Proceedings of the 5th International Conference on Civil Engineering for Sustainable Development (ICCESD 2020), 7~9 February 2020, KUET, Khulna, Bangladesh (ISBN-978-984-34-8764-3)

APPLICATION OF BIO COAGULANT ON DRINKING WATER TREATMENT

Md. Shakhawath alam[1] and Sk. Md. Imdadul Islam*[2]

[1]Graduate Student , Khulna University of Engineering & Technology, Bangladesh, e-mail:shakhawathalam13@gmail.com
[2]Lecturer, World University of Bangladesh, Dhaka-1205, Bangladesh,email: imdadulemon109@gmail.com

***Corresponding author**

ABSTRACT

Removal of turbidity is essential for treatment of surface water and is often carried out with coagulation using metal salts as aluminium sulphate. Natural coagulants have bright future and are concerned by many researchers because of their abundant source, low price, environment friendly, multifunction, and biodegradable nature in water purification. This study focused on the evaluation of plant-based natural coagulant sources, processes, effectiveness and relevant coagulating mechanisms for treatment of river and pond water. The raw water samples were collected from the Bhairab River near Fulbarigate and pond near the Khan Jahan Ali Hall, KUET.

In this study, Sajna seeds were selected as bio coagulant. The optimum dose for the sajna seeds coagulant was found as 32 and 24 mg/l for the river and pond water, respectively. It is found that the turbidity removal efficiencies of the coagulants are varied from 96.0 to 96.5%, 90.8 to 86.3% with compared to alum coagulation for river and pond water, respectively. The color removal efficiencies of the coagulants are varied from 83.6 to 86.6%, 77.1 to 81.2% with compared to alum coagulation for river and pond water, respectively. It is also observed that the turbidity and color removal efficiency linearly decreases with increasing values initial values of raw water for both river and pond water. This study showed the performances of bio-coagulant such as Sajna seeds are used for the treatment of pond and river water. It is concluded that the turbidity and color removal efficiencies are satisfactory for the coagulant which is significant for use as a coagulant in water treatment purpose. Linear correlations for the turbidity and color removal efficiencies are also proposed.

Such bio-coagulants have found a high degree of significance for use as a coagulant in water treatment purpose. The main advantages of using natural plant based coagulants as water treatment material are apparent; they are cost-effective, unlikely to produce treated water with extreme pH and highly bio-degradable. The use of bio-coagulant would be a possible alternative to chemical coagulant for the same treatment of drinking water in rural areas and developing country like Bangladesh. Hence, it is concluded that these natural coagulant such as Sajna seeds could be used as coagulant for surface water treatment purpose.

Keywords: *Coagulation, Bio-coagulant, Turbidity removal, Color removal, Water treatment.*

1. INTRODUCTION

Water is essential for human survival. It has been reported that the total amount of water in the world is about 1400 million cubic km and remains constant. Apparently, more than 97% of this total volume is seawater of the rest 22% is ground water and 97% is ice locked away in the glaciers and the polar ice cap. This obviously leaves less than 1% of the supply of fresh water (Gleick, 1996).Most of the fresh water is polluted. In many developing counties, access to clean and safe water is a crucial issue. Pollution has increased alarmingly, in both developed countries (groundwater severely threatened by industrial and agricultural waste) and poor countries (domestic or agricultural waste in aqueous medium without treatment, poor waste management).This qualitative and quantitative degradation of water resources becomes a big problem in the water sector especially for developing countries. This problem is critical in Bangladesh. About more than 80% of people in Bangladesh lack clean, safe water. One of the problems with treatment of surface water is large seasonal variation of turbidity. Chemical coagulation is one of the most popular and effective methods for suspended particle and turbidity removal. However, these reagents may exert a negative impact on health as applied to drinking water treatment because they leave harmful monomer, aluminum, and unwanted side products in effluent, especially for excessive usage (Srinivasan and Viraraghavan, 2002). More than 99% of the coagulants used in drinking water treatment fall into the aluminum series. Even though they possess good particle removal efficiency, these coagulants may contaminate drinking water via aluminum residue, which has been recognized as a factor in Alzheimer's disease (Mclachlan, 1995).

1.2 Objectives of The Study

The main objectives of the study are given as follow:

- To choose suitable bio-coagulant for the treatment of surface water for drinking purpose.
- To study the turbidity removal capacity of the selected bio-coagulant.
- To study the color removal capacity of the bio-coagulant.
- To check the efficiency of the bio-coagulants with respect to traditional alum (K_2 $[SO_4]$.Al_2 $[SO_4]_3$.$24H_2O$) coagulation.

2. METHODOLOGY

Firstly, the raw water samples were collected from the Bhairab River and KUET pond (near Khan Jahan Ali Hall). SAJNA (*M. oleifera)*) seeds were taken as locally available bio-coagulant. The following tasks were performed:

- Collection of raw water sample from different areas of the Bhairab River and KUET pond.
- Selection of SAJNA (*M. oleifera)* as bio-coagulant.
- Preparation of bio-coagulant.
- Determination of water quality parameters (turbidity, color, pH and conductivity) of collected sample.
- Performing of Jar test (coagulation) for both seeds for both river water and pond water sample.
- Determination of optimum dose for the turbidity and color removal capacity for the selected bio-coagulants.
- Analyzing the test results and plotting relevant graphs.
- Analyze the efficiency of Sajna seeds as bio coagulants with respect to traditional chemical alum coagulant.

2.1 Selection of Coagulants

There are different types of naturally available bio-coagulant like Sajna or Drumstick Seed (*Moringa oleifera)*,Neem seed (*Azadirachta indica*) organic PAC (Polyaluminium chloride),*Acanthocereus tetragonus*, Aloevera leaf, Chitosan, Anionic polymer, Cationic polymer, Non-ionic polymer, *Cicer arietinum*, *Delonixregia*, *Dolichosl lablab*, PG-M (hybride type), *S.potatorum* (seeds of nirmali trees), guar plant (*Cyamopsis tetragonoloba*), tamarind tree (*Tamerindous indica*), fenugreek (*Trigonella*

foenum), Redsorrel plant (*Hibisicus sabdariffa*), *Strychnos potatorum*, *Cactus* species, *Phaseolus vulgaris*, maize seed, tannin, gum arabic, *Prosopis juliflora* and *Ipomoea dasysperma* seed gum, as coagulants. *Moringa oleifera* or locally named Sajna seeds were selected as bio-coagulant due to their availability in Khulna district and cost effective. Alum is selected as chemical coagulant. It is a common coagulant available in local market and cheaper than other chemical coagulants.

2.2 Collection of Raw Water Sample

The raw water samples were collected from the Bhairab River located at Fulbarigate of Khulna and pond near the Khan Jahan Ali Hall at Khulna University of Engineering & Technology, Khulna. Raw water was collected from different locations of the sources in order to maintain varying turbidity. The river water sample is turbid in whole the year due to high amount of silt carried by the river and also due to the low depth of river in some places water is super turbid.

Figure 1: Typical map of Bhairab River

Table 1: The source and time of sample collection

Source	Date	Time	Temperature	Remarks
KUET Pond ($22^0$54’03.0” N $89^0$29’58.0” E)	2.2.2017	10 am	25.0^0 C	P1
	5.2.2017	10.30 am	26.5^0 C	P2
	7.2.2017	11.40 am	27.5^0 C	P3
	24.4.2017	5.00 pm	33.0^0 C	P4
	25.4.2017	4.30 Pm	33.5^0 C	P5
Bhairab River ($22^0$53’56.4” N $89^0$31’06.8” E)	3.2.2017	5.00 pm	25.5^0 C	R1
	4.2.2017	5.00 pm	27.0^0 C	R2
	8.2.2017	9.00 am	28.5^0 C	R3
	23.4.2017	5.30 pm	32.5^0 C	R4
	24.4.2017	10 am	33.0^0 C	R5

2.3 Preparation of Bio-Coagulant

The collected seed was vigorously washed thoroughly tap water. The seeds were naturally sun dried for 2-3 days. Then the outer cover the seed kernels were removed and the kernels were converted into powder using a blender. The prepared powders were used for each batch run. The jar test operations using different coagulants were carried out in different turbidity ranges. Turbidity was measured before and after treatment.

Figure 2: Sajna (*Moringa oleifera*) seeds and prepared powder

2.4 Test for Physical and Chemical Properties of Raw and Treated Water

At first the physical and chemical properties such as pH, color, conductivity and turbidity of the raw water were tested by pH meter sension-156, conductivity meter sension-5 and turbidity meter, respectively. Then the indicated doses (Table 3.2) for each coagulant were applied in the 6 nos. of beakers containing 500 ml of raw water. The filled jars were then placed on the gang stirrer, with the paddles positioned identically in each beaker. The first beaker was left as a blank one and increasing dosages of the first coagulant was added to subsequent beakers. Coagulants were injected as quickly as possible, below the liquid level and about halfway between the stirrer shaft and beaker wall. The mixing speed was increased to 100 rpm for 3minutes (rapid mix). The mixing was reduced to 20 rpm and continued the slow mix for 20 minutes. The mixer was turned off and allowed settling to occur. After settling for a period of time of 1-hour supernatant appearance was noted. The jars were removed from the gang stirrer and the physical and chemical properties (i.e. turbidity, pH, conductivity and color) were tested again. Then the contents were emptied and thoroughly the beakers were cleaned. The above procedure was repeated for all collected samples, but substituting for the blank the dosage selected as providing the desired level of performance in the first series of test.

Table 2: Indicated doses for each coagulant

Coagulant	**Indicated doses for each coagulant (mg/l)**					
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Sajna	0	8	16	24	32	40

Figure 3: Jar Test set

3. RESULTS AND DISCUSSION

This represents the experimental results of physical and chemical properties such as color and turbidity of treated water sample after the application of Sajna seeds as coagulant. Jar test is carried out to determine the optimum dose and removal efficiency of turbidity and color. This will also describe the merits of natural or bio-coagulant over chemical coagulant.

3.1 Physical and Chemical Properties of Treated Water

Water samples collected from both Bhairab River and pond (near the Khan Jahan Ali Hall at Khulna University of Engineering & Technology, Khulna) were treated using bio coagulant. For Bio-coagulation, Sajna seeds were used. The doses were varied from 0 to 40 with an increment of 8 mg/l for the Sajna seeds. Table 3 and Figure 4 show the variation of the turbidity of the river water after coagulation for the Sajna seeds coagulant, whereas Table 4 and Figure 5 show the variation of the turbidity of the pond water after coagulation for the same coagulant. It was seen that the optimum dose for the sajna seeds coagulant was found as 32 and 24 mg/l for the river and pond water, respectively.

Table 3: Variation of turbidity after each dosing of bio-coagulation with Sajna seeds (River Water)

Sample No.	Initial Turbidity (NTU)	Turbidity after coagulation for indicated Sajna seeds doses (mg/l)					
		0	8.0	16.0	24.0	32.0	40
R1	234	87.6	70.2	57.2	39.3	19.5	27.2
R2	288	92.4	73.3	61.2	45.3	27.7	34.5
R3	327	97.3	82.2	69.1	52.7	31.9	37.8
R4	447	120.7	91.7	75.2	53.5	44.8	48.2
R5	533	133.5	98.6	81.3	62.3	55.3	62.1

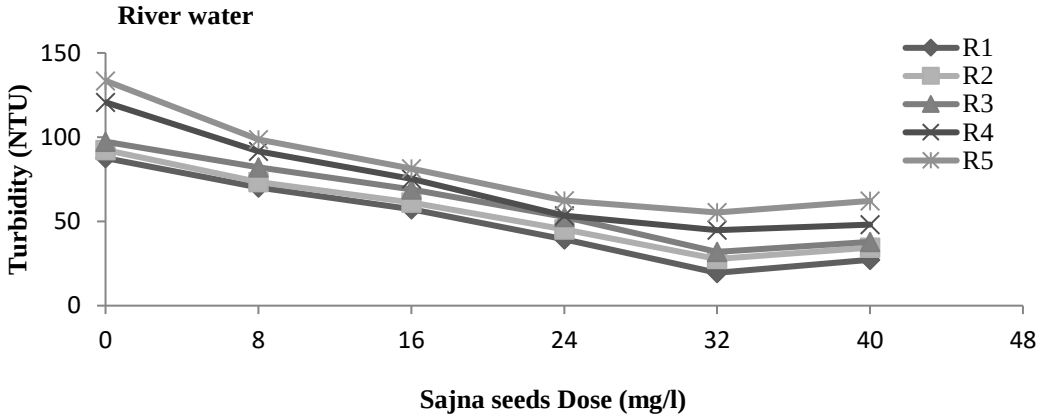

Figure 4: Variation of turbidity after bio-coagulation with Sajna seeds (River Water)

Table 4: Variation of turbidity after each dosing of bio-coagulation with Sajna seeds (Pond Water)

Sample No.	Initial Turbidity (NTU)	Turbidity after coagulation for indicated sajna seeds doses (mg/l)					
		0	8.0	16.0	24.0	32.0	40
P1	62	39.7	30.2	21.6	9.8	17.3	20.6
P2	79	59.6	38.5	31.7	13.3	24.2	31.3
P3	113	75.5	59.4	37.2	23.6	30.6	35.2
P4	148	81.9	64.9	48.9	31.3	37.7	43.9
P5	185	89.6	70.3	52.4	40.5	45.1	51.2

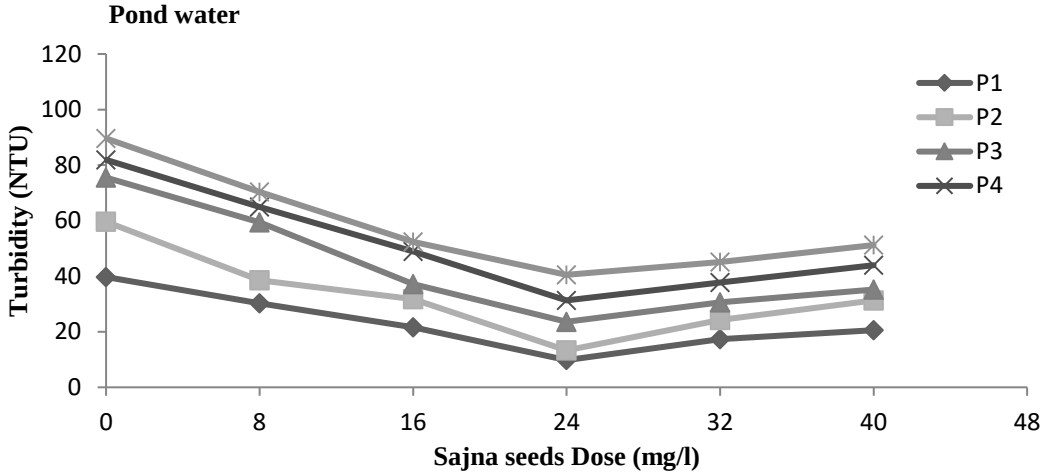

Figure 5: Variation of turbidity after bio-coagulation with Sajna seeds (Pond Water)

Table 5 and Figure 6 show the variation of the color of the river water after coagulation for the Sajna seeds coagulant, whereas Table 6 and Figure 7 show the variation of the color of the pond water after coagulation for the same coagulant. It was seen that the optimum dose for the Sajna seed coagulants were found as 32 and 24 mg/l for the river and pond water, respectively.

Table 5: Variation of color after each dosing of bio-coagulation with Sajna seeds (River Water)

Sample No.	Initial Color (Pt-Co)	Color after coagulation for indicated Sajna seeds doses (mg/l)					
		0	8.0	16.0	24.0	32.0	40
R1	407	252	210	173	146	88	116
R2	439	267	231	191	156	113	126
R3	488	287	268	220	184	134	147
R4	556	367	286	232	198	160	177
R5	674	443	320	276	227	201	236

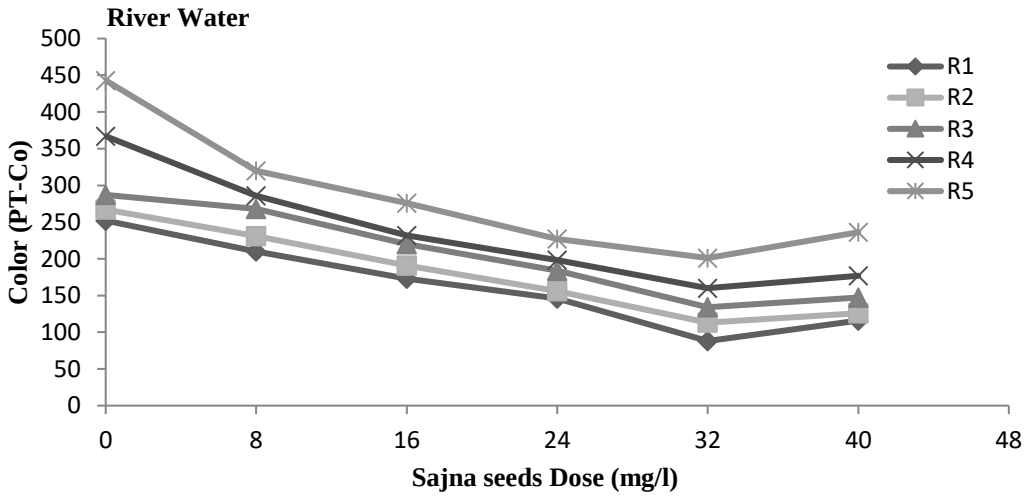

Figure 6: Variation of color after bio-coagulation with Sajna seeds (River Water)

Table 6: Variation of color after each dosing of bio-coagulation Sajna seeds (Pond Water)

Sample No.	Initial Color (Pt-Co)	Color after coagulation for indicated Sajna seeds doses (mg/l)					
		0	8.0	16.0	24.0	32.0	40
P1	170	92	76	59	37	53	68
P2	210	107	82	67	48	61	72
P3	270	131	95	78	62	69	78
P4	315	163	121	93	75	79	86
P5	332	178	136	102	89	92	101

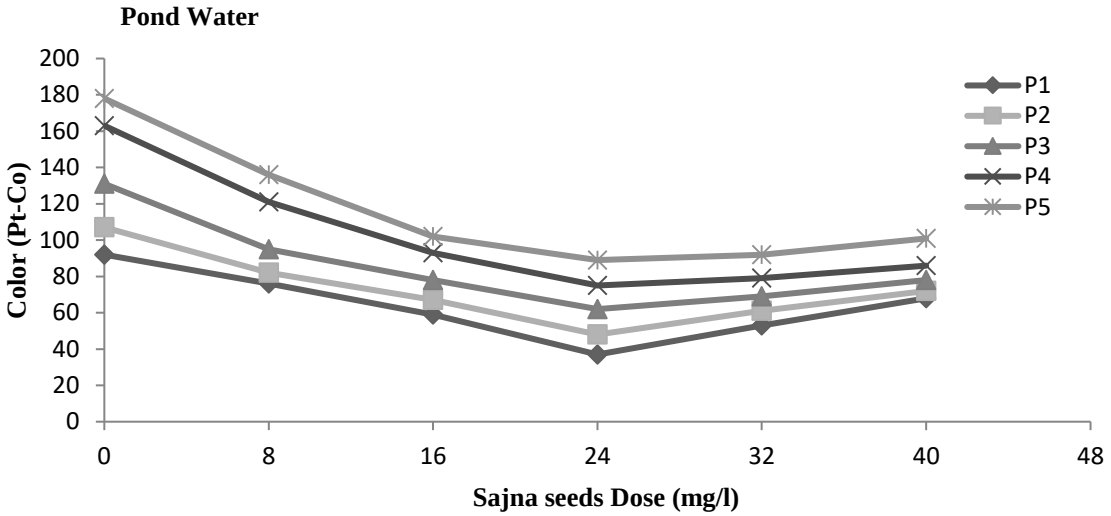

Figure 7: Variation of color after bio-coagulation with Sajna seeds (Pond Water)

3.2 Turbidity and Color Removal Efficiency of Coagulant

Turbidity and color removal efficiency of three coagulants alum, Sajna seeds were calculated from the values found in experiment.

$$Removal\ Efficiency\ (\%) = \frac{(A-B)}{A} \times 100 \quad (1)$$

Where, A = Initial value of raw water sample
B = Final value after the coagulation

It is found that the turbidity removal efficiencies of the coagulant are varied from 96.0 to 96.5%, 90.8 to 86.3% with compared to alum coagulation for river and pond water, respectively. The color removal efficiencies of the coagulants are varied from 83.6 to 86.6%, 77.1 to 81.2% with compared to alum coagulation for river and pond water, respectively.

Figure 8 show the variation of the turbidity removal efficiency for coagulants for river water respectively. It is seen that the efficiency linearly decreases with increasing initial turbidity. Linear correlations for the turbidity removal efficiency are proposed by Equations (2) to (5) for the all coagulants.

$$Sajna\ (river\ water): \quad y = 92.717 - 0.0064x; \quad R^2 = 0.93 \quad (2)$$
$$Alum\ (river\ water): \quad y = 96.707 - 0.0077x; \quad R^2 = 0.92 \quad (3)$$
$$Sajna\ (pond\ water): \quad y = 86.689 - 0.051x; \quad R^2 = 0.84 \quad (4)$$

$$Alum\ (pond\ water): \quad y = 93.665 - 0.0181x; \quad R^2 = 0.95 \tag{5}$$

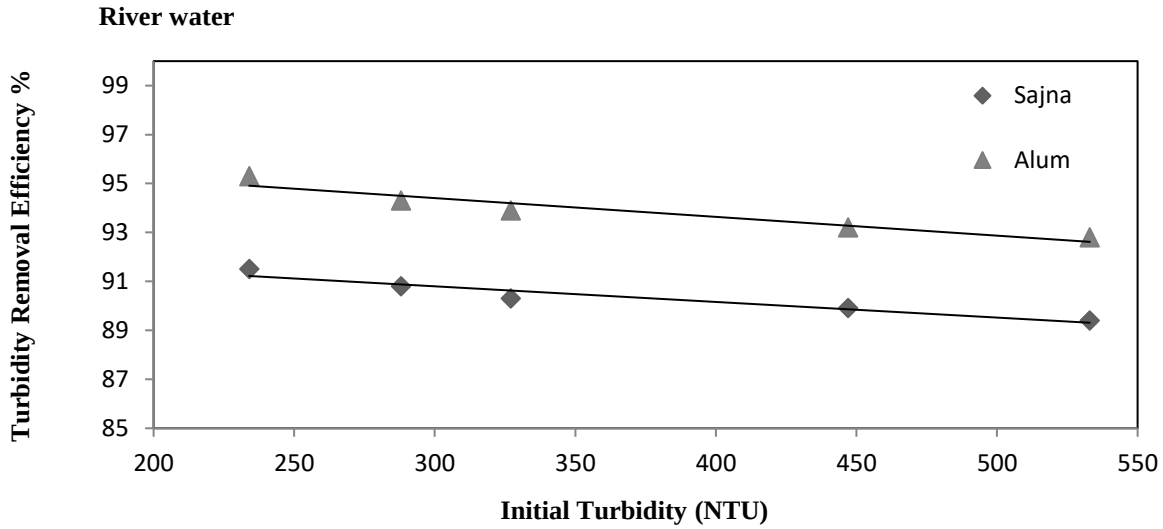

Figure 8: Variation of the turbidity removal efficiency for the coagulants (River water)

Figure 9 show the variation of the color removal efficiency for coagulants for river water. It is seen that the color removal efficiency linearly decreases with increasing initial color for both river and pond water. Linear correlations for the color removal efficiency are proposed by Equations (8) to (11) for the all coagulants.

$Sajna$ (river water): $y = 81.748 - 0.0137x; \quad R^2 = 0.92$ (8)
Alum (river water): $y = 98.820 - 0.0235x; \quad R^2 = 0.91$ (9)
Sajna (pond water): $y = 82.222 - 0.0219x; \quad R^2 = 0.86$ (10)
Alum (pond water): $y = 97.605 - 0.0080x; \quad R^2 = 0.97$ (11)

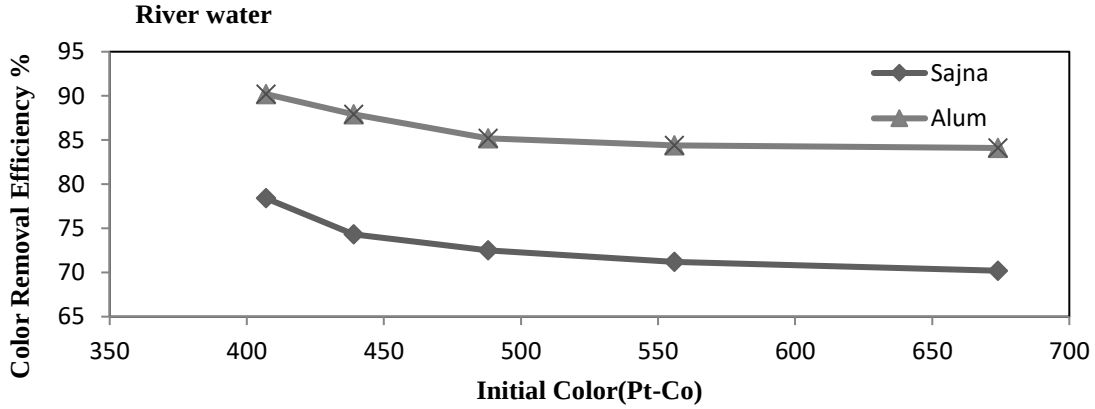

Figure 9: Variation of the color removal efficiency for the coagulants (River water)

4. CONCLUSIONS

This study showed the performances of bio-coagulant such as Sajna seeds which are used for the treatment of pond and river water. The optimum doses for the Sajna seeds coagulant was found as 32 and 24 mg/l for the river and pond water, respectively. The turbidity removal efficiencies of the coagulants are varied from 86.3 to 96% with compared to alum coagulation. It is found that the turbidity and color removal efficiencies (>70%) are satisfactory for the coagulant which is significant for use as a coagulant in water treatment purpose. The use of bio-coagulant would be a possible

alternative to chemical coagulant for the same treatment of drinking water in rural areas and developing country like Bangladesh. Hence, it is concluded that these natural coagulant such as Sajna seeds could be used as coagulant for surface water treatment purpose.

4.1 Further Studies

Further studies are outlined as follows:

- In this study, performance study of bio-coagulant such as Sajna seeds are performed as coagulant. Similar research could be conducted using other easily available natural bio-coagulants.
- Some physical and chemical properties of water samples such as pH, turbidity, color and conductivity are analyzed. Some other important physical and chemical properties such as total solid, total dissolved solid, total suspended solids and Total coliform could also be analyzed.
- In this study, bio-coagulants are used for the treatment of drinking water only. Similar research could be conducted for industrial waste water treatment using bio-coagulant.

ACKNOWLEDGEMENTS

We would like to express my deep sense of gratitude, grateful appreciation and heartiest thanks to our supervisor Dr. Kh. Md. Shafiul islam, professor, department of civil engineering, Khulna university of engineering and technology, Khulna, Bangladesh for having faith in us for carrying the responsibility of doing research work under his profound guidance. His prominence giving us this opportunity and his constant attention and support throughout our study conferred us with sense of responsibility.

REFERENCES

Ali, E. N., Muyibi, S. A., Salleh, H. M., and Alam, M. J. 2009. *Moringaoleifera* Seeds as Natural Coagulant for Water Treatment.Thirteenth International Water Technology Conference, P. 163-168.

Amagloh, F., and Benang, B. 2009. Effectiveness of *Moringaoleifera* seeds as Coagulant for Water Purification. African. Journal of Agric, Vol. 4 (1), P.119-123.

Antov, M.G., Šciban, M.B., and Petrovic, N.J. 2010. Proteins from Common Bean (Phaseolus Vulgaris) Seed as a Natural Coagulant for Potential Applicationin Water Turbidity Removal, Bioresour. Technol,Vol. 101, P. 2167–2172.

Antov, M.G., Šciban, M.B., and Prodanovic, J.M. 2012. Evaluationofthe Efficiency of Natural Coagulant Obtained by Ultrafiltrationof Common Bean Seed Extract in Water Turbidity Removal, Ecol. Eng, Vol. 49, P. 48–52.

Arnoldsson, E., Bergman, M., Matsinhe, N., and Persson, K. P.2008.Assessment of Drinking Water Treatment using *MoringaOleifera* Natural Coagulant. VATTEN, Vol. 64, P. 137–150.

Bakare, B. F. 2016. An Investigation of MoringaOleifera Seed Extract as a Natural Coagulant in Water Treatment. World Congress on Engineering and Computer Science, Vol. 2.

Crittenden, J.C., Trussell, R.R., Hand, D.W., Howe, K.J., and Tchobanoglous, G.2005. Water Treatment Principles and Design, 2nd Ed. John Wiley & Sons, Inc. Hoboken, New Jersey.

Gassenschmidt, U., Jany, K.D., Tauscher, B., and Niebergall, H.1995. Isolation andCharacterization of a flocculating protein from *Moringa oleifera* Lam. Biochimicaetbiophysicaacta, Vol. 1243. P. 477–481.

Ghebremichael, K.A., Gunaratna, K.R., Henriksson, H., Brumer, H., and Dalhammar, G. 2005. A Simple Purification and Activity Assay of the Coagulant Protein from *Moringaoleifera* Seed. Journal of Water Research, Vol. 39, P. 2338-2344.

Gleick, P. H., 1996. Water resources. In Encyclopedia of Climate and Weather, ed. by S. H. Schneider, Oxford University Press, New York, Vol. 2, P.817-823.

Hellsinga, M. S., Kwaambwab, H.M., Nermarkc, F. M., Nkoanec, B. B.M., Jacksond, A. J. M. J., Wasbroughe, M. J.,Bertsg, F. I.,Porcarh,L.,and Renniea, A. R.2013. Structure of flocs of latex

particles formed by addition of protein from*Moringa* seeds. Elsevier Journal of Colloids and Surfaces A: Physicochemical and Engineering Aspects.

Libanius, M. 2008. Fundamentals of Quality and Water Treatment. 2nd Ed. Campinas. Atom Ed, P. 444.

Lilliehöök, H. 2005. Use of sand filtration on river water flocculated with *Moringaoleifera*. Division of sanitary engineering, department of civil and environmental engineering, luleå, University of technology.

Magaji, U. F., Sahabi, D. M., Abubakar, M. K., and Muhammad, A. B. 2015. Biocoagulation Activity of *Moringaoleifera* Seeds for Water Treatment. The International Journal of Engineering and Science, Vol.4, P.19-26.

McLachlan, D. R. C. 1995. Aluminum and the risk for Alzheimer's disease, ActaCosmol, Vol. 6, P. 223–275.

Miller, S.M., Fugate, E.J., Craver, V.O., Smith, J.A., and Zimmerman, J.B. 2008. Toward Understanding the Efficacy and Mechanism ofOpuntia Spp. as a Natural Coagulant for Potential Applicationin Water Treatment. Environmental Science Technology, Vol. 42.

Muyibi, S. A., and Alfugara, A. M. S.2003. Treatment of Surface Water with *MoringaOleifera* seeds and alum – a comparative study using a pilot scale water treatment plant. International Journal of Environmental Studies, Vol. 60(6), P. 617–626.

Nandini, M., and Sheba, M. C. 2016. Emanating Trends in the Usage of Bio-coagulants in Potable Water Treatment: a Review. International Research Journal of Engineering and Technology, Vol. 3, (11), P. 970-974.

Ndabigengesere, A., Narasiah, S.K., and Talbot, B.G. 1995. Active Agents and Mechanism of Coagulationof Turbid Waters using. Water Research, Vol. 29, (2), P. 703-710.

Okoli,C., Boutonnet, M., Jaras, S., and Kuttuva, G. R. 2012. Protein-functionalized magnetic iron oxide nanoparticles: time efficient potential-water treatment. Journal of Nanoparticle, Vol.14, P. 1194-1203.

Richter, C.A. 2009. Water Methods and Treatment Technology. 1st Ed. São Paulo. Ed Blucher, P.333.

Rico, T. E. F., Santos, L. M., Reis, E. M., Silva, F. F., andZonetti, P. C. 2010. Treatment of Tannery Wastewater using Seeds of *Moringa* (*MoringaOleifera L.*). Agro Magazine Environment, Vol. 4, (2), P. 96-101.

Saharudin, N. F. A., and Nithyanandam, R.2014. Effluent Treatment by using Natural Coagulant. 2nd Eureka.

Schwarz, D. 2000. Water Clarification using *Moringaoleifera*. Technical Information W1e, Gate Information Service.Eschborn, Germany.

Sikkema, J., Bont, J. A. M., and Poolman, B. 1995. Mechanisms of Membrane Toxicity of Hydrocarbons. Journal of Microbiol, Vol. 59, P. 201-222.

Srinivasan, P. T., and Viraraghavan, T. 2002. Characterization and Concentration Profileof Aluminum during Drinking Water Treatment. Water SA, Vol. 28, P. 99–106.

Srinivasan, P. T., Viraraghavan, T., and Subramanian, K. S.1999. Characterization and concentrationProfileof Aluminum during Drinking Water Treatment. Water SA, Vol. 25, P. 47–56.