Studies on Ecofriendly approach for removal of water hardness by *Moringa oleifera* Lam. seed extract

Ranadive Ananth Govindaraju[1], Bijaya Kumar Nayak[1]*, N. Arun[1], Gayathri Parivallal[2], Anima Nanda[3]

[1]Department of Botany, Kanchi Mamunivar Govt. Institute for Postgraduate Studies and Research (Autonomous), Puducherry - 605008, India.

[2]Chief Operating Officer, Green Enviro Polestar, Puducherry - 605007, India.

[3]Department of Biomedical Engineering, Sathyabama Deemed University, Chennai, India.

*Corresponding Author E-mail: **animananda72@gmail.com, bijuknayak@gmail.com**

ABSTRACT:

Water softeners helps in removing hardness of water and make them fit for our daily decisive usages. For our work, different water sources like surface water (Hebbal Lake), Bore well water (NPS School, Ozone Urbana, Bangalore) and Corporation water (BWSSB) were selected and their respective hardness as $CaCO_3$ were analysed before and after treatment with *Moringa oleifera* seed extract. The seeds of *Moringa oleifera*, one of the best natural coagulants as per the previous studies were used in this protocol. In normal water treatment scheme most preferably ion exchange techniques were used for the removal of hardness, which would likely to be a resin based technology. Also the ion exchange procedure was completely dependent on industrial resins, which were manufactured by major corporate concerns (like Lancer, Toyota, Ion Exchange India Ltd, Thermax Ltd, LG etc.), hence incur huge cost. Industrial resins have Na^+ ions attached to the resin beads replaces Ca^{2+} and Mg^{2+} ions present in water during the ion exchange process. The resin beads can be regenerated or recharged again with Na^+ ion by NaCl solution once the resin gets exhausted. Our work persuaded in another way of removing hardness from water by the principle means of adsorption and conversion of soluble hardness-causing ions to insoluble products by precipitation reactions. *Moringa oleifera* seed extracts were prepared and performed jar test to obtain the best required dosage for hardness removal in the selected water samples. The obtained dosage (mg/l) or ppm of *Moringa oleifera* was dosed to the selected water samples through the dosing system present in an existing water treatment system of capacity 2 m3/hr. The removal efficiency was observed to be between 50 to 60% after passing through the treatment system with *Moringa oleifera* dosage. Hence this work can pave way to find a best alternate method for hardness removal water.

KEYWORDS: *Moringa oleifera* Lam., Water Hardness removal, Alternate water softeners, adsorption, Natural Coagulants, Plant Based Water Treatment, Surface water treatment.

INTRODUCTION:

Water hardness is the traditional measure of the capacity of water to react with soap and producing lather[1]. Hardness in natural water is caused by dissolved minerals, mainly calcium and magnesium compounds[2]. Hardness is mostly and commonly expressed as milligrams of calcium carbonate equivalent per litre.

Water containing calcium carbonate at concentrations below 60mg/l is generally considered as soft; 60–120 mg/l, moderately hard; 120–180mg/l, hard; and more than 180mg/l, very hard[3]. Hardness may be discussed in terms of carbonate (temporary) and non-carbonate (permanent) hardness. In other words, the temporary hardness is due to the presence of soluble ions and permanent hardness is due to the presence of insoluble ions. Water softeners have lucrative applications in attenuating the scaling compound mainly calcium and magnesium in water[4,5]. *Moringa oleifera* seed suspension is known to be a natural coagulant and coagulant aid[6,7,8,9]. In Sudan, dry *Moringa oleifera* seeds are used in place of alum by rural women to treat highly turbid Nile water[4]. Suleyman[1] carried out jar tests with *Moringa oleifera* as the primary coagulant using water from four different sources viz., two surface and two shallow wells with turbidity's from 100 to 800 NTU and 80 to 150 NTU respectively and hardness from 180 to 300 mg/l as CaCO3[10,11,12]. It was observed that in addition to turbidity reduction of 92-99%, the hardness was also reduced to between 60-70% after coagulation and two hours settling. The softening property of *Moringa oleifera* which was accidentally discovered in that study is the only one documented to date. The present study was therefore carried out to find an alternate method for water softening at industrial scale usage. Hence an existing industrial scale water treatment system of capacity 2m3/hr was used in this study.

MATERIALS AND METHODS:

Water Samples Collection from different sources:

Bore well water obtained directly from the bore well (NPS School, Bangalore) through transfer pumps, Surface Water collected from Hebbal Lake, Bangalore through private water tanker having capacity 5000L, BWSSB Water collected from corporation line. All these water samples were stored in the storage tank of capacity 10m^3 Volume (existing). Each sample volume of 4000 Litres was used in this study.

Extract Preparation from *Moringa oleifera* seeds:

Moringa oleifera seeds were collected from Arakandanallur, Thirukoilur Taluk, Villupuram District, Tamilnadu, India. The pods collected were allowed to dry completely on the tree (the brown colour pods) because the green pods do not possess any coagulation activity[3,13,14]. Even sized seeds were separated and ground in a blending machine to a fine powder. 10 grams the ground seeds were weighed and distilled water was added and mixed properly. The suspension was filtered through a muslin cloth and the filtrate was made up to 500ml in a graduated beaker using sterile distilled water. The prepared extract will be of 2% (w/v) concentration and will act as a standard solution to carry out further downstream works[12,13]. The stock solutions were prepared freshly for each steps involved.

Jar Test for Turbidity and Hardness removal:

Each water samples were taken in (one set) 6 numbers of 500ml beakers[14]. Hence totally 18 beakers were taken for the procedure each with separate magnetic stirrer for mixing. The Freshly prepared *Moringa oleifera* extract was added to each set of beakers with dosage ranging from 10mg/l to 60mg/l and let for proper stirring. The stirring procedure was done for 2 minutes and allowed for coagulation, precipitation and settling for 10 minutes at 100rpm (Jar testing Apparatus: Phipps and Bird Inc., USA) and tested for hardness removal.

Water Treatment Plant working with Resin Based Technology for the Hardnes Removal:

Project Name : National Public School, Ozone Urbana, Bangalore
Project Type : Water Softener
Flow Capacity : 2cum/hr
Operation Hours : 10hrs

Water Sources:

- Surface water from Hebbal Lake, Bangalore,
- Bore well water from NPS School, Ozone Urbana, Bangalore,
- Corporation Water from BWSSB (Bangalore Water Supply and Sewerage Board)

The scheme and technical specifications for softening of hard water was erected by M/S. Green Enviro Polestar were employed in the study is given in Table 1.

Table 1: The scheme and technical specifications for softening of hard water

Sl. No.	Scheme	Technical specifications
1.	Raw Water Storage Tank	Capacity: 20 KL, RCC Tank water proofed
2.	Filter Feed Pumps	Flow Rate: 2m^3/hr Head: 35m Quantity: 2 Make: Kirloskar Type: Vertical Submersible MOC: Cast Iron
3.	Alum Dosing System	Pump Flow rate: 6 Lph Make: Edose Tank Capacity: 250 L Make: HDPE (High Density Poly Propylene)
4.	Pressure Sand Filter	Design Velocity: 12-15m/hr Pressure: 3.5Kg/cm^2 Filter Diameter: 600mm HOS (Height on Straight): 1250mm Material of Construction: MS (Mild Steel) Filter Make: GEPS
5.	Activated Carbon Filter	Design Velocity: 14-18m/hr Pressure: 3.5Kg/cm^2 Filter Diameter: 600mm, HOS (Height on Straight): 1250mm Material of Construction: MS (Mild Steel) Filter Make: GEPS
6.	Softener	Filtering Media: Ion Exchange Resin

	Filter	Resin Make: Ion Exchange India Ltd Model: INDION 220 Na Pressure: 3.5Kg/cm^2 Filter Diameter: 600 mm HOS (Height on Straight): 1250mm Material of Construction: MS (Mild Steel) Filter Make: GEPS
7.	Chlorine Dosing System	Pump Flow rate: 6 Lph Make: Edose Tank Capacity: 250 Litre Make: HDPE (High Density Poly Propylene)
8.	Treated Water Storage Tank	Capacity: 10 KL RCC tank water proofed.

Each collected water samples of volume 4000 Litres were filled one by one in the raw water tank and the system was operated for 1 hr each. For each batch 2000 L of the sample water was treated and the treated samples were taken for Hardness analysis Standard Methods[9].

Water Treatment Plant working with *Moringa oleifera* extract for Hardness Removal:

In the above sorted water treatment scheme we have bypassed the softener filter and the alum in the dosing system was replaced with *Moringa oleifera* extract[12,13]. *Moringa oleifera* extract of 2% strength (2 kg of extract in 100 L of normal water) was prepared and stirred with a mechanical mixer for 2 minutes at 100rpm (Table 2). Also the dosage concentration of 60mg/l obtained through jar test was dosed online to the treatment plant via dosing pump of capacity 6 Lph at full stroke rate.

Table 2: Procedure of softening of hard water by Jar Test

Plant Flow Rate	2 m^3/hr
Operating hours	10 hrs
Flow per day	Flow rate * Operating hrs 2 m^3/hr * 10 hrs : **20 m^3/d**
Dosage obtained from jar test	60 mg/l
Dosage for 20 m^3/d capacity in (Kg)	(20 m^3/d * 60 mg/l)/1000: **1.2 Kg/d**
Converting to Lpd (Litres/day)	Dosage in Kg/Solution strength 1.2 Kg/0.02 : **60 Lpd (Litres/day)**
Dosing Pump Flow rate (per hr)	Dosage per day/operating hrs 60 Lpd/10 hrs : **6 Lph (Litre/hr)**
Dosing Pump Stroke Rate (%)	100 %

All the three water samples were allowed to pass on the water treatment system separately at a designed flow rate of 2cum/hr and the resulted treated water was tested for Hardness (Table 2).

RESULTS AND DISCUSSION:

Jar test analysis:

The below tabulated values showed a clear picture that 60mg/l dosage of *Moringa oleifera* extract of 2% strength will be the best opted dose for effective hardness removal in all the three selected water samples. The removal efficiency observed to be in the range of 40 – 60%. Hence the same dosage was used in an existing water treatment plant of capacity 2m3/hr, which can treat up to 20000litres of water per day. Waters collected from different regions and their hardness are given in Table 3, 4 and 5.

Table 3: Bore Well Water: Initial hardness (265 mg/l as $CaCO_3$)

Water Source	Moringa Dosage (mg/l)	Total Hardness mg/l as ($CaCO_3$)	Removal Efficiency (%)
Bore Well Sample	10	232	12.5
	20	202	23.8
	30	185.6	29.9
	40	146.2	44.8
	50	135.2	48.9
	60	127	**52.1**

Table 4: Surface Water: Initial hardness (364 mg/l as CaCO3)

Water Source	Moringa Dosage (mg/l)	Total Hardness mg/l as ($CaCO_3$)	Removal Efficiency (%)
Surface	10	324.1	10.9

water	20	321	11.8
	30	253	30.5
	40	221	39.3
	50	203	44.2
	60	196	**46.2**

Table 5: BWSSB Water: Initial hardness (98 mg/l as $CaCO_3$)

Water Source	Moringa Dosage (mg/l)	Total Hardness mg/l as ($CaCO_3$)	Removal Efficiency (%)
BWSSB Water	10	96.5	1.5
	20	94	4.1
	30	86	12.2
	40	55	43.9
	50	55	43.9
	60	49.1	**49.9**

The water samples collected from BWSSB (Bangalore Water Supply and Sewerage Board) was pre treated with Pressure Sand Filter, Activated Carbon Filter and Water Softener. The Water treatment system used in this study was erected by M/S. Green Enviro Polestar at National Public School, Devanahalli, Bangalore. Schemes available with the system are Filter Feed Pumps, Alum Dosing System, Pressure Sand Filter, Activated Carbon Filter and Softener. Here we used the Alum Dosing System for dosing our *Moringa oleifera* extract with the obtained dosage of 60mg/l at strength of 2% concentration. Also the softener filter was bypassed during *Moringa oleifera* dosage. The selected water samples were checked for hardness and turbidity after treating through the system. There was a considerable reduction of hardness in all the selected water samples observed.

Hardness removal efficiency of the resin based technology was observed to be 90 -95% and the removal efficiency of *Moringa oleifera* extract with 60mg/l litre dosage was observed to be 50 -60% which was likely to be the best positive note to find an alternate eco-friendly procedure for hardness removal (Table 6 and Fig 1).

Table 6: Efficiency resulting from Resin treatment and *Moringa oleifera* extract treatment.

Water Source	Sample Type	TH as ($CaCO_3$)	Removal Efficiency (%)
Bore Well	Untreated	238	-
	Resin Treated	11	95.4%
	Treated with Moringa	113	52.5%
Surface Water	Untreated	124	-
	Resin Treated	5	95.9%
	Treated with Moringa	51.2	58.7%
BWSSB Water	Untreated	101	-
	Resin Treated	9.1	93.6%
	Treated with Moringa	47	53.45%

Fig1: Chat showing Hardness Removal of different water

CONCLUSION:

The present study was undertaken to find out a cost effective and eco-friendly alternate for water softeners. During our study it was found that the hardness removal efficiency of resin based technology was observed as the highest in comparison to the elimination efficiency of herbal *Moringa oleifera* extracts, but the later was found to be a suitable and ecofriendly procedure in order to remove the hardness from different types of water found in the cities.

REFERENCES:

1. Suleyman A. *Moringa oleifera* seeds for softening Hardwater. Water Research 1994. 29(4): 1099-1104.
2. Min Kyung Ahn et.al. Removal of Hardness from Water Samples by a Carbonation Process with a Closed Pressure Reactor. Water 2018.
3. Ndabigengesere A, Narasiah KS, Talbot BG. Active agents and mechanism of coagulation of turbid waters using Moringa oleifera. Water Res. 1995. 29:703–710.
4. Jahn, S.A.A. Proper Use of African Natural Coagulants for Rural Water Supplies Research in the Sudan and a Guide to New Projects. GTZ Manual No. 191, 1986.
5. Folkard G. K. Sutherland J. P. and Grant W. P. Optimisation of the use of natural coagulants for water purification. Tech. Rep. No. R4254. University of Leicester. 1989.
6. Kaser F., Werner C. and Nahayo D. Rural water treatment using Moringa oleifera seeds as coagulant. Natural Resources Development, 1990. 33: 33-47. Institute of Scientific Co-operation, Tubingen, Germany.
7. Bhole AG. Relative evaluation of a few natural coagulants. J. Water Supply Res. Technol. Aqua. 1995. 44:184–190.
8. Bhole AG. Performance studies of a few natural coagulants. J. Indian Water Works Assoc. 1990. 81–84.
9. Apha, Awwa, Wpcf. Standards Methods for the Examination of Water and Wastewater, 7th edn. American Public Health Association, American Water Works Association and Water Pollution Control Federation, Washington, D.C. 1992.
10. WHO. Guidelines for Drinking Water Quality: Vol. I; Recommendations. World Health Organisation, Geneva. 1984.

11. Bhole AG. 1993. Relative evaluation of a few natural coagulants, p. 146-156. In Proceedings of the International Workshop on Alternative Methods of Water Treatment, Nagpur.
12. Hitendra Bhuptawat et.al (2006) Innovative physico-chemical treatment of wastewater incorporating *Moringa oleifera* seed coagulant. Journal of Hazardous Materials, 2007, 142: 477-482
13. Mustapha Hassan Bichi. A Review of the Applications of *Moringa oleifera* Seeds Extract in Water Treatment. Civil and Environmental Research, 2013: 3.8.
14. Tripathi PN, Chaudhuri M, Bokil SD. Nirmali seed - a naturally occurring coagulant. Indian J. Environ. Health 1976. 18:272–280.

Received on 21.06.2020 Modified on 16.05.2021
Accepted on 24.11.2021
Research J. Pharm. and Tech 2022; 15(10):4473-4476.
DOI: 10.52711/0974-360X.2022.00750