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Physicochemical characterization of Moringa Oleifera seeds and possibility of using oil extraction cakes in the treatment of drinking water

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Abstract: *The objective of this paper was the characterization of Moringa Oleifera seeds and the possibility of using oil extraction cakes in the treatment of water intended for consumption. Water samples from the Biyeme River being used by the inhabitants of Ahala 2 in Yaounde 3 district in Cameroon were treated with different concentrations of Moringa Oleifera seed cake. The monitoring of certain physicochemical parameters at different settling times by the Jar-test flocculation technique made it possible to determine the optimal dose of the coagulant and to evaluate the effectiveness of the treatment. This dose was 0.26 kg.m-3 with a residual turbidity of 0.92 NTU in filtered water, a reduction of 98 %. There was an increase in organic matter beyond the WHO standard, which was a disadvantage for this method of treatment. Bacteriologically, the reduction in total coliforms and faecal streptococci was 90 % and 86.6 % respectively. The water obtained after this treatment had physico-chemical characteristics of a drinking water. Bacteriologically, a complementary treatment of disinfection remains to be done.*

Keywords: *Moringa Oleifera, purifloc, Optimal Moringa dose, Physicochemical characterization, Bacteriological characterization, Water treatment*

1. INTRODUCTION

The supply of drinking water remains a serious and permanent problem for developing countries in general and for Cameroon in particular where the quality of the water consumed by the populations, beyond the quantitative aspect, is very high. This is a matter of concern due to competition from traditional water points, lack of maintenance of hydraulic structures, poor hygiene and sanitation and lack of appropriate family-level treatment methods. This results in a very high rate of waterborne diseases such as infantile diarrhea, which is a public health problem, due to the proliferation of enteropathogenic germs, most often transmitted through untreated drinking water [1]. However, there are conventional techniques widely used in the treatment of water. Although insufficient and restricted for some urban centers and whose water quality is not always convincing, these techniques use imported and very expensive chemicals that are not safe for health and the environment. Their use would expose consumers to the high risk of Alzheimer's disease, since aluminium residues are implicated by several scientists as being responsible for this disease ([2], [3], [4]).

As a result of these disadvantages, new, simple, inexpensive, longer-lasting techniques suitable for small-scale treatments or for developing countries need to be developed. Thus, in this work, the extraction cakes of Moringa Oleifera seeds were valued for their coagulant, flocculant and disinfectant properties in the autonomous treatment of drinking water.

Moringa Oleifera is a very particular plant with several properties and one of its most spectacular ability is that treating water for consumption. The properties of natural polypeptides obtained from Moringa seeds have been known for centuries in China during the British colonization of India, this knowledge has been disseminated elsewhere in the world. They have been used very effectively in Egypt and Sudan, among other things, to purify the water of the Nile for human consumption [5].

As the flocculant is a protein, it is found in the cake after extraction of oil, which makes possible a double valuation of the seeds. In addition, extracting the oil improves the effectiveness of the flocculant because when the raw seed powder is used, the fat contained therein causes its flotation and clogging filters.

Several researchers have highlighted the coagulating and disinfecting properties of this plant in the treatment of water ([6], [7], [8], [9], [10], [11], [1], [12], [13], [14], [15], [16]). However, very little work has been done on the use of Moringa oil extraction cakes in the treatment of water intended for consumption. Haritiana et al. extracted Moringa oil by pressure and solvent, and used the cakes to treat water by conducting a comparative study with alumina sulfate [17]. However, they dwelt on the analysis of certain physicochemical parameters only. Shan et al. also extracted oil with ethanol and used oil cake for the treatment of wastewater samples and the extraction of heavy metals [15]. It should be noted that practically, all these researchers identified a problem of settling

time which would be a brake on the use of this plant. As part of this work, we will:

- Improve the treatment technique by using a flocculation catalyst (anionic polyacrylamide or purifloc) which has an effect on the settling time by allowing magnification of the flocs and facilitating their settling;
- Extend physicochemical and bacteriological analyses.

2. MATERIAL AND METHODS

2.1Material

The material used in this work was comprised of some devices and software namely:

- A Digital Ultrasonic LMUC Series sonicator and a rota-steam equipped with a round bottom flask for extracting Moringa oil;
- A six-station FC6S Jar Test Velp electric control floculator Scientific for coagulation, flocculation and settling operations;
- A portable multimeter WTW Multi 350i brand for the measurement of certain parameters such as: pH, temperature, electrical conductivity, total solids dissolved;
- A turbidimeter brand SEREIEN NR 201301136 for the measurement of turbidity;
- An electric hot plate to heat or boil certain reagents during the assay;
- Pleated filter paper for filtration operations;
- Several chemical reagents and glassworks for the determination of certain chemical parameters;
- Color comparators fitted with chlorine, iron and manganese chips, all brand ORCHIDIS for the determination of the content of chlorine, iron, and manganese.

2.2 Methods

2.2.1 Sampling

The water samples were collected in 1.5×10^{-3} m^3 containers previously rinsed with water to be analysed and then stored in coolers and transported to the laboratory for treatment and analysis. Samples were taken very early in the morning before any human activity to reduce anthropogenic pollution.

2.2.2 Preparation of coagulant Moringa Oleifera

The ripe and dry Moringa Oleifera seeds obtained in the town of Obala, a town in the centre region of Cameroon, were shelled in an oven for 48 hours at a temperature of 60 °C and crushed using a kitchen mixer [19]. Fractions of Moringa Oleifera obtained were previously extracted from the oil Soxhlet before the use of cakes.

2.2.2.1 Extraction of oil from Moringa Oleifera seeds

Oil extraction from the Moringa Oleifera seed was done at the Organic Chemistry Laboratory of the University of Yaoundé I. It was done by adding hexane to the seed powder. For a mass of 75 g of Moringa seed powder, 2.5×10^{-3} m^3 of hexane was added and the mixture placed in a sonicator brand Digital Ultrasonic Cleaner LMUC Series, containing water with temperature set at 37 °C and programmed for 30 minutes of operation. Upon cessation of the sonicator the filtration was done on filter paper and the experiment was repeated twice until the hexane became clear to ensure a good extraction of oil from the seeds (Fig -1). The three filtrates obtained were transferred into a round bottom flask and placed in a rota-steam to concentrate and obtain oil. This oil was left half open in a cabinet to allow traces of solvent to evaporate. The formula for the yield of Moringa oil extraction is given by:

$$\boldsymbol{R = \frac{massofoilobtained}{massofseedpowder} \times 100}$$

Fig -1: Extraction of Moringa Oleifera oil

2.2.2.2 Preparation of the coagulant based on extraction cake

Moringa Oleifera cakes obtained after extraction of oil were dried in an oven at 60 °C for 48 h and ground into fine powders and sieved and used for the preparation of Moringa Oleifera coagulant. For this, 20 g of cake powder were introduced into 10-3 m3 of distilled water and the mixture stirred for one hour for a good extraction of the coagulant, then filtered on filter paper in order to use it to treat the water samples [20].

2.2.2.3 Preparation of Anionic Polyacrylamide (Purifloc)

The anionic polyacrylamide flocculant (Purifloc), which allowed a magnification of the flocs and facilitates their decantation while accelerating the treatment with the Moringa coagulant, was taken from the tarpaulins feeding the dosing pumps of the Mefou Yaounde treatment plant and then diluted to prepare the useful

solution that we used.

2.3 Physicochemical characteristics of seeds and water samples

2.3.1 Physicochemical characteristics of Moringa Oleifera seeds

The previously crushed Moringa Oleifera seeds were deposited at the Food and Nutrition Research Center (CRAN) of the Ministry of Scientific Research and Innovation (MINRESI) for characterization. The different levels of macro elements were determined according to various methods described in the literature.

2.3.2 Physicochemical characteristics of water samples

The physicochemical parameters of the drinkability of the targeted drinking water are essentially those adopted by the Mefou treatment plant of Yaounde. These include pH, temperature, conductivity, total dissolved solids (TDS), turbidity, color, organic matter, iron and manganese. These parameters were determined first on the raw water samples and on the treated water after determining the optimal doses of the coagulant.

2.4 Methods of treatment of water samples

2.4.1 Methods of treatment

Jahn's experiments (cited by Wolfrom) highlight the first-order importance of agitation on the result of flocculation, both agitation material and speed [21]. The regularity and duration of agitation strongly influence the quality of the flocculation process [21].

The method used in this work is the Jar-test flocculation test, suitable material and very appropriate for the respect of the speed and agitation of the solutions. According to Bratby[22], this is the most appropriate mechanism for flocculation coagulation activity.

2.4.2 Operating principle of the Jar-test

In the laboratory, the samples were treated with increasing volumes of coagulants in order to be able to determine the appropriate doses according to the characteristics of the different samples. To do this, 10^{-3} m^3 of raw water from the Biyeme river being, used by the inhabitants of Ahala 2 in Yaounde 3 district in Cameroon, was introduced into the 6 beakers of the six-station electric flocculator (FC6S Jar Scientific Test Velp), followed by the addition of different volumes of coagulant. The stirring of the water after introduction of the coagulant was done in rapid phase for 5 minutes and in slow phase for 20 minutes. We followed then the decantation in these beakers for an interval of time ranging from 30 minutes to 2 hours. After this settling time, a sample was taken 3 cm from the surface at the centre of each beaker using the bottom of a pipette. The decanted water is then filtered on filter paper. Turbidity was measured before and after 30 minutes for all samples to determine optimal conditions and factors influencing treatment. In order to obtain the optimal dose of the coagulant, the experiment was repeated until the beginning of the increase in the turbidity of the decanted water and consequently that of the filtered water. The other parameters were determined under optimal conditions in order to evaluate the effect of the treatments on the physicochemical and bacteriological composition of raw water. Fig -2shows the flocculator device in the Jar-test.

2.5 Experimental methods of analysis

To achieve our goals, we needed not only a well-conducted sampling, but also an appropriate method of analysis. The methods used were for the most part standard.

2.5.1 Measurement of pH, temperature, electrical conductivity and total dissolved solids

PH, temperature, conductivity, and total dissolved solids were measured from a WTW Multi 350i brand portable digital multimeter calibrated for each parameter. The electrodes were immersed in a beaker containing 5×10^{-5} m^3 of water to be analysed and the value of the search is displayed on the screen. We waited about thirty seconds to read the value.

2.5.2 Measurement of turbidity

The measurement of the turbidity of the samples was carried out using a SERIEN NR 201301136 laboratory turbidimeter. The result was read directly on the turbidimeter screen a few seconds after introduction of a 2.5×10^{-5} m^3 tank containing the water sample to be analysed. The results are expressed in NTU (Nephelometric Turbidity Unit).

Fig -2: Jar-test flocculator device

2.6 Quantitative chemical analyses

The quantitative chemical analysis performed allows us to determine the levels of the different species highlighted by volumetric and colorimetric assays.

2.6.1 Volumetric dosages

Volumetric dosages consist of measuring a volume of a titrated solution proportional to the concentration of the desired element. The determination of the equivalent point can be made using a colored indicator.

2.6.1.1 Determination of the Complete Alkalinity Title (TAC)

The TAC makes it possible to determine the content of hydrogen carbonate and half of the carbonates. The procedure for determining the TAC had been to add 2 to 3 drops of helianthine (methyl orange) in 10^{-4} m^3 of water to be analysed and titrating with the alkalimetric liquor (N/25). The reading of the value of the TAC on the burette was made when the liquid had taken an orange hue.

2.6.1.2 Determination of the concentration of organic matter

The determination of the organic matter dissolved in the water was carried out by the oxidation with potassium permanganate. We used per 100 ml of water to be analysed, 2 ml of sulphuric acid (N/20), 10 ml of Mohr salt (N/80) and a plate heating. The value in $mg.l^{-1}$ of organic matter content is deduced from the appearance of the persistent violet coloration.

2.6.2 Colorimetric assays

These assays involve color reactions whose intensity of the color obtained is evaluated by means of standard comparators.

2.6.2.1 Determination of iron concentration (Fe^{2+})

In an ammoniacal medium, the alcoholic solution of dimethylglyoxime gives, with the iron brought to the ferrous state, a complex whose pink coloring at an increasing intensity with the concentration of iron. In 10^{-4} m^3 of water to be analysed introduced into a Erlenmeyer flask, a pinch of sodium hydrosulphite was added. After stirring, 16 drops of dimethylglyoxime and 16 drops of ammonia were introduced into the same Erlenmeyer flask. A pink color characteristic of iron was observed. Subsequently, the reading was carried out after 15 minutes of reaction with the aid of a comparator of the ORCHIDIS mark (reference laboratory 1PF006P203A).

2.6.2.2 Determine the concentration of manganese ions (Mn^{2+})

In acetic acid, the manganese ions are oxidized to permanganate ions, in the presence of sodium periodate, and react with tetramethyl-diomino-diphenylmethane (TDD) for 15 to 30 seconds, taking a blue tint which varies proportionally with the concentration Mn^{2+} ions. The procedure was consisted in rinsing two cuvettes with distilled water, then with the water to be analysed, filling the two cuvettes with the water to be analysed. In one of the cuvettes, we added a pinch of sodium periodate and we stirred until dissolution, then we added 6 drops of acetic acid, then 12 drops of TDD. We introduced the solution into a comparator and quickly read the value using the ORCHIDIS brand manganese wafer (Reference Laboratory 1PM001P210).

2.6.2.3 Determination of water color

The color of the water was compared to color screens calibrated with platinum-cobalt solution. No reagent was used for this manipulation. We rinsed two cuvettes ABC with distilled water, then filled one of the cuvettes with water to analyse (up to trait C) and the other cuvette with distilled water (until trait C). The reading was then made from an ORCHIDIS color plate comparator (Reference Laboratory 1PC015P220).

2.7 Microbiological characteristics of waters

Some microbiological indicators of faecal water pollution such as: total coliforms and faecal streptococci were determined on the samples before and at optimal treatment conditions. The determination was made by the membrane filtration method. The water samples were filtered through a 0.45 µm membrane using a vacuum pump under sterile conditions with a burner (Bunsen burner). After filtration, the membrane was placed in a petri dish containing the appropriate culture medium. The culture media consist of Bile EsculinAzide agar (BEA) for total coliforms (CT) and Tetraphenyl Tetrazolium Chloride (TTC) and tergitol 7 for faecal streptococci (SF). The membranes are then introduced into incubators at 35 °C for SF and at 44.5 °C for CT for 24 h. After incubation, the colonies were counted and their total number estimated by the formula:

$$\mathbf{UFC} = \frac{\mathbf{Numberofcoloniescounted}}{\text{Filtered}\mathbf{samplevolume\ (ml)}} \times \mathbf{10^{-4}m^3}$$

Where UFC = Unit Colyform for 10^{-4} m^3 (for bacteria).

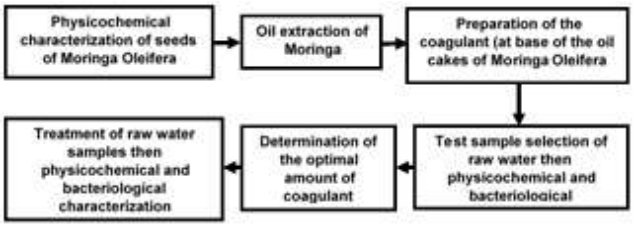

Fig -3 summarizes the experimental protocol used.

3. RESULTS

3.1 Physicochemical characteristics of Moringa Oleifera seeds

The results of the physicochemical characterization obtained for 100 g of dried seed powder are given in Table 1. The values mentioned are the average of the three tests carried out. Protein is one of the essential

elements responsible for coagulation in the water treatment process. These analyses showed that Moringa Oleifera samples contain an average of 31.30 % protein.

Table 1: Physicochemical characteristics of Moringa Oleifera seeds

Searched parameter	Value obtained(in %)
Dry matter	94.93
Water content	5.7
Total ash	03.47
Organic material	91.46
Total lipids	50.73
Raw protein	31.30
Totalcarbohydrates	10.95
Raw fibers	07.52

3.2. Oil extraction from Moringa oleifera

For a seed powder mass of 75 g and an oil mass obtained of 26.5 g, the yield of the extraction of Moringa oil at the soxhlet was 35.33 % of the weight of the seeds, results in agreement with those of Haritiana et al. [17]. This extraction of oil makes it possible to double the value of the seeds given the importance of this oil and the fact that it is the cakes (extraction waste) that will be used for the treatment of water.

3.3. Characterization of the raw water

Samples of Biyeme River water supplying the populations of the Ahala 2 district in Yaounde 3 town hall, were used in this work. The physicochemical and bacteriological parameters of the raw water coming from this river before treatment were shown in Table 2.

Table2: Physicochemical and bacteriological parameters of water before and after treatment

Parameters	Raw water	Processed and filtered water	WHO standards
Hydrogen potential (PH)	6.66	7.03	6.5 – 9.5
Temperature (°C)	24.0	24.2	≤ 25
Turbidity (NTU)	54.00	0.92	5
Electrical conductivity (10^2 µS.m^{-1})	586	589	180-1000
Total Dissolved Solids (10^{-3} kg.m^{-3})	15	0	1000
Full Alkalimetric Title (10^{-3} kg.m^{-3})	7.4	8.2	25
Ion Fe^{2+} (10^{-3} kg.m^{-3})	0,6	0	0,3
Ion Mn^{2+} (10^{-3} kg.m^{-3})	0,3	0	0,05
Color (Pt/Co)	100	15	20
Organic materials (10^{-3} kg.m^{-3}d'O_2)	1.2	16	2.5
Total Coliforms (UFC/10^{-4} m^3)	4000	388	0
Fecal Streptococci (UFC/10^{-4} m^3)	1400	188	0

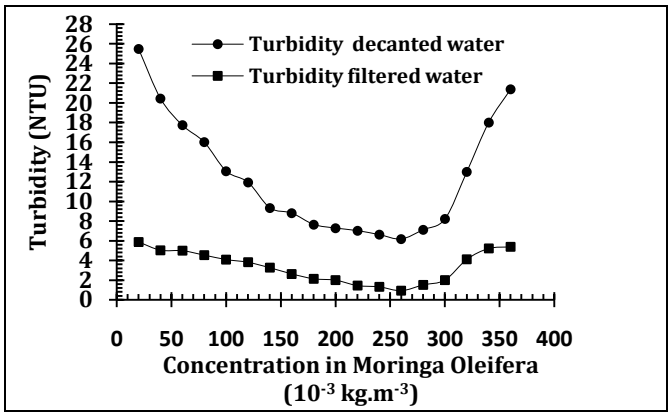

Fig -4: Evolution of turbidity with Moringa Oleifera doses

3.4 Determination of the optimum dose of Moringa Oleifera coagulant

In order to determine the optimal doses of Moringa Oleifera seed cake extract, we measured the change in water turbidity as a function of Moringa Oleifera coagulant dose. The optimal dose matches with the lowest turbidity value obtained, that is at least each of the curves obtained. Fig -4 shows how turbidity decreases to a limiting value and then increases beyond that limit. The optimal dose of Moringa Oleifera obtained to treat raw water was 0.26 kg.m^{-3}.

3.5 Qualitative aspect resulting from flocculation

Fig -5 illustrates the formation of flocs over time in two beakers containing 10^{-3} m^3 of raw water, after injection of 0.260 kg.m^{-3} of Moringa coagulant and 2×10^{-7} m^3 of purifloc. Otherwise, Fig -6 showed the visual appearance of Moringa Oleifera treated water.

Fig -5: Appearance of beakers during evolution of flocculation over time

Fig-6: Raw water and water treated with Moringa Oleifera coagulant

3.6 Influence of the concentration of Moringa Oleifera seed cake on pH and temperature

Fig -7 shows the evolution of pH and temperature with variation Moringa Oleifara seed cake dose. This study showed that the use of Moringa cake slightly increases the pH, but has almost no influence on temperature.

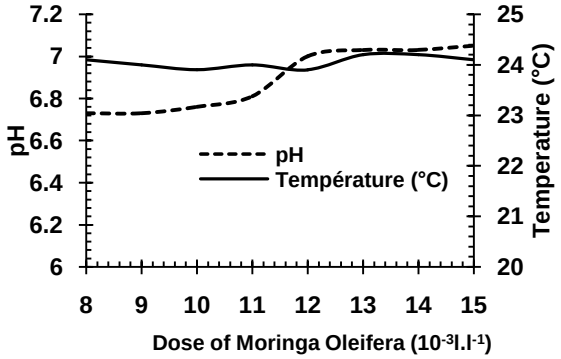

Fig -7: Evolution of pH and temperature with Moringa Oleifera doses

3.7 Determination of other parameters under optimal treatment conditions

The optimal dose of the Moringa Oleifera coagulant being determined, all other parameters were evaluated and compared to the WHO standards for drinking water. The results obtained are shown in Table 2. We tested the effectiveness of plant extracts (Moringa Oleifera) on the treatment of drinking water.

4. DISCUSSION

before and after treatment under optimal conditions. The treatment of raw water samples with Moringa Oleifera. For a seed powder mass of 75 g and an oil mass obtained of 26.5 g, the yield of the extraction of Moringa oil was 35.33 % of the weight of the seeds, results in agreement with those of Haritiana et al. [17]. This extraction of oil makes it possible to double the value of the seeds given the importance of this oil and the fact that it is the cakes (extraction waste) that will be used for the treatment of water.

Some researchers such have also carried out the physicochemical characterization of Moringa oleifera seeds. Kenmogne [18] showed that Moringa Oleifera contain an average of 31 % protein. The results of Haritiana et al. [17], showed that Moringa Oleifera contain 37.34 % of protein content. Ndikumana and Rutikanga[23] obtained, as results on the physicochemical parameters of Moringa Oleifera, 5.8 % of water content, 31.8 % of oil content and 61.9 % of cakes and protein content. According to the results obtained by Ralezo Malandy[24], Moinga Oleifera contained 4.08 % of water content, 38.40 % of protein content, 3.20 % of ash content, 34.70 % of gray content and the 3.50 % of fiber content. For the same parameters analyzed, the physicochemical characterization results obtained remain in the margin with some exceptions ready of those obtained by these researchers. The deviations from different results may be attributed to the Moringa Oleifera production regions, used in the different research.

The optimal dose of Moringa Oleifera used to treat 10^{-3} m^3 of raw water was 0.26 $kg.m^{-3}$ for a settling time of 30 minutes, with residual turbidities of 6.16 NTU for decanted water and 0.92 NTU for filtered water on folded filter paper, that is a reduction of turbidity of around 98 % in filtered water. Since the turbidity of the filtered water obtained after treatment with the optimal dose is less than 5 NTU [26], the cakes of Moringa Oleifera seeds behave, from this point of view, as a good coagulant. Note that from 0.080 $kg.m^{-3}$ of Moringa injected into the raw water, we obtained a filtered water turbidity of 4.53 NTU; but our wish was to find the best dose with the lowest possible turbidity as it influences the disinfection treatment. Also, turbidity can provide food and shelter for pathogens, thereby promoting their proliferation and outbreaks of water-borne diseases, hence the importance of this parameter in the treatment and stability of drinking water. The increase in turbidity above the optimal dose is due to the replacement of colloidal turbidity by particulate turbidity which is the consequence of the presence of organic matter in the plants used. In the absence of purifloc, the same results are obtained for a settling time of 2 hours. It is concluded that the purifloc actually acts as a catalyst in the Moringa treatment. Using the optimal dose, we observed (figure 5) the progressive purification resulting from the formation and deposition of the flocs at the bottom of the beakers.

The increase of pH with the concentration of Moringa Oleifera seed cake can be explained by the proton acceptor character of the basic amino acids present in the protein contained in the seeds of the Moringa species, which results in a release of a hydroxyl group. The pH values obtained after treatment are fairly close to neutrality (about 7), a value that respects those of the WHO standards (6.5 <pH <9.5) of water intended for human consumption. These results were in agreement with those of Folkard[25], which show that the chemical composition of water evolves shortly after treatment with Moringa Oleifera.

Concerning the other parameters under optimal treatment conditions (table 2), all results obtained from physicochemical and bacteriological analyses, except for organic matter and bacteria, were in line with WHO standards for water intended for human consumption. We can therefore conclude that Moringa Oleifera was a good coagulant and a disinfectant that can help many families solve, at their level, the problem of drinking water supply. Combining this method of treatment with a flocculation catalyst (the purifloc), the results are exploitable on an industrial scale.

Electrical conductivity measures the ability of water to conduct electrical current and therefore the ion content of this water. We noted, on table 2, a slight increase in the electrical conductivity of the treated water, not exceeding the standards set by the WHO (1000 µs/cm). This increase in conductivity, which accounts for the mineralization of water, is a physicochemical parameter that can reassure consumers suffering from cardiovascular diseases [17].

Table 2 also shows the variation of total dissolved solids before and after treatment under optimal conditions. The treatment of raw water samples with Moringa Oleifera removes total dissolved solids of the order of 100 %.

The complete alkalimetrictiter (TAC) is the basis of the study and control of a softening treatment by chemical precipitation; the pre- and post-treatment TAC values are shown in table 2. These results indicated an increase in the TAC of 7.4 to 8.2 mg/l, which is lower than the standard established by the WHO (25 mg/l), which reflects the gentle characteristic of the treated water.

Iron and manganese are two important metals whose verification of contents is essential for drinking water. Table 2 shows the variation in iron and manganese levels before and after treatment with Moringa oleifera. The treatment of the raw water, with Moringa Oleifera, helped remove almost all of the iron and manganese with 100 % reduction rates for both elements. The elimination of the two metallic elements would be simultaneous with that of the colloidal particles. Thus, Fe^{2+} and Mn^{2+} ions would be trapped in the aggregates formed during the destabilization of the colloidal particles by the coagulant.

The color is due to the presence of dissolved or colloidal organic matter in the water. Treatment of raw water with Moringa Oleifera gave the results shown in table 2. The Moringa Oleifera coagulant, significantly reduced the color of the water with a reduction rate of nearly 85 %. The appreciation of the color abatement rate (85 %) can be explained by the decrease in dissolved or colloidal organic matter. It should be noted that a colored water is not pleasant for the domestic uses and in particular for the drink, because it always presents a doubt on the potability. The treated water had an estimated color of 15 Pt-Co meeting drinking water standards for human consumption of 20 Pt-Co [26].

The presence of organic matter in water is not necessarily toxic, but only this promotes the development of certain undesirable parameters in water such as: bacteria, color, smell, taste. Table 2 shows the change in organic matter before and after treatment. The increase in organic matter after treatment with Moringa Oleifera was considerable and this is a handicap for the use of this plant in the treatment of drinking water because it will be a conservation problem. The treated water cannot be kept at the risk of favoring a possible pollution.

Total coliforms are considered as indicators of microbial quality of water because they may be indirectly associated with faecal pollution. Table 2 shows the effect of Moringa Oleifera on these germs. We observed that the treatment of the raw water with Moringa Oleifera reduced the total coliforms of the order of 90 %.

Fecal Streptococci are associated with Fecal Coliforms, and are considered a good indicator of pollution, and also an indicator of treatment efficacy, as they are significantly more resistant than Coliforms and other pathogenic Enterobacteriaceae[27]. The variation of faecal streptococci before and after treatment is shown in table 2. The analysis of our treated sample showed a reduction of faecal streptococci with a reduction rate of 86.57 %.

The ability of Moringa Oleifera to significantly reduce pathogens showed that it contains antimicrobial substances and therefore plays an important role in the purification of polluted water. Bratby also showed a strong relationship between turbidity abatement and that of microorganisms [28].

5. CONCLUSIONS

After extraction of the Moringa oil with hexane, the cakes were used for the treatment of raw water taken from the Biyeme river in Ahala 2 in the Yaounde 3 district of Cameroon. The optimal dose of Moringa Oleifera determined by the Jar - test flocculation technique, based on the reduction of turbidity as a function of settling time, was 0.26 kg.m-3. The results of the physicochemical and bacteriological analyzes of the treated water prove that Moringa cakes are a good natural coagulant for the treatment of water at family and even industrial scale using a flocculation catalyst. Moringa Oleifera cakes used for water treatment effectively reduces turbidity around 98 %, total dissolved solids (TDS) for 100 %, bacteria (CT and SF) for 87 to 90 % and has little influence on pH and temperature. This treatment slightly increased the Complete Alkalinity Title (TAC) and the electrical conductivity to values that do not exceed the standards of potability. As for the organic matter content, it increased considerably and exceeds the norm. Despite the minor deficiencies observed, this solution may be recommended in developing countries where the shortage of drinking water was greater. Economically, socially and environmentally, this coagulant has several advantages over the commonly used chemical coagulant. It is easy to produce and has no toxicity. Plants of Moringa Oleifera are cultivable (even intensively) in many countries without requiring too much space.

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