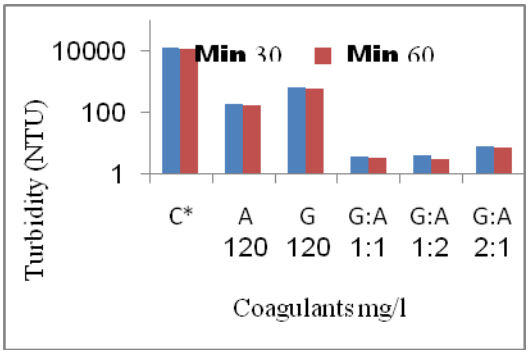

Fig 2: Effect of a mixture of guar gum and alum at two sedimentation times on turbidity of the treated water during July 2007.

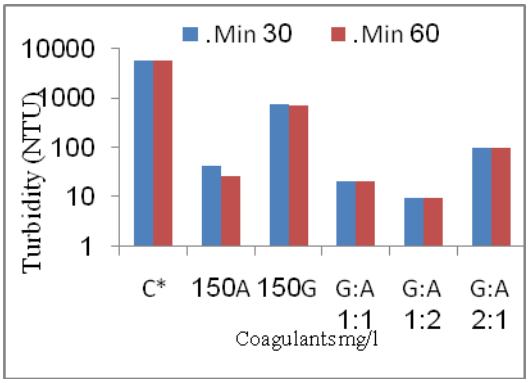

Fig 3: Effect of a mixture of guar gum and alum at two sedimentation times on turbidity of the treated water during August 2007

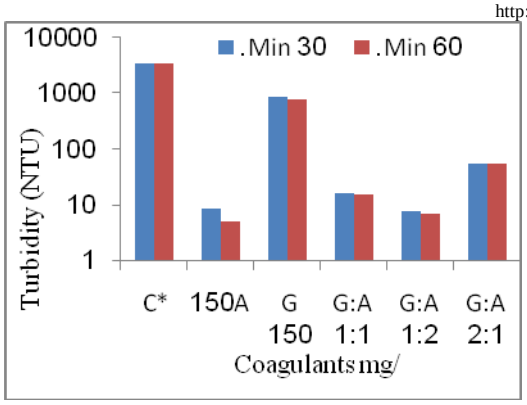

Fig 4: Effect of a mixture of guar gum and alum at two sedimentation times on turbidity of the treated water during September 2007.

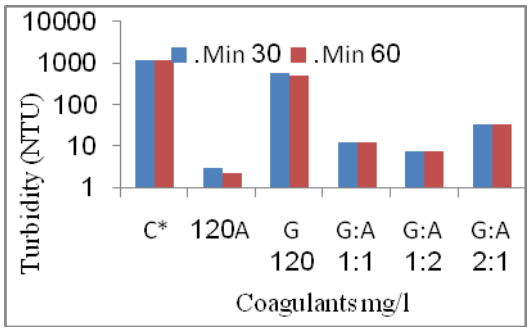

Fig 5: Effect of a mixture of guar gum and alum at two sedimentation times on turbidity of the treated water during October 2007**.**

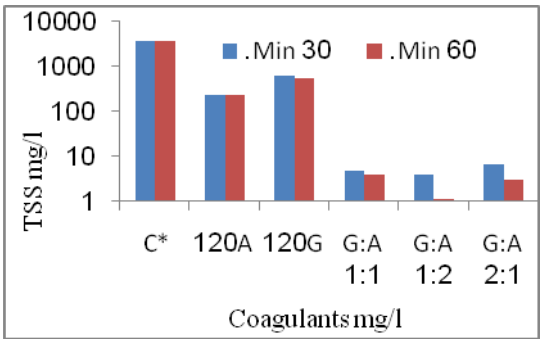

Fig 6: Effect of a mixture of guar gum and alum at two sedimentation times on total suspended solids (TSS) of the treated water during July 2007

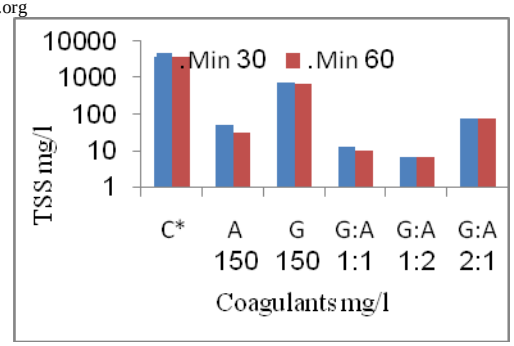

Fig 7: Effect of a mixture of guar gum and alum at two sedimentation times on total suspended solids (TSS) of the treated water during August 2007

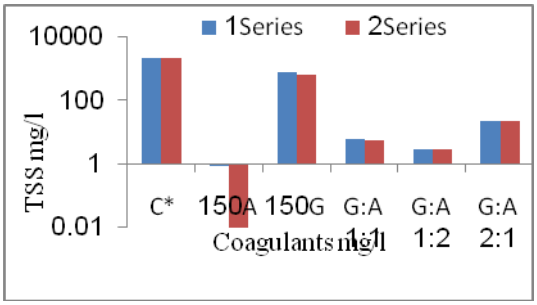

Fig 8: Effect of a mixture of guar gum and alum at two sedimentation times on total suspended solids (TSS) of the treated water during September 2007

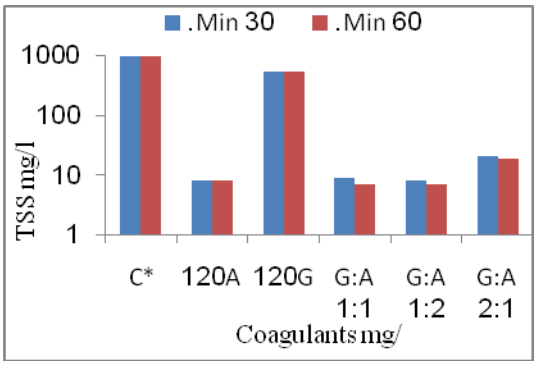

Fig 9: Effect of a mixture of guar gum and alum at two sedimentation times on total suspended solids (TSS) of the treated water during October 2007.

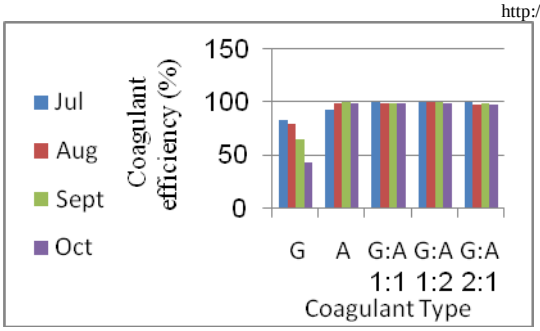

Fig 10: Efficiency of guar gum as coagulant aid with alum at different mixing ratios in reducing total suspended solids for the Blue Nile water during July – October 2007

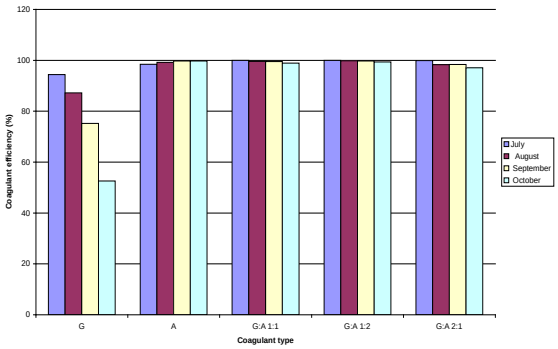

Fig 11: Efficiency of guar gum as coagulant aid with alum at different mixing ratios in reducing turbidity of the Blue Nile water during July – October 2007**.**

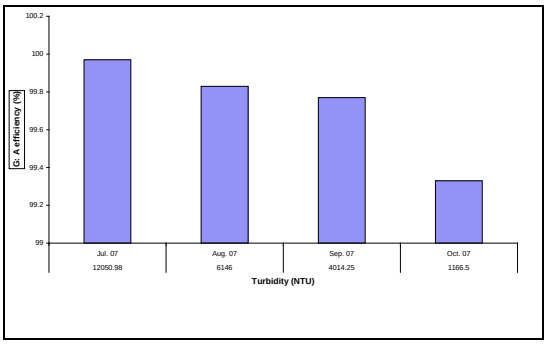

Fig 12: Efficiency of guar gum as coagulant aid with alum at Blue Nile water during (July 0 October 2007

4.3 Total Dissolved Solids (TDS) and Electric Conductivity (EC).

It was observed that the lower value of TDS (93.0mg/l) and EC (186.0 us/cm) were recorded when guar gum was used alone while high value of TDS (186.8 mg/l) and EC (373.6us/cm) were obtained when alum was used alone during July – October 2007 Fig. 13- 16. This increase of TDS and EC with alum is caused by sulphate ions remaining in the treated water, so the decrease of pH and increasing in TDS and EC place this chemical coagulant at a relative disadvantage compared to the natural coagulant. Statistical analysis showed significant difference ($p \leq 0.001$) in TDS among the different levels of coagulant agents after considering the effects of differences in sedimentation time; for the period from July to October 2007. However, there is no significant difference ($p \leq 0.098$) in TDS between the two sedimentation times (30 and 60 minutes) when using guar gum mixed with alum at ratio 1:2 reaching 159.2 and 159.1 mg/l at 30 and 60 min. sedimentation time, respectively in July. The statistical analysis found that there is insignificant differences ($p = 0.944$) in TDS among the different levels of sedimentation times for the pure guar gum which gave 107.6 mg/l at 30 and 60 min. sedimentation time in August.

4.4 pH value and Alkalinity

Fig. 17 shows that the pH value is slightly decreased as the dose of alum increased; In July the maximum value of pH was 8.11 for untreated water, while a low value of it obtained at an optimum alum dose of 120 mg/l, the pH-value dropped to 6.95, this is mainly due to the excess of sulphate ions from the alum coagulant (Amagloh and Benang, 2009)13. When alum was aided by guar gum was used, the pH-value had dropped (8.11) into 7.07, 7.05 and 7.35 at mixing ratios of 1:1, 1:2 and 2:1, respectively. Therefore guar gum at different concentrations had no significant impact on pH value which was found to be within the WHO standard range for the drinking water (11). There is a statistically significant difference ($p \leq 0.001$) in the mean values of pH between the different levels of coagulants during the experimental period (Figs 17 - 20). Observation on Figures (21 - 24) reveals that there are statistically significant differences ($p \leq 0.001$) in the mean values of alkalinity for the water treated by guar gum and alum separately and when mixed together at different mixing ratios. Fig 23 and 24 shown that alkalinity decreased with the increase of alum dose either when it was mixed with guar gum or when it was used alone in September and October. The decrease of alkalinity may be due to the liberation of sulphuric acid by alum (13). Moreover, 150 mg/l of alum resulted in 42.07 mg/l $CaCO_3$ in September. The high values for pH and alkalinity were recorded for untreated water during July – October, while the minimum values were obtained with alum

5. CONCLUSION

Guar gum is achieved the highest efficiency (as coagulant aid with alum at the ratios of 1:1, 1:2 and 2:1, respectively) in reducing turbidity for the Blue Nile water during July – October.. Therefore guar gum can be used as a natural (safer) coagulant aid with alum in the treatment of drinking water, with the purpose of reducing the chemical coagulant dose, in addition to decreasing the cost. It may be necessary to have primary sedimentation as part of the overall treatment system by using guar gum as coagulant aid with alum

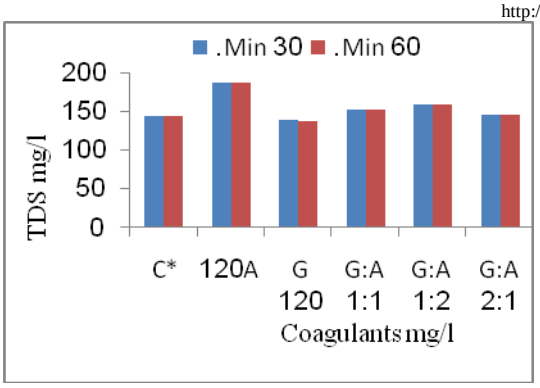

Fig 13: Effect of a mixture of guar gum and alum at two sedimentation times on total dissolved solids (TDS) of the treated water during July 2007

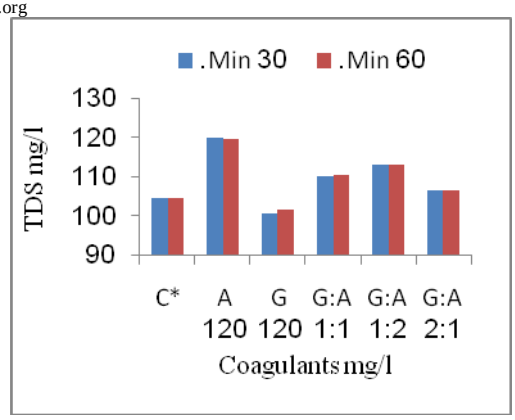

Fig 16: Effect of a mixture of guar gum and alum at two sedimentation times on total dissolved solids (TDS) of the treated water during October 2007.

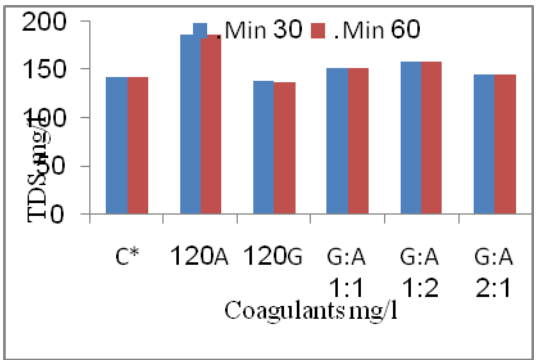

Fig 14: Effect of a mixture of guar gum and alum at two sedimentation times on total dissolved solids (TDS) of the treated water during August2007.

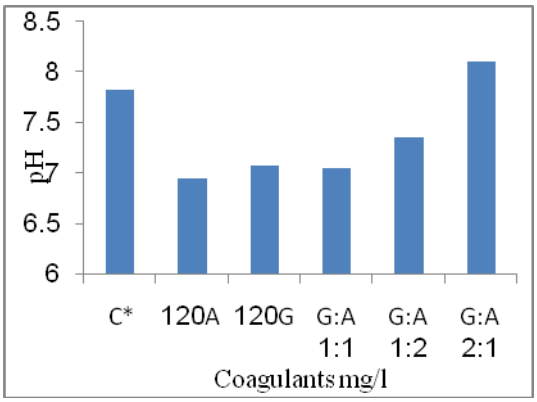

Fig 17: Effect of a mixture of guar gum and alum on pH value of the Blue Nile water during July 07.

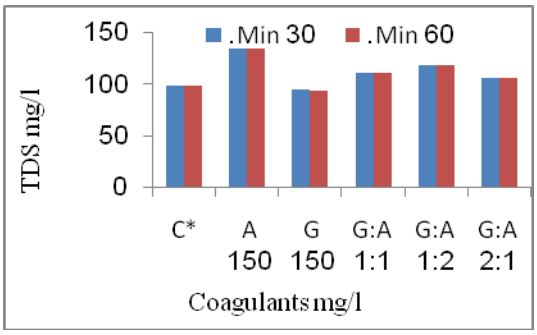

Fig 15: Effect of a mixture of guar gum and alum at two sedimentation times on total dissolved solids (TDS) of the treated water during September2007.

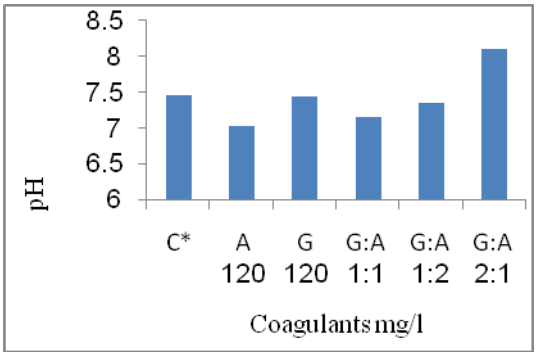

Fig 18: Effect of a mixture of guar gum and alum on pH value of the Blue Nile water during August 07.

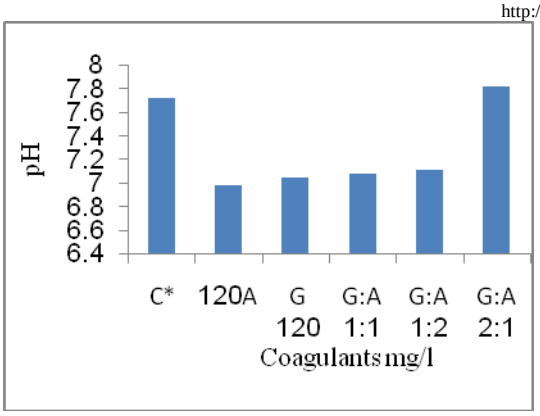

Fig 19: Effect of a mixture of guar gum and alum on pH value of the Blue Nile water during September 07.

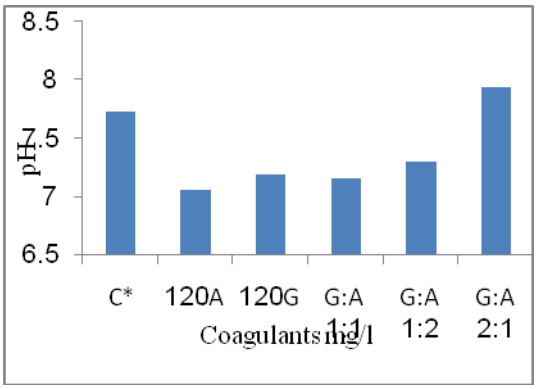

Fig 20: Effect of a mixture of guar gum and alum on pH value of the Blue Nile water during Oct2007.

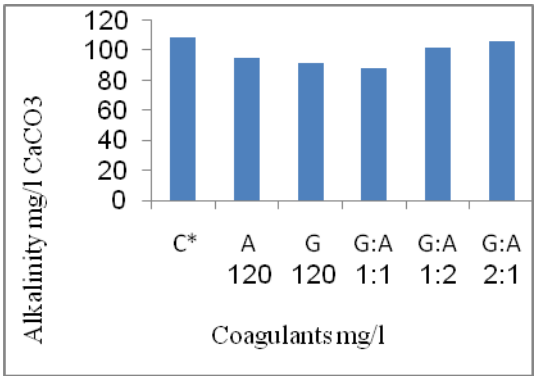

Fig 21: Effect of a mixture of guar gum and alum on Alkalinity of the Blue Nile water during Jul 2007.

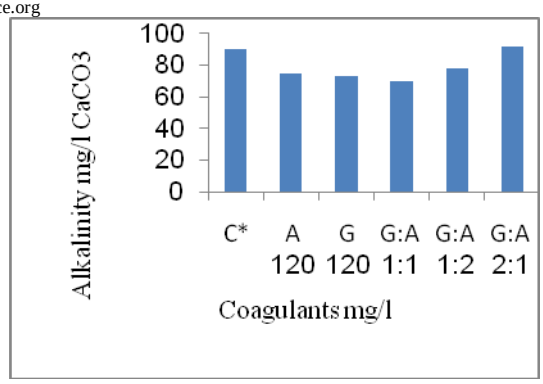

Fig 22: Effect of a mixture of guar gum and alum on Alkalinity of the Blue Nile water during August 2007.

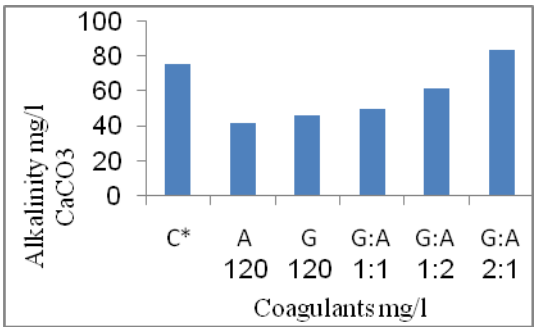

Fig 23: Effect of a mixture of guar gum and alum on Alkalinity of the Blue Nile water during September 2007.

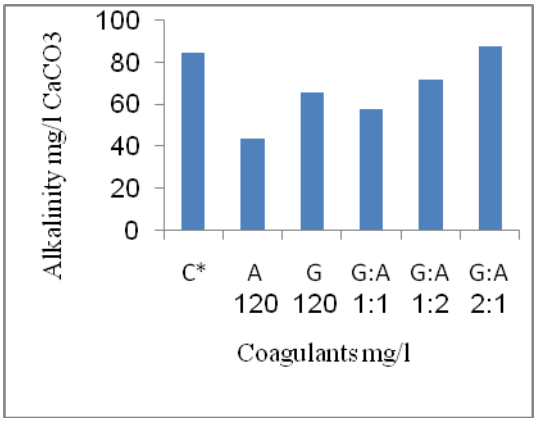

Fig 24: Effect of a mixture of guar gum and alum on Alkalinity of the Blue Nile water during October 2007.

REFERENCES

[1] Miller RG. Kopier FC., Ketty KC.,Stober JA. and Ulmer NS. (1984). The Occurrence of Aluminum in Drinking Water. J. Am. Wat. Wks. Ass. 76 (1): 84 -91. In Amagloh F. K. and Benang A. (2009)

[2] Letterman RD. and Driscoll CT. (1988). Survey of Residual Aluminium in Filtered Water. J. Am. Wat. Wks Assoc. B2: 154 -158. In Amagloh F. K. and Benang A. (2009).

[3] James C. and O'Melia CR. (1982) Considering sludge production in the selection of coagulants. *J. Am. Wks Ass*. 74, 158-251.

[4] Degremont, (1989). In Ndabigengesere A. and Narasiah K. S. (1998).

[5] Haarhoff J. and Cleasby JL. (1988) Comparing aluminum and iron coagulants for in-line filtration of cold waters. *J. Am. Wks Ass*. 80, 168-175

[6] Poland J. and Pagano, T (2005). Jar Testing. Environmental Information Management. Civil Engineering Dept. Water Treatment Primer

[7] Wef LS. Apha, AE., Awwa, AD. and Franson, MA. (1998). Standard Methods for the Examination of Water and Wste water, 20 ed., American Public Health Association. Washington

[8] Gomez AK. and Gomez AA. (1984). Statistical Procedures for Agricultural Research. John Wiley and Sons

[9] AOAC (1990): Official Methods of Analysis (15thedn), Association of official analytical chemists .Washington D.C.USA, pp

[10] Cohen JM. and Hannah SA. (1971). Water Quality and Treatment. American Water Works Association, Inc. Third Edition. New York

[11] WHO (1995). Guidelines for Drinking- Water Quality pp. 173 – 181. Regional Centre for Environmental Health Activities (CEHA), Jordan

[12] American Water Works Association (AWWA) (1971). Water Quality and Treatment. 3rd ed. Toronto. McGraw-Hill, pp. 66-103

[13] Amagloh FK. and Benang A. (2009). Effectiveness of *Moringa oleifera* seeds as Coagulant for Water purification. African Journal of Agricultural Research V. 4 (1). pp. 119 – 123. Available online at htt:/www. Academicjournals.org/AJAR