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Remediation of Water Wells Used for Drinking Water by Moringa Seeds Powder

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Abstract: This study deals with the suitability of applying Moringa seeds powder (MSP), as natural environmentally friend, alone and in combination with calcium hypochlorite (CaH) for remediation of contaminated well water. The study evaluated the effectiveness of MSP on water quality parameters (total bacterial count (TBC), *E. coli* count, pH, turbidity, total dissolved solids (TDS), electric conductivity (EC) and some ions). Data showed various reducing rates in either TBC or *E. coli* counts. The highest reducing rate was calculated when MSP (1.5%) + CaH (1%) treatment was applied. Use of MSP2 came in the second order for reducing the bacteriological load. pH values did not affect either by MSP, CaH or their mixture. Application of MSP (1.5%) with calcium hypochlorite (1%) came in the first order followed by MSP (2%) in reduction of water turbidity. TDS and EC did not affect either by MSP or CaH with different concentrations. The use of a mixture of MSP and CaH was more efficient in minimizing (Fe) and (Mn) ions concentration with 72.5 and 80% out of its corresponding control value, respectively. The synergistic effect of MSP was also noticed with (SO_4) but with moderate reduction percentage (32.5%).

Key words: *Moringa oleifera* · Contaminated well · Remediation · Water quality parameters

INTRODUCTION

Water is one of the most important natural resources, useful in development purposes in both urban and rural areas [1]. It is the most drinkable liquid by living things and is the universal solvent; therefore often a potential source of causing infections [2]. Ground water can become contaminated from natural sources or numerous types of human activities. Residential, municipal, commercial, industrial and agricultural activities can all affect ground water quality. Ground water and surface water are interconnected and can be fully understood and intelligently managed only when that fact is acknowledged. If there is a water supply well near a source of contamination, that well runs the risk of becoming contaminated. If there is a nearby river or stream, that water body may also become polluted by the ground water. In Egypt, the groundwater aquifer at the newly reclaimed areas in north and west of Delta region receives leakage from the agricultural drains and irrigation canals as well as from industrial and human wastes [3]. The gravest of all dangers to which water supplies can be exposed is contamination by pathogenic organisms. It is reported that 80% of all illness in developing countries is related to water sanitation [4]. Fecal coliform and *E. coli* are not usually health threats in themselves; it used to indicate whether potentially harmful bacteria or viruses may be present. Its presence in wells shows that well is not correctly sealed, improperly constructed or the on-site sewage disposal system has failed [5]. Disinfection is a chemical process for eliminating pathogenic microbes from environment. The most common of these are the oxidizing chemicals and chlorine is the most universally used [6] which has a problem of forming carcinogenic and mutagenic by-products [7]. It may also be associated with increased risks of cardiovascular diseases, cancers and birth defects. Moringa is a highly valued plant, distributed in many tropic and subtropic countries. It has an impressive range of medicinal uses with high nutritional value [8]. Seeds of this pan tropical tree contain water soluble, positively charged proteins that act as an effective coagulant for water and wastewater treatment [9]. An extensive literature has concluded that aqueous *Moringa oleifera* seeds or presscake extract presents low toxicity, e.g. in the low range of optimal doses there is no germicide effect and there are no risks from toxic substances [10]. To date, all the studies have concluded that there is no evidence to suggest any acute or chronic effects on humans, particularly at the low doses required for water treatment [11]. The coagulant activity

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of *M. oleifera* seeds is widely known and applied in water treatment at household level in rural areas of developing countries [12].

This study aimed to evaluate the microbiological and physicochemical water quality parameters of contaminated well water at Sadat city, Minofyia Governorate, Egypt after treated with crushed seeds of *M. oleifera* as a natural substance that more safer and less expensive than chemical ones.

MATERIALS AND METHODS

Sampling and Preparations: Water samples were collected from contaminated covered well with depth 165m at Sadat city; Minofyia Governorate, Egypt in sterilized bottles and transferred into ice box to the Lab., then placed in the refrigerator till analysis. Seeds of Moringa (*Moringa oleifera*) were shelled, milled into powder and sieved through a small mesh (0.8mm) to get its fine powder. Different concentrations of Moringa seeds powder (MSP) and/or calcium hypochlorite (CaH) were prepared by dissolving 1, 1.5 and 2g from each, separately, into 100 ml of distilled water to obtain MSP1, MSP1.5, MSP2, CaH1, CaH1.5 and CaH2 treatment concentrations, respectively. In addition, mixed solutions of both MSP and CaH were prepared as follows: MSP1+CaH1 and MSP1.5+CaH1 treatments. Solutions were shacked well for 1 minute to extract and activate the coagulant and antimicrobial proteins in seeds powder. Each treatment solution was poured into one liter of the well water and mixed properly. Treated water samples were allowed to stand undisturbed for 6 hrs, then 100 ml of each top water sample was collected and subjected to microbiological and physicochemical analysis.

Analysis: Water samples were analyzed for total bacterial count (TBC) using plate count agar (Himedia - India) [13] and *E. coli* count using Endo broth and brilliant green bile broth (Difeco – France) according to APHA [14, 15]. The pH was measured using pH meter (HACH Company sensIon1). Turbidity was determined using HACH Company 2100P Turbidimeter. Total dissolved solids (TDS) and electric conductivity (EC) were performed using TDS meter (HACH Company sensIon5). Ions were detected as follows: iron (Fe) using 1, 10 phenanthroline method (powder pillows), manganese (Mn) using periodate oxidation method (powder pillows), nitrite (NO_2) using ferrous sulfate method (powder pillows), nitrate (NO_3) using cadmium reduction method (powder pillows) and sulphate (SO_4) by Sulfaver method (powder pillows), using spectrophotometer (HACH Company DR/ 2000 with software versions 3.0), according to Hach Company/Hach Lange GmbH [16].

Statistical Analysis: The data obtained from three replicates were subjected to statistical analysis of variance by using SAS computer program [17].

RESULTS AND DISCUSSION

Bacteriological Examination: The bacteriological analysis of well water as affected by MSP and/or CaH was given in Table 1. Suggested treatments showed various significantly reducing rates in either TBC or *E. coli* counts. The highest one was calculated when MSP1.5+CaH1 treatment was applied. It was 94.4 and 97.5 decrement percent for TBC and *E. coli* counts, respectively. Use of MSP2 came in the second order for reducing the bacteriological load with 91.36 and 96.25% for TBC and *E. coli* counts, respectively. It means that MSP could be used as natural disinfectant with concentration of 2% instead of using chemical agents, in addition to its synergistic effect that clearly noticed when MSP1.5+CaH1 treatment was applied. The active agents Moringa seeds solution are water soluble materials as seen from their coagulation and antimicrobial activities of the raw turbid water. Thus, one can easily recover turbid water with low microbial concentration consumption. These active agents have been reported to possess antimicrobial activities include: 4-(4'-O-acetyl-α-L-rhamnopyranosyloxy) benzyl isothiocy-anate [18], 4-(α-L-rhamnopyranosyloxy) benzyl isothiocy-anate [19], niazimicin [20], pterygospermin [21], benzyl isothiocyanate [22] and 4-(α-L-rhamnopyranosyloxy) benzyl glucosinolate [23]. The mode of Moringa seeds extract action on *E. coli* cells was explained as rupturing cells and damaging the intercellular components, when water dips into the cell which causes it to swell more and burst leading to death [24]. The *M. oleifera* protocol can produce potable water of higher quality that of the original source, but is unable to guarantee (100%) virus- and/or bacteria-free water immediately after treatment or storage. Still, it has to be recognized that such low-cost efficiency is of significant importance to people relying almost exclusively upon untreated surface water for their drinking water needs [25]. Finally, it could be concluded that treated water with *M. oleifera* seeds extract at different concentrations lead to significantly drastic reduction in water microbial counts [26]. As well as the antimicrobial activity of *M. oleifera* is dependent on extract dose, the lower the concentrations, the lower the activity was [27].

Table 1: Bacteriological analysis of well water treated with different concentrations of moringa seeds powder (MSP) and calcium hypochlorite (CaH)

	Bacteriological analysis			
Water treatments	TBC (cfu/1ml)	Decrement %	*E. coli* (cfu/100ml)	Decrement %
Control	410.6^{A}	0	40^{A}	0
CaH1	206.5^{B}	49.72	19^{B}	52.5
CaH1.5	106.5^{C}	74.07	12^{C}	70.00
CaH2	61.00^{DE}	85.15	3.0^{D}	92.50
MSP1	194.0^{B}	52.76	17^{B}	57.50
MSP1.5	84.00^{CD}	79.55	8.5^{C}	78.75
MSP2	35.50^{E}	91.36	1.5^{D}	96.25
MSP1+CaH1	63.50^{D}	84.54	9.0^{C}	77.50
MSP1.5+CaH1	23.00^{F}	94.40	1.0^{D}	97.50

CaH1: 1g calcium hypochlorite/100ml water CaH1.5: 1.5g calcium hypochlorite/100ml water

CaH2: 2g calcium hypochlorite/100ml water MSP1: 1g Moringa seeds powder /100ml water

MSP1.5: 1.5g Moringa seeds powder /100ml water MSP2: 2g Moringa seeds powder /100ml water

MSP1+CaH1: 1.5g Moringa seeds powder +1g calcium hypochlorite /100ml water

MSP1.5+CaH1: 1.5g Moringa seeds powder+1g calcium hypochlorite/100ml water

Means with the same letter in the same column are not significantly different (at $p \leq 0.05$)

Table 2: Physicochemical analysis of treated well water.

		Water treatments					
Parameters	Units	Control	CaH1	CaH2	MSP1	MSP2	MSP1.5+CaH1
pH	--	8.1	7.91	7.9	7.93	7.92	7.84
Turbidity	NTU	8.0	4.1	3.6	5.0	3.20	1.40
TDS	Ppm	500	483	480	498	498	488
EC	µs/ml	765	748	746	764	764	748
Fe	ppm	4.0	3.4	2.3	4.0	4.0	1.1
Mn	ppm	4.5	2.1	1.3	4.4	4.4	0.9
NO_2	ppm	4.0	3.8	3.0	4.0	3.8	2.9
NO_3	ppm	3.8	3.4	3.0	3.8	3.7	1.8
SO_4	ppm	80	65	60	73	70	54

CaH1: 1g calcium hypochlorite/100ml water, CaH2: 2g calcium hypochlorite/100ml water.

MSP1: 1g Moringa seeds powder /100ml water, MSP2: 2g Moringa seeds powder /100ml water.

MSP1.5+CaH1: 1.5g Moringa seeds powder +1g calcium hypochlorite /100ml water.

TDS: total dissolved solids, EC: electric conductivity.

Means with the same letter in the same row are not significantly different (at $P \leq 0.05$)

Physicochemical Analysis: Data given in Table 2 represented physicochemical properties of treated well water either with Moringa seeds powder (MSP), calcium hypochlorite (CaH) or mixed of them as coagulant and disinfectant agents. Such properties include: pH value, turbidity, total dissolved solids (TDS), electric conductivity (EC) as well as Fe, Mn, NO_2, NO_3 and SO_4 ions. Regarding to the pH value, Fig. 1 illustrated both of pH and turbidity values as affected by two agents (MSP and CaH). The pH values were not affected either by MSP, CaH or mixture of them; it was about 8.0 that coincided with Egyptian Standards [28]. This finding is in agreement with the pH range reported by Oloruntoba *et al.* [29] and Okonko *et al.* [30] for drinking water supply. On the other hand, the turbidity was greatly affected. The reducing rate of turbidity could be descendingly ordered as: 82.5, 60.0, 55.0, 48.75 and 37.5% using MSP1.5+CaH1, MSP2, CaH2, CaH1 and MSP1 treatments, respectively. It means that use of MSP (1.5%) with calcium hypochlorite (1%) came in the first order followed by MSP (2%) in reduction of turbidity. It is of interest to notice that, use of 1% MSP gave the lowest reducing rate of turbidity. The use of MSP mixed with CaH was more efficient in remediation of water than MSP alone (Table 2 and Fig. 1). These findings go in parallel to those of Folkard *et al.* [31], who reported dramatic improvements in floes characteristics and significant savings in imported alum usage of the order of 50 to 80%. Muyibi and Okuofu [32] also observed that the floes formed in conjunctive use were bigger, denser and settled faster after slow mixing than when alum or *M. oleifera* were used separately.

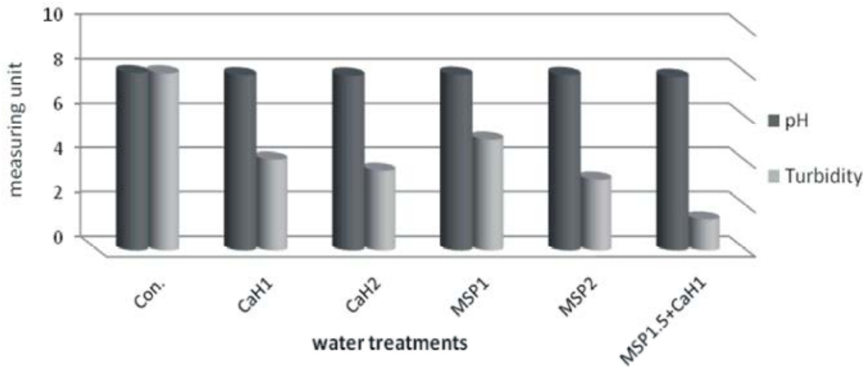

Fig. 1: Effect of MSP and CaH on pH and turbidity (NTU) values of treated well water

CaH1: 1g calcium hypochlorite /100 ml water, CaH2: 2g calcium hypochlorite /100 ml water
MSP1: 1g moringa seeds powder /100 ml water, MSP2: 2g morings seeds powder /100 ml water,
MSP1.5+CaH1: 1.5g morings seeds powder +1g calcium hypochlorite /100 ml water

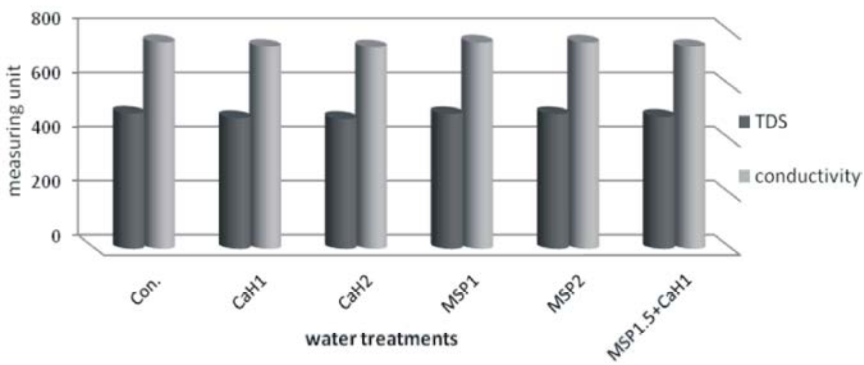

Fig. 2: Effect of MSP and CaH TDS (ppm) and conductivity (µs/ ml) levels of treated well water

CaH1: calcium hypochlorite /100 ml water, CaH2: 2g calcium hypochlorite /100 ml water
MSP1: 1g moringa seeds powder /100 ml water, MSP2: 2g morings seeds powder /100 ml water,
MSP1.5+CaH1: 1.5g morings seeds powder +1g calcium hypochlorite /100 ml water

From the same Table 2 and Fig. 2 it could be noticed that total dissolved solids (TDS) and electric conductivity (EC). Such parameters were not affected by different MSP or CaH treatments. The TDS level (ranged between 480-498 ppm) was almost similar to that of control sample that possessed 500 ppm. Similar findings were also observed in case of electric conductivity (EC). All values ranged between 746-764 µs/ml being similar to control one (765 µs/ml). Addition of MSP and/or CaH to well water did not affect such parameter. This is in agreement with the findings of Egbuikwem and Sangodoyin [33], who reported no significant change on pH, TDS and EC for water samples treated with *M. oleifera.*

Concerning ions concentration that given in Fig. 3 (Fe, Mn, NO_2 and NO_3) and Fig. 4 (SO_4), it could be noticed that MSP has not detected effect on Fe ion when it was used alone, however, synergistic effect was noticed when mixed with calcium hypochlorite. Such effect minimized (Fe) ion concentrations with 72.5% out of its corresponding control value. It is of interest to record that use of calcium hypochlorite alone at high concentration minimized (Fe) ion content by 42.5%. Regarding (Mn) ion, similar trend was greatly noticed. The minimizing rate reached 80% when MSP was mixed with calcium hypochlorite. The increasing quality of raw water for drinking can be afforded because of coagulation process between MSP and metal colloid. The mechanism of coagulation is caused by colloid destabilization or the repulsion force reduction from water parameter colloid. In case of NO_3 and NO_2 atomic groups, the aforementioned minimizing rate was 52.6 and 27.5%, respectively.

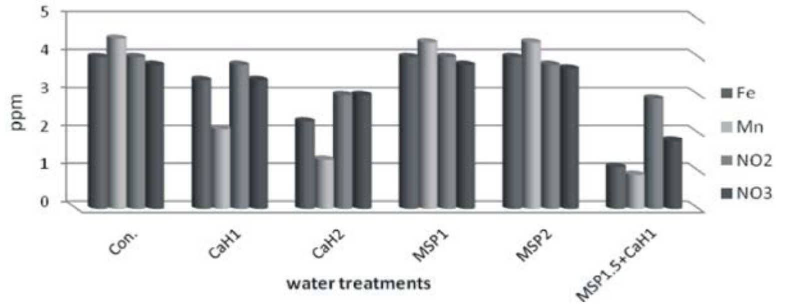

Fig. 3: Effect of MSP and CaH on Fe, Mn, NO_2 and NO_3 levels of treated well water

CaH1: 1 g calcium hypochlorite /100 ml water, CaH2: 2g calcium hypochlorite /100 ml water
MSP1: 1g moringa seeds powder /100 ml water, MSP2: 2g morings seeds powder /100 ml water,
MSP1.5+CaH1: 1.5g morings seeds powder +1g calcium hypochlorite /100 ml water

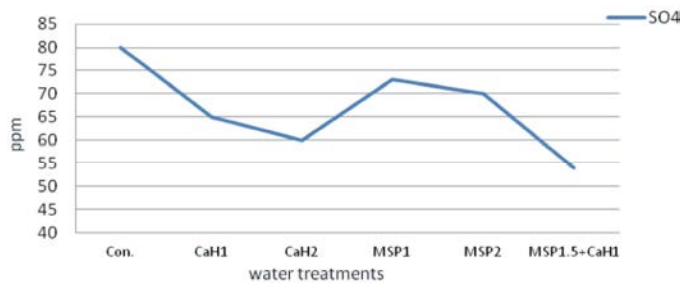

Fig. 4: Effect of MSP and CaH on SO_4 levles of treated well water

CaH1: 1 g calcium hypochlorite /100 ml water, CaH2: 2g calcium hypochlorite /100 ml water
MSP1: 1g moringa seeds powder /100 ml water, MSP2: 2g morings seeds powder /100 ml water,
MSP1.5+CaH1: 1.5g morings seeds powder +1g calcium hypochlorite /100 ml water

On the other hand Table 2 and Fig. 4 indicated the behavior of sulfate atomic group (SO_4) as affected by different water treatments. The synergistic effect of MSP was also noticed but with moderate reduction percentage (32.5%). Finally, the minimizing rate owing to using MSP as synergizing coagulant agent could be descendingly ordered as Mn, Fe, NO_3, SO_4 and NO_2.

As a final conclusion it could be said that such investigation greatly reduced the levels of either bacteriological or physicochemical contaminants. So, the followed processing steps till produce bottled water could completely reduced with saving more production costs and treatments using a natural agent instead of chemical one that caused harmful and has side effects on human health.

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