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Removal of iron and turbidity from ground water by natural and chemical coagulants

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Abstract

Water is an essential element of our life. But when this water contains impurities like iron, turbidity, it impacts on water consumption. The objectives of this study were removal of iron and turbidity by using coagulation, sedimentation, jar test and filtration. Dolichos lablab, Litchi chinensis were used as natural coagulant and alum was used as chemical coagulant. Turbidity was removed by Litchi chinensis (88%) which was better than of Dolichos lablab (48%). But chemical coagulant alum (98.4%) was more successful than natural coagulants. pH was differed for Dolichos lablab (8.36) and Litchi chinensis (8.16) due to addition of alum in the treatment process. Salinity (359.13mg/l) was unaffected throughout the whole experiment. EC (406.2µS/cm) and TDS (201.99g/l) were decreased for natural coagulants `and increased (466.23µS/cm, 232.99g/l) for chemical coagulant. Initial value of Iron was measured 2.19mg/l. Both natural and chemical coagulant were successfully removed Iron up to 97.17%. All the analyzed parameters were compared with national and international drinking water quality standards to understand treated water quality. All of the physicochemical parameters of samples were in acceptable limits. The study recommended that, treated water could be used for drinking and domestic purposes.

Keywords: Natural coagulants, turbidity, iron, water quality

Introduction

Iron (Fe) is troublesome metal that easily found naturally in soils, rocks and minerals. When iron contact with ground water, it dissolved itself thus releasing its constituents. Iron present in the water at 0.3mg/L can cause serious impact, e.g., plumbing fixtures and metallic taste. However, the health risk of dissolved Fe in drinking water is very little[1]. Water quality largely depends on water composition contributed mainly by natural process and then by human activities. Human health is at risk if the quality of water standard values surplus accepting values[2]. Soil and water resources pollution poses a problem of significant concern not only to the biota in the environment but also to human beings[3]. Limited people have access public distribution system, which only use chemicals to treat water. That pose serious financial burden for developing countries[4]. Developing countries pay high cost for water treatment[5]. It is serious problem in Bangladesh. Majority of people (80%) in Bangladesh is lack of clean and safe water[6]. Moreover, using chemicals for water treatment result in causing serious health hazards (conjunctivitis, choroiditis, and retinitis)[7]. So, low-cost and replicable non-chemicals would be very effective in the treatment of water. Natural coagulant and vegetable parts have potentialities on hardness, turbidity iron and microbial count of contaminated water[4]. For centuries natural coagulants have been used for in traditional water treatment in tropical rural areas[8]. Water turbidity and other impurities can easily be removed by means of Coagulation and flocculation[9]. As the socio economical condition is poor and the distribution of water supply is inadequate, we have to find alternative way of treatment of water. Natural coagulant serves a best way to solve this problem. Water treatment by using natural coagulant is not only cheap but also effective. It also harmless, easy to perform and its availability are frequent[10]. Iron in drinking water create occupational hazard. As iron converts itself from ferrous to ferric it tends to attach with household equipment and decolorized clothes if wash with iron containing water[11]. The main objective of the study is to remove iron and turbidity from drinking water by using *Dolichos lablab*,*Litchi chinensis* and compare the effect of treatment with chemical coagulant (Alum). The overall aim is to develop a process which is economic efficient and can be used alternative source of chemical coagulant.

Materials and methods

Materials: Alum, *Dolichos lablab*, *Litchi chinensis* seeds were collected from local store. Then they were air dried in two steps: i. Sun dry, then, ii. Oven dry.

After the outer layer was removed, they grained with grinding machine. The seed kernels were ground to fine powder using a kitchen blender to make it of approximate size of 600µm to achieve solvents of active ingredients in the seed. The water sample was sterilized in plastic bottle. Sample was collected from jug, tube well and before taking the sample the plastic bottle was rinsed with sample water for the finding of accurate result.

Methods: 1g of seed and 0.5g of alum was mixed with 100ml of distilled water to prepare 1% stock solution. To promote water extraction of the coagulant proteins the suspension was continuously shaken for 45 minutes using a magnetic stirrer and this was then passed through filter paper (Whatman No. 42, 125 mm dia). Jar test was performed to identify the various responses of pH, turbidity, total dissolved solids and electronic conductivity of sample water[12].

Specific amount of coagulants were added to the suspensions at various mixing speed and time (200-240 rotation per minute, rpm for 1-5minutes and slow mixing 50-80rpm for 35-45 minutes). The suspensions were allowed to settle for 20-30 minutes. The sample was collected with pipette for the measurement of turbidity, pH, TDS, EC and Iron. Then a filter paper or cotton cloth was used to filter water to remove the residuals. After that water was collected in sample jar. Turbidity, pH, and electronic conductivity, total dissolved solids measured again to observe the values. Iron was determined by Atomic Absorption Spectrometry. All tests were performed at an ambient temperature (26-32°C).

Result and discussion

pH: The value of pH significantly changed after treatment. The initial value was increased as high as 8.36 for *Dolichos lablab* seed extract (50% dose) and was deceased as low as 8.16 for *Litchi chinensis* seed extract (25% dose). But it was in acceptable limit (6.5-8.5)[13]. So, the treatment process had an impact on water pH. Similar study Amagloh F. *et al*., (2009) showed *Moringa oleifera* seed as a coagulant could increase pH value. pH was ranged 7.2 to 7.9 for treatment of water[14]. Shan T. *et al*., (2009) experimented on Sungai Baluk River where initial pH was 8.03 which did not change after treating with natural coagulant (*Moringa oleifera*)[14]. Also Sarker P. *et al*.,(2015) observed pH was increased while treating turbid water with natural coagulant (*Litchi chinensis, Dolichos lablab*)[15].

Table-1: Parameters observed for *Litchi chinensis* seed extract.

Parameters	Initial value	Dose		
		25%	50%	75%
pH	7.70	8.13	8.16	8.20
Ec	450.23(µS/cm)	442.22	442.22	426.21
TDS	225(g/L)	220.99	225.3	212.99
Salinity	359.13(mg/l)	359.13	359.13	359.13
Turbidity	44.1(NTU)	8.51	8.37	13.8
Iron	2.19(mg/l)	<0.05	<0.05	<0.05

Table-2: Parameters observed for *Dolichos lablab* seed extract.

Parameters	Initial value	Dose		
		25%	50%	75%
pH	7.70	8.31	8.33	8.30
Ec	450.23(µS/cm)	420.2	420.2	406.21
TDS	225(g/L)	218.99	208.3	202.99
Salinity	359.13(mg/l)	359.13	359.13	359.13
Turbidity	44.1(NTU)	19.1	18	23
Iron	2.19(mg/l)	<0.05	<0.05	<0.05

Table-3: Parameters observed for Alum.

Parameters	Initial value	Dose		
		25%	50%	75%
pH	7.70	8.33	8.24	8.27
Ec	450.23(µS/cm)	466.23	446.22	464.23
TDS	225(g/L)	232.99	232.99	231.99
Salinity	359.13(mg/l)	359.13	359.13	359.13
Turbidity	44.1(NTU)	13.1	3.88	0.7
Iron	2.19(mg/l)	<0.05	<0.05	<0.05

Salinity: The salinity of water was measured 359.13mg/l and it was observed to be same for every coagulant. So, the treatment process did not impact on salinity of water. But natural coagulant could impact salinity. Salinity was observed to be increased as a result of treatment process for different doses of coagulant[16].

Turbidity: Turbidity was successfully removed by *Litchi chinensis* seed. The turbidity of Sample water was measured 44.1NTU. The turbidity was observed significantly less after treatment of water. For 25%, 50%, 75% doses of *Litchi chinensis* seed turbidity were 6.53NTU, 6.92NTU, and 10.2NTU. At this stage turbidity was removed up to 85% of water for 25% dose. And after filtration turbidity was measured 8.51NTU, 8.37NTU, 13.8NTU for respective doses. So turbidity removed by 81% for 50% dose. This was matched with standard of 10 NTU[17]. But treated water was getting turbid (reddish in color) as time progress. It was for the presence of seed extract used in the treatment process. The turbidity was removed successfully for 50% dose for each process and it was well below 10 NTU.

Turbidity was removed successfully by *Dolichos lablab* seed extract. After treatment of water for 25%, 50%, 75% doses turbidity were observed 22.34NTU, 19.67NTU, and 15.3NTU. At this stage turbidity was removed up to 65% for 50% dose range. And after filtration turbidity was measured 19.1NTU, 18NTU, 23NTU for respected doses. So, turbidity was removed 59% for 50% dose. Turbidity was increased while two or three drops of alum was added to *Dolichos lablab* seed extract. It was not as successful as previous. After jar test turbidity was calculated 36.2NTU, 36NTU and 26.73NTU. After filtration turbidity was measured 34.3NTU, 36.3NTU and 24.1NTU for respected doses. So turbidity was removed 45% for 75% dose. The turbidity removal was remarkable but it was well above than Bangladesh drinking standard 10NTU[18].

Alum was also found to be effective. At 25% dose turbidity was measured (before filtration) 13.45NTU. After filtration it was measured 13.1NTU. Turbidity was decreasing as doses were increasing. At 50% dose turbidity was measured 4.03NTU (before filtration). After it was filtrated with general tissue paper turbidity was measured 3.88NTU. It represented 92% removal of turbidity. Similarly for 75% dose turbidity was measured .73NTU after jar test. After it was filtrated with general tissue paper turbidity was calculated .70NTU. It represented 98.4% removal of turbidity.

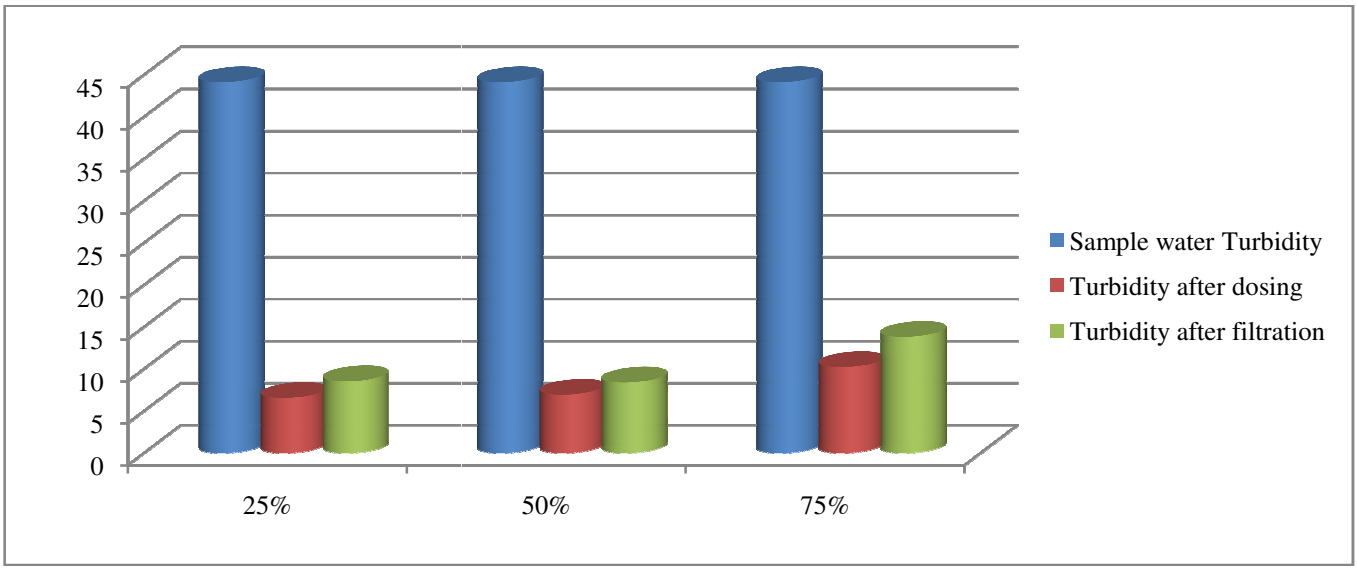

Figure-1: Removal of turbidity using various doses of *Litchi chinensis.*

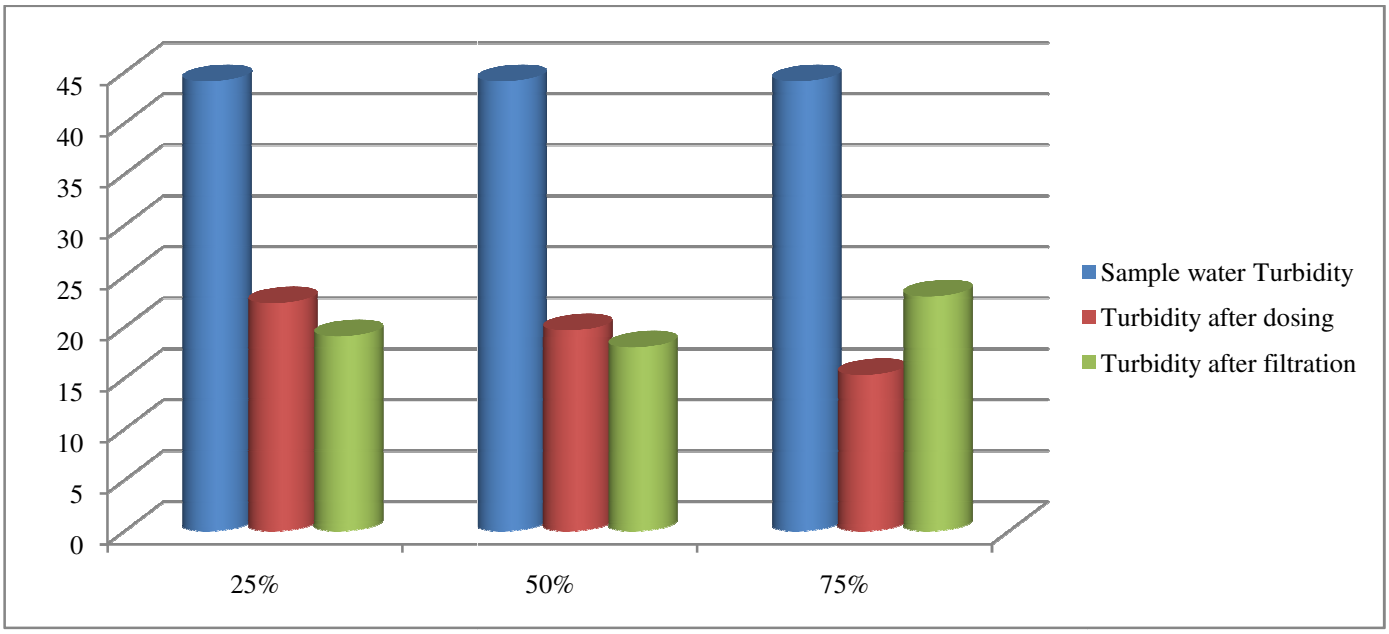

Figure-2: Removal of turbidity using various doses of *Dolichos lablab.*

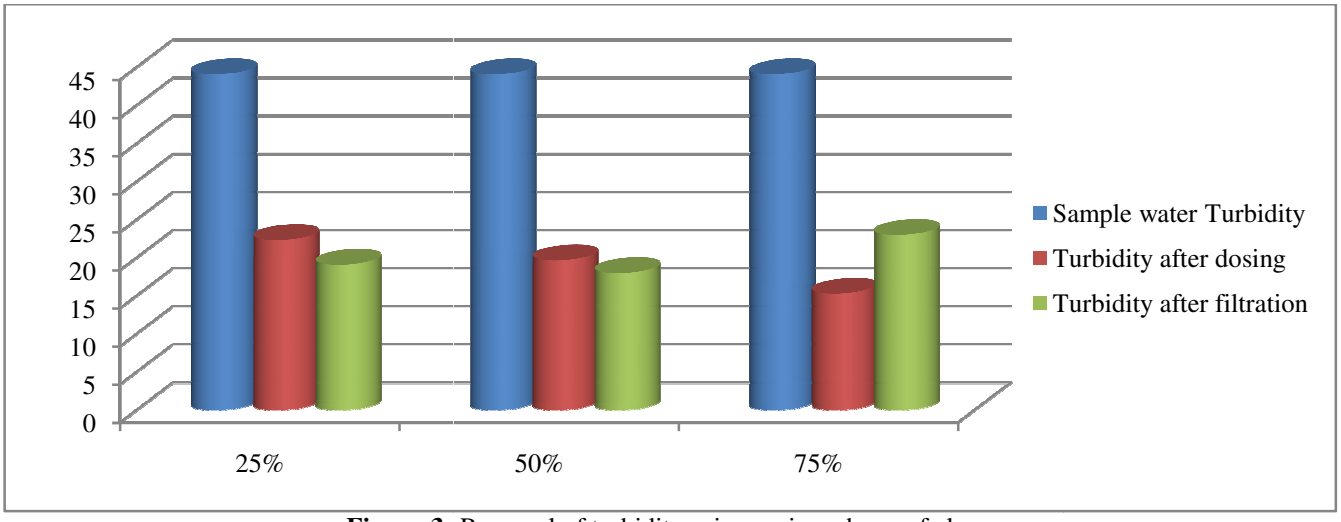

Figure-3: Removal of turbidity using various doses of alum.

Similar study, H. Zemmouri showed that turbidity was reduced from 129NTU to 39.4NTU corresponding to 69.45% of abatement rate for *Moringa oleifera* seed extract[16]. A H Birima *et al* showed turbidity was removed up to 25% and the real value was 200NTU to 150NTU for peanut seeds extract[17]. Sarker P. *et al* found that turbidity reduction was very efficient for *Litchi chinensis* and *Dolichos lablab* seed. Turbidity reduction efficiency of *Litchi chinensis* for 50, 75 and 100mg/l doses were 95.19%, 96.61% and 94.51%. Also for similar doses turbidity reduction efficiency of *Dolichos lablab* was 86.01%, 87.70% and 84.77%[10]. Jafari A. *et al* found natural coagulant *Moringa foleifera* (MO) was an efficient coagulant with some advantages over chemical coagulants. And at effective dose and controlled pH condition turbidity could be removed 94.41%[19].

Table-4: Efficiency of turbidity removal by using *Litchi chinensis* seed extract.

Dose	Initial value NTU	After treatment, NTU	Final value NTU	Reduction %	Reduction efficiency %
25%	44.1	6.53	8.51	80.7	76.8
50%	44.1	6.92	8.37	81	
75%	44.1	10.2	13.8	68.7	

Table-5: Efficiency of turbidity removal by using *Dolichos lablab* seed extract.

Dose	After treatment	Final value	Reduction %	Reduction efficiency %
25%	22.34	19.1	56.7	54.53
50%	19.67	18	59	
75%	15.3	23	47.9	

Table-6: Efficiency of turbidity removal by using for alum.

Dose	After treatment	Final value	Reduction %	Reduction efficiency %
25%	13.45	13.1	70.3	86.56
50%	4.03	3.88	91	
75%	0.73	0.7	98.4	

TDS: TDS was measured 225mg/l for sample water. TDS was measured 220.99mg/l, 225.3mg/l and 212.99mg/l for 25%, 50%, and 75% doses of *Litchi chinensis* seed wxtract. TDS removed efficiently at 75% dose and the reduction of TDS was 5.33 TDS value was decreased randomly for *Dolichos lablab* seed extract. TDS was increased for 50% dose and was decreased for 75% dose of seed extract. TDS was removed efficiently for 75% dose and the reduction of TDS was 10.22%. Alum was failed to reduce TDS from collected water. Because alum contained $Al_2(SO)_3$, K_2SO_4 and these elements mixed while treating with sample water. But TDS was considered to be in acceptable limit. Similar study Sarker S. *et al*[10] found TDS was reduced from 773mg/l to 660, 70 and 60mg/l for 50, 75 and 100mg/l doses of *Litchi chinensis* and 640, 650 and 60mg/l for respective doses of *Dolichos lablab*. Also, Shan *et al*[16] found that TDS increased from 307mg/l to 400mg/l as a result of treatment with natural coagulant (*Moringa oleifera*).

EC: EC was calculated 450.23µS/cm for sample water. EC was observed 442.22µS/cm, 442.22µS/cm, 426.21µS/cm for 25%, 50%, 75% doses of *Litchi chinensis* seed extract. EC was 438.21µS/cm, 420.21µS/cm and 406.2µS/cm for *Dolichos lablab* seed extract for respective doses. EC was decreased for 75% dose in both cases. Alum was failed to reduce EC from sample water. EC was increased 3.73% for 75% dose. Same study Shan *et al.*[16] showed that, EC could be increased while

treating with natural coagulant and it could increase as high as 13.25% from initial measurement. EC was reduced from 1601µs/cm to 57.1µs/cm, 8.05µs/cm and 7.02µs/cm for 50, 75 and 100mg/l doses of *Litchi chinensis* and 68.2µs/cm, 65.1µs/cm and 6.86µs/cm for respective doses of *Dolichos lablab*[10]. All values were observed within standard limit of TDS (<1500µs/cm) recommended by WHO[13].

Iron: Iron was successfully removed from drinking water. Iron was treated with different coagulant at different doses. Sample water was treated with alum, *Litchi chinensis* and *Dolichos lablab* seed extract. The result was astonishing. The efficiency of iron removal was up to 97.17%.

Table-6: Measurement of Iron observed for coagulant.

Dose	Initial value mg/l	Final reading (mg/l)	Removal efficiency
25% dose	2.19	<0.05	97.17%
50% dose	2.19	<0.05	97.17%
75% dose	2.19	<0.05	97.17%

Similar study Ravikumar and Sheeja[20] examined the coagulation mechanism of the *Moringa oleifera* (heavy metals with initial concentration of 5mg/L Copper, Lead, Cadmium, and Chromium). Moringa seeds were successful to remove metals tested in some water samples. The of removal percentage by Moringa seeds were observed 93% for lead, 95% for copper, 70% for chromium and 76% for cadmium. Also Salma Shahid[11] reveled that at effective doses of Alum iron could be removed up to 90%. S.M. Sajidu *et al*[21] found the potentiality of *Moringa Oleifera* in removing lead, iron, and cadmium ions from synthetic contaminated water was observed ranging from 89.40% for lead, 92.14% for iron and 47.73% for cadmium[21].

Conclusion

Present study tried to investigate physicochemical characteristics change and their impact due to treatment process of water. From result analysis it was known, almost all parameters were in acceptable limit. And treated water was drinkable. These results could be used finding an alternative and cheap way for water treatment.

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