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Moringa oleifera seeds: An efficient & cost effective bio alternative for waste water treatment

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Abstract
The present study was carried out to confirm the effectiveness of seed powder extracted from mature-dried *Moringa oleifera* seeds which are commonly available in most rural communities. In our studies, the water samples were collected from Jayoti Vidyapeeth Women's University campus for treatment by *Moringa* seeds in powdered form, resulting in an effective natural clarification agent for highly turbid and untreated water. Various doses of *Moringa* seed powder viz. 2, 4, 6 g/l were taken and checked for their efficiency dose on raw water. After treatment of seed powder water samples were analyzed for different parameters like pH, EC, TDS, alkalinity, hardness and sulphates. All the parameters were reduced with increasing time with the treatment with seed powder. Maximum reduction was in Sewage water in reference to pH, alkalinity and sulphates. In Duckpond, maximum reduction in EC, TDS and Sulphates. Hardness of water was maximum reduced in Tubewell water after 2 hrs . Application of low cost *Moringa oleifera* seeds is therefore, recommended for eco-friendly, nontoxic, simplified water treatment where rural and peri-urban people living in extreme poverty.

Keywords: *Moringa oleifera*, waterborne diseases, seed extract, water purification

Introduction
Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater). Agriculture, domestic and industrial activities are the main cause of surface and groundwater pollution.
Drinking water supplies around the world are contaminated with thousands of chemicals which are considered potentially hazardous to human health at relatively high concentrations [1]. One of the main problems in developing countries are waterborne diseases due to contaminated water and more than a million people (of which two million are children) die from diarrhoea each year [1]. The physical, chemical, and biological characteristics are altered by dissolved impurities, which is comprised of organic compounds, gases, minerals and *E-coli* these effect can be controlled by the concentration and composition of chemical reactions among pollutants [2].
Presently, there are no appropriate low-cost technologies available for *Moringa oleifera* is a perfect example of a so called "multipurpose tree". *Moringa oleifera* Lam (syn. *M. ptreygosperma* Gaertn.) referred to as the 'drumstick tree' is one of the best known and most widely distributed and naturalized species of a monogeneric family *Moringaceae* [3]. It is believed that the seed is an organic natural polymer. The active ingredients are dimeric proteins. The protein powder is stable and totally soluble in water. The coagulation mechanism of the *M. oleifera* coagulant protein has been explained in different ways. It has been described as adsorption and charge neutralization and interparticle bridging. Flocculation by inter-particle bridging is mainly characteristic of high molecular weight polyelectrolytes.
The unique property is the ability of its dry, crushed seed and seed press cake, which contain polypeptides, is to serve as natural coagulants for water treatment [4]. Preliminary investigations into the possible use of *Moringa oleifera* seed suspension for the softening of hardwater. Four water sources: synthetic water (distilled water spiked with calcium chloride), naturally hard surface water and groundwater from two tube wells at different locations were studied. Water hardness from the sources varied from 300 up to 1000 mg/l as CaCO3. Removal efficiency was found to increase with increasing dosage of *Moringa oleifera.* Higher dosages were required to achieve equivalent residual hardness for water samples with the same initial hardness but higher number of hardness-causing species in the water. Hardness removal was found to be independent of pH of the raw water [5].
Moringa oleifera seeds when treated with water on two levels acts both as a coagulant and an antimicrobial agent. *Moringa* works as a coagulant due to positively charged, water-soluble proteins, which bind with negatively charged particles (silt, clay, bacteria, toxins, etc) allows "flocs" to settle to the bottom and is removed by filtration. Treatments with *Moringa* solutions removes 90-99.9% of the impurities in water [6]. The seeds of plant species *Strychnos potatorum* and *Moringa oleifera* with natural polyelectrolytes act as coagulants to clarify turbid waters [7].
Different doses of the powder processed from *Moringa* seeds (4, 6, 8, 10, and 12 g/L) were evaluated and aluminium sulphate (alum) as coagulant for water purification The use of 12 g/L treatment of *Moringa* and 10 and 12 g/L alum treatments resulted in safe drinking water with pH values (7.29 to 7.89) in accordance withe World Health Organisation (WHO) guidelines. Turbidity was removed up to 97% in high turbid water and 86% in low turbid water [8]. Research was carried out to confirm the effectiveness of powder extracted from mature-dried *Moringa oleifera* seeds used as a coagulant for purification [9].

Various doses of *Moringa* seed powder were studied viz. 50, 100 and 150 mg/l and checked for their efficiency dose on raw water and analyzed the water samples for different parameter like pH, Turbidity, TDS, TS, Hardness, Chlorides, Alkalinity, Acidity, MPN and SPC. All parameters were reduced with increasing dose of 50, 100 and 150 mg/l seed powder respectively (except alkalinity and pH) [10].

Water treatment with *M. oleifera* seed powder in combination with household sand filter was found to be more effective for water purification than treatment with *Moringa* seed powder alone [11]. Work on the suitability of *Moringa oleifera* as an alternative and cheap purification method in the improvement of water quality in terms of turbidity, pH and hardness on pond water was carried out. Increased dose of application of *Moringa* seed powder decreased the parameter values. Hardness removal efficiency of *Moringa oleifera* was found to increase with increasing dosage [12].

Coagulation affects the performance of the other stages of the treatment, favours microbial quality of the final product, increased the lifetime of filters and reduced the final cost of the treated water [13].

Moringa oleifera seed acts as natural coagulant and studies were conducted in order to replace the synthetic coagulant. *M. oleifera* reduced turbidity of wastewater, conductivity, BOD and removed its metal contents (Cd, Cr, Mn). *M. oleifera* was found effective at the concentration of 80 to 100 mg/L as a coagulant to treat wastewater from textile industry and ground water. In regard to ground water, *M. oleifera* removed the turbidity of ground water, reduced the conductivity and BOD of ground water . The advantage of using *M. oleifera* was no reduction in pH as PAC, hence no need to adjust pH of the treated water [14].

Investigations were carried out to find suitability of coagulation-flocculation process using *Moringa oleifera* seeds as natural coagulant for purification of water for drinking purpose. The doses taken were 50, 100 and 150 mg/litre and checked for their efficiency dose [15]. The physical and chemical characteristics of water are changed by coagulant chemicals and its associated products worsens the disposal of sludge. The natural polymers are most efficient as they provide several benefits are exempted from physical and chemical changes from the treated water [16].

Earlier studies have found *Moringa* to be non-toxic and recommended it for use as a coagulant in developing countries. The use of *Moringa* has an added advantage over the chemical treatment of water because it is biological and has been reported as edible. So the main objective of this study is to confirm the effectiveness of powder processed from *M. oleifera* seeds for water purification of local water sources.

Materials and Methods

Coagulants Used

The *Moringa oleifera* seeds harvested when they are fully matured from herbal garden of Jayoti Vidyapeeth Women's University, Jaipur. This is determined by observing if there are any cracked pods on the plants. The pods that were plucked were cracked to obtain the seeds which were air-dried at 40°C for two days. The shells surrounding the seed kernels were removed using knife & sieved using grinder to obtain a fine powder.

Water Sample Collection

Water sample for further purification process was collected from the Jayoti Vidyapeeth campus. Pond water sample collected from duck pond of college campus & Sewage water from sewage treatment plant of college campus & Tube well water from tube well of campus. Collected water sample were mixed in different proportions and separately analysed for different parameters.

Experimental Design

For the purification of collected water in 1000 ml of flask.

- 21 flask of 1000mL capacity was taken & 1000ml of each water sample was taken in 3 different flask for 3 different concentration of *Moringa* seed powder.
- In each flask different – different concentrations of *Moringa* seed was added. 2gm, 4gm & 6gm of *Moringa* seed powder was added in flask containing water sample.
- Now the solutions were mixed rapidly for 10 min & gently for 2 min.
- The suspension were left to stand for 2 hrs without disturbance.
- After 30min we collected the 100ml of supernatant from all solution & filtered the solution with the help of filter paper & then solution was tested for observing changes in pH, EC, TDS, Alkalinity, Hardness and Sulphates.
- These all test were also repeated after 1 hrs, 1.30 hrs & 2hrs.

Water Analysis

Collected water samples were analysed for different parameters with the help of WHO Guidelines for Drinking-water Quality 2006. The parameters are:

pH, Electrical Conductivity, Total dissolved solid, Alkalinity, Hardness and Sulphates

Result & Discussion

Physico-chemical analysis of collected water sample was done before & after treatment with *Moringa oleifera* seed. After 2 hrs the results showed the following change in parameters in samples collected.

pH

During the analysis, it was observed that after treatment with *Moringa* seeds, the value of pH decreases with the increasing concentration of *Moringa* seed powder & also decreases with the increasing treatment hours. There is slight decrease in pH

after 30min of treatment but pH decreases more after 1 hour & continues to decrease till 2 hours of treatment. pH decreases 18.9 % after 2 hours treatment with 6gm/l concentration of *Moringa oleifera* seed powder, which is the maximum changes in pH due to seed powder in sewage water & minimum changes in pH is 2.23% by 2gm/L concentration of *Moringa oleifera* seed powder in Tubewell water. The recommended acceptable range of pH for drinking water specified by WHO [1] is between 6.0 and 8.0. The treatment with *Moringa* seed gave a pH range of 6.4 to 7.9 and within the limit. The action of *M. oleifera* as a coagulant lies in the presence of water soluble cationic proteins in the seeds. This suggests that in water, the basic amino acids present in the protein of *Moringa* seed powder would accept a proton from water resulting in the release of a hydroxyl group making the solution basic. Similiar results have also been reported by other workers[3, 8, 10, 12, 14].

Electrical Conductivity

In case of electrical conductivity, it was observed that the EC decreases with the increasing doses of *Moringa* seed powder. EC maximium reduction was with the 6gm/L concentration of *Moringa* seed is 45.8% in Duck Pond water and minimum reduction with 2gm/l with 14.19% in Tubewell water. Similiar results have also been reported [14].

Total dissolved solid

The range of total dissolved solid decreases with the increasing dose of *Moringa* seed powder with time from 30 min to 2 hours. The maximum decrease of TDS was observed with the concentration of 6gm/l *Moringa* seed powder 43.5% in Duck Pond water and minimum reduction with 2gm/l with 17.75% in Sewage water. The seed kernels of *M. oleifera* according to Schwarz (2000) contain lower molecular weight water-soluble proteins which carry a positive charge. When the seeds are crashed and added to water, the protein produces positive charges acting like magnets and attracting predominately negatively charged particles such as clay, silk, and other toxic particles. Under proper agitation, these bound particles then grow in size to form the flocculates which are left to settle by gravity. This accounted for the effectiveness of *Moringa seed* as a coagulant for raw water purification.

After the treatment with *Moringa* seeds TDS was in acceptable limit (100-400 mg/L) for all water sample. The TDS was present within the limit according to the recommended guideline value of TDS in drinking water is 1000 mg/l based on taste (WHO, 2006) [1]. Our results have been supported by following researchers [6, 8, 10, 12, 14].

Alkalinity

Maximum decrease of alkalinity of all raw water samples decreases with the increasing conc. of *Moringa* seed. With the *Moringa* seed powder it ranges between 40-80mg/l which comes under the limit of WHO guidelines. The maximum % alteration in alkalinity is due to treatment with 6gm/l of *Moringa* seed powder in sewage water is 77.5%. & the minimum % alteration in alkalinity is due to 2gm/l of *Moringa* seed extract in Tubewell water is 38.09%.The *Moringa oleifera* seed extract appears to have natural buffering capacity. The precipitates (solids / flocks) were light and did not settle easily. The chemical constituent of the precipitate is however not known [8]. Similiar, reduction in alkalinity was also obtained in results of previous researchers [8, 10, 12]

Hardness

The maximum decrement due to seed powder in hardness is 54.7% in Tubewell water by 6gm/l of *Moringa oleifera* seed & minimum decrement is 20.0% in pond water by 2gm/l of *Moringa oleifera* seed powder in Duck Pond water. According to scientists, as a polyelectrolyte it may therefore be postulated that *Moringa oleifera* removes hardness in water through adsorption and inter-particle bridging. Secondly, with the observation that light, slow-settling solids/flocks were formed and precipitation reaction lead to the conversion of soluble hardness-causing ions to insoluble compounds would also be a good prediction of the reaction mechanism. The higher value of hardness in raw water samples is due to the fact that they contain hardness due to calcium, magnesium and other hardness-causing substances. Hardness removal was found to be independent of pH of the raw water. Our results have been supported by other scientists. [5, 10, 12]

Sulphate

For determining the values of sulphate, standard graph of sulphate was prepared & with the help of standard graph, sulphate content present in water sample was determined. Sulphate content is present in all water samples ranges between 11- 49 mg/l. Sewage water water contains the highest sulphate content 52.6% and tubewell water contains the lowest sulphate content 26.53%. After the treatment with the *Moringa oleifera* seed, the sulphate content present in water samples decreases with increasing concentration of seed powder with increasing treatment time. It ranges 5-20mg/l after treatment with seed powder. Similiar results were obtained by other scientists [10].

Table 1: Physicochemical properties of water treated by 2gms of *Moringa* seed powder

Samples	Duck pond water					Sewage water					Tubewell water				
Parametes	Initial value	After Treatment				Initial value	After Treatment				Initial value	After Treatment			
		½ hr	1hr	1½hr	2hr.		½ hr	1 hr	1½hr	2 hrs		½ hr	1hr	1½hrs	2 hrs
Ph	9.11	8.42 (-7.5)	8.30 (-8.8)	8.2 (-9.9)	7.60 (-16.5)	7.90	7.65 (-3.6)	7.50 (-6.83)	7.36 (-7.72)	7.29 (-7.72)	7.62	7.60 (.26)	7.56 (-0.26)	7.50 (-1.57)	7.45 (-2.23
Ec (millisiemens /cm)	7.2	6.1 (-15.27)	5.8 (19.44)	5.5 (23.6)	5.2 (-27.7)	5.9	5.7 (--3.36)	5.2 (-11.86)	4.6 (-22.03)	4.0 (-32.03)	15.5	15.0 (-3.22)	14.6 (-5.80)	13.6 (-12.25	13.3 (-14)
Tds (mg/l)	390	385.6 (-1.13)	320.5 (-17.82)	301.3 (-22.7)	276. (-29.15)	283.3	280.13 (-1.19)	265.5 (-6.28)	253 (-10.69)	233 (-17.75)	1116.6	1090.1 (-2.37)	1925.73 (-17.09)	827.57 (-23.51)	720.01 (-35.51)
Alkalinity (mg/l)	81	72 (-11.3)	64 (-21.18)	52 (-35.9)	45 (-44.5)	71	60 (-15.73)	48 (-32.58)	38 (-46.63)	30 (-57.86)	118	80 (-29.04)	72 (-32.38)	65 (-33.8)	56 (-38.09)
Hardness (mg/l)	133	130 (-2.35)	122 (-8.36)	114 (-14.37)	106 (-20.0)	145	120 (-17.29)	113 (-22.12)	104 (-28.32)	92 (-36.59)	420	298 (-29.04)	284 (-32.38)	278 (-33.80)	260 (-38.09)
Sulphate (mg/l)	12.5	11 (-12)	10.5 (-20)	9.2 (-26.6)	8.9 (-28.7)	19	18 (-5.26)	16 (-15.79)	13 (-31.57)	11 (42.10)	49	47 (-4.08)	42 (-14.28)	40 (-18.36)	36 (-26.53)
Toc (%)	0.12	0.214 (+78.3)	0.202 (+68.3)	0.156 (+30)	0.128 (+6.6)	0.14	0.253 (+80.71)	0.245 (+74.9)	0.237 (+69.28)	0.214 (+52.8)	0.16	0.398 (+148.3)	0.391 (+144.3)	0.384 (+140)	0.373 (+133.1)
Organic matter (%)	0.36	0.63 (+75)	0.66 (+66.6)	0.46 (+27.7)	0.38 (+5.5)	0.42	0.75 (+78.57)	0.73 (+73.8)	0.70 (+66.6)	0.636 (+51.4)	49	1.180 (+140.8)	1.16 (136.7)	1.14 (+132.6)	1.09 (+122.4)

Values in the () represent the % alterations in the parameter after treatment. (-) means decrease, (+) means increase in value

Table 2: Physicochemical properties of water treated by 4gms of *Moringa* seed powder

Samples	Duck pond water					Sewage water					Tubewell water				
Parametes	Before Treat	After Treatment				Before Treat	After Treatment				Before Treat	After Treatment			
		½ hr	1hr	1½hr	2hr.		½ hr	1hr	1½hr	2 hr		½ hr	1hr	1½hr	2 hr
pH	9.11	8.05 (-11.6)	7.98 (-12.4)	7.72 (-15.2)	7.50 (-17.6)	7.90	7.10 (-10.1)	7.02 (-11.1)	6.82 (-13.6)	6.75 (-14.5)	7.62	6.96 (-8.6)	6.80 (-0.76)	6.58 (-13.6)	6.40 (-6.01)
EC (Millisiemens /cm)	7.2	5.8 (-19.4)	5.2 (-25)	4.7 (-34.7)	4.2 (-41.6)	5.9	5.4 (-8.4)	4.7 (-20.3)	4.1 (-30.5)	3.6 (-38.9)	15.5	14.2 (-8.3)	13.5 (-7.7)	12.9 (-16.7)	12.4 (-20)
TDS (mg/l)	390	380.6 (-2.4)	318.4 (-18.3)	294.3 (-24.5)	253.1 (-35.1)	283.3	276 (-2.5)	262.3 (-7.4)	245.7 (-13.4)	215.1 (-24)	1116.6	999.9 (-10.4)	903.16 (-0.45)	811.4 (-27.3)	709.6 (-36.4)
Alkalinity	81	62	56	44	34	71	52	42 (-	30 (-	22 (-	118	74	62	52	42

(mg/l)		(-23.4)	(-30.8)	(-45.6)	(-58)		(-26.7)	40.8)	57.7)	69.0)		(-37.2)	(-47.4)	(-55.9)	(-66.1)
Hardness (mg/l)	133	112 (-4.5)	119 (-10.5)	110 (-17.2)	102 (-23.3)	145	108 (-25.5)	101 (-30.3)	92 (-36.5)	84 (-42)	420	262 (-37.6)	256 (-9.04)	249 (-40.7)	220 (-47.6)
Sulphate (mg/l)	12.5	10 (-20)	8 (-36)	7.5 (-40)	7 (-44)	19	17 (-10.5)	15 (-21.0)	12 (-36.8)	10 (-47.3)	49	45 (-8.16)	41 (-19.5)	36 (-26.5)	32 (-34.6)
TOC (%)	0.12	0.21 (+75)	0.19 (+58.3)	0.16 (+33.3)	0.13 (+8.3)	0.14	0.35 (+150)	0.33 (+142)	0.33 (+135)	0.31 (+121)	0.16	0.43 (+168)	0.42 (+162)	0.41 (+156)	0.40 (+150)
Organic Matter (%)	0.36	0.61 (+69.4)	0.56 (+55.5)	0.49 (+36.1)	0.48 (+33.3)	0.42	1.05 (+150)	1.01 (+140)	0.99 (+135)	0.96 (+128)	48	1.26 (+162.5)	1.24 (+158)	1.22 (+154)	1.18 (+145)

Values in the () represent the % alterations in the parameter after treatment. (-) means decrease, (+) means increase in value

Table 3: Physicochemical properties of water treated by 6gms of *Moringa* seed powder

Samples	**Duck pond water**					**Sewage water**					**Tubewell water**				
Parametes	**Before Treat**	**After Treatment**				**Before Treat**	**After Treatment**				**Before Treat**	**After Treatment**			
		½ hr	**1hr**	**1½hr**	**2hr.**		**½ hr**	**1hr**	**1½hr**	**2 hr**		**½ hr**	**1hr**	**1½hr**	**2 hr**
pH	9.11	8.12 (-10.8)	7.88 (-14.3)	7.56 (-7.01)	7.42 (-18.5)	7.90	6.96 (-15.3)	6.80 (-13.9)	6.58 (- 16.7)	6.40 (-18.9)	7.62	7.20 (-5.52)	7.14 (-6.2)	7.6 (-7.34)	7.2 (-7.87)
EC (Millisiemens /cm)	7.2	5.3 (-26.3)	4.9 (-31.9)	4.4 (-38.8)	3.9 (45.8)	5.9	5.3 (-10.16)	4.5 (-23.7)	4.05 (-21.1)	3.5 (-40.6)	15.5	12.8 (-17.4)	11.9 (-23.2)	11.1 (-28.3)	10.9 (-29.6)
TDS (mg/l)	390	378.2 (-3.02)	305.4 (-21.6)	282.7 (-26.2)	220.1 (-43.5)	283.3	272 (-3.98)	255.6 (-9.6)	238.7 (-15.6)	213.4 (-24.6)	1116.6	950.4 (-14.8)	840.7 (-24.7)	734.4 (-34.2)	677.4 (-39.3)
Alkalinity (mg/l)	81	54 (-33.4)	50 (-38.4)	42 (48.27)	28 (-65.5)	71	44 (-38.2)	34 (-52.2)	24 (-66.2)	16 (-77.5)	118	68 (-42.3)	58 (-50.8)	46 (-61.0)	32 (-72.8)
Hardness (mg/l)	133	122 (-20.3)	112 (-15.7)	106 (-20.3)	95 (-28.5)	145	102 (-29.6)	94 (-35.1)	86 (-40.6)	78 (46.2)	420	230 (-45.2)	225 (-46.42)	210 (-50)	190 (-54.7)
Sulphate (mg/l)	12.5	8.5 (-32)	7.5 (-40)	7 (-44)	6 (-52)	19	16.5 (-13.15)	14.5 (-23.8)	11.5 (-39.4)	9.0 (-52.6)	49	43 (-12.24)	37 (-24.4)	33 (-30.3)	28 (-34.8)
TOC (%)	0.12	0.236 (+96.6)	0.230 (+91.6)	0.225 (+87.5)	0.22 (+83.3)	0.14	0.384 (+174.2)	0.376 (+168.5)	0.367 (+162.1)	0.35 (+150)	0.16	0.443 (+176.8)	0.436 (+172.5)	0.428 (+167.5)	0.423 (+164)
Organic Matter (%)	0.36	0.69 (+91.6)	0.68 (+88.8)	0.66 (+83.3)	0.64 (+77)	0.42	1.138 (+170)	1.08 (+157.1)	1.06 (+152.3)	1.04 (+147)	48	1.31 (+172.9)	1.29 (+168)	1.27 (+164.5)	1.25 (+160)

Values in the () represent the % alterations in the parameter after treatment. (-) means decrease, (+) means increase in values.

Conclusion

Moringa oleifera seed powder gave encouraging results Aftertreatment of seed powder water samples were analyzed for different parameters like pH, EC, TDS, alkalinity, hardness and sulphates. All the parameters were reduced with hrs, maximum reduction was in Sewage water in regard to pH, alkalinity and sulphates. Whereas, maximum reduction in EC, TDS and Sulphates in Duckpond. Hardness of water was maximum reduced in Tubewell water after 2 hrs.

After the analysis it is observed that the *Moringa oleifera* seed power is effective with nontoxic effect. It is eco-friendly and cheaper method of purification of water and therefore can be used in the rural areas where no facilities are availablefor the treatment of drinking water. Application of low cost *Moringa oleifera* seeds is therefore, recommended for eco-friendly, nontoxic, simplified water treatment where rural and semi-urban people living in extreme poverty.

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