



Physico-Bacteriological Parameters of the Pond Water Treated with Powdered *Moringa oleifera* Almonds Dried at Different Temperatures for the Purpose of Drip Irrigation

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Authors' contributions

This work was carried out in collaboration between both authors. Author YBDA designed the study, wrote the protocol and the first draft of the manuscript. Author GGY managed the analyses of the study, performed the statistical analysis and managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Surface waters are generally turbid because they contain suspended matter, organic matter, chemical and physical or even biological elements that make these waters unfit for drip irrigation. The almond powder of *Moringa oleifera* that was used in the study was dried in an oven for one month at temperatures of 25, 40 and 50°C and used to treat the water of Kongou Gorou Zarmagandey pond so it is suitable for localized irrigation. The purpose of this study was to evaluate the physico-bacteriological quality of the waters of this pond. The parameters studied are *Escherichia coli*, faecal Streptococci, total germs and sulphito-reducers, organic matter, total residues and the color of treated water. After treatment of water with 100 mg/Lp *Moringa oleifera* seed powders dried at the respective temperatures of 25, 40 and 50°C, the supernatants were removed and analyzed. The results of this analysis show an increase in organic matter of 52.59, 55.84 and 57.14%; a slight reduction in total residues of 0.7%, 4.3% and 2.5% at the respective temperatures of 50, 40 and 25°C; an abatement of *Escherichia. Coli* is total (100% for all

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temperatures). For Streptococci, a reduction of 99.24% was observed for the dose at 25°C and 98.48% for those at 40 and 50°C. For Sulfo-reducing agents, the efficacy of the treatments is therefore total, 100% for doses of 100 mg. 1 to 25 and 40°C and about 99.99% for that at 50°C. Finally, in terms of color, there was a drop of 97.62%; 97.858% and 98.167% at the respective temperatures of 50°C, 25°C and 40°C. The analysis of the water in the study area shows that the latter is in line with the FAO guidelines on the physico-bacteriological aspects of irrigation water in general and that of drip irrigation in particular.

Keywords: Water treatment; drip irrigation; Moringa oleifera; Kongou Gorou Zarmagandèye, fao guidelines.

1. INTRODUCTION

Water in Africa remains one of the major concerns of governments and its issue affects all age groups. Its relationship to health status is often put forward as a priority, but it has curiously received relatively little attention from researchers.

The use of chlorine and its derivatives (with the exception of chlorine dioxide) for the disinfection of drinking water such as irrigation water in a pressurized irrigation system (sprinkling, drip) not only has the drawback of producing tasty substances, a source of public complaints about tastes and odors when it is in excess [1]. Chlorine also causes the formation of by-products, in particular trihalomethanes, by reaction with the organic matter contained in the water or with the bromide ions [2,3].

Today, it is imperative to think about no longer using this disinfectant, which is so harmful to humans, obviously replacing it with other less expensive, safe and above all accessible to our populations. It seems that the integration of biological water treatment processes could be a sustainable alternative in improving the quality of drinking water as well as that of irrigation due to the availability and atoxicity of bio-coagulants [4]. Indeed, Moringa seeds prove to be a sustainable and inexpensive solution [5], because they reduce water turbidity and pathogenic microorganisms [6]. In addition, this approach is ecological and respectful of the environment, it is inexpensive, simple and beneficial for the populations of rural areas [4]. In this article, the question of the physico-bacteriological parameters of the pond water treated with dried Moringa almond powder at different temperatures for drip irrigation will be discussed.

2. MATERIALS AND METHODS

2.1 Collection and Transport of Samples for Analysis

Taking a water sample seems very simple at first glance. However, it must be ensured that it is representative (that is to say that it faithfully reflects the state of the watercourse where and when it was sampled), that it does not undergo no contamination and that it retains its integrity until the time of analysis [7].

The 25l PET (polyethylene terephthalate) plastic cans were used during this study to collect the water samples to be treated at the Kongou Gorou Zarmagandey pond. An indelible marker was used to annotate the initial collection points before each sampling.

2.2 Transport of Samples

The samples collected were hermetically sealed, stored at 4°C in collection coolers transported to the soil science laboratory of the Faculty of Agronomy at the University of Niamey according to the sampling principle described by [8] Rodier.

2.3 Storage of Samples

The preservation process preserves the integrity of samples taken between the time of sampling and the time of laboratory analysis to prevent certain parameters from undergoing physical changes or chemical reactions in the container, which adversely affects the original quality of the sample [7]. In order to obtain analyzes that represent the conditions of the pond as faithfully as possible, samples were preserved in the soil science laboratory of the Faculty of Agronomy of Niamey.

Thus, the bacteriological analyzes were carried out directly and the rest of the samples were well stored in the refrigerator for subsequent physicochemical analyzes in order to characterize the water in the Kongou Gorou pond.

2.4 Preparation of the Powder and Water Treatment Process

For the preparation of *Moringa oleifera* almond powder and the treatment of pond water for the various parameters to be studied, the following procedure was carried out chronologically:

- Shell and crush the dry seeds of *Moringa oleifera* until you obtain a flour;
- Put 100 ml of water in each bottle of distilled water;
- Shake vigorously for 2 min;
- Pour the contents of the bottle into the container of water to be purified through a fabric filter;
- Stir rapidly for 2min then slowly for 10 min;
- Leave the mixture to stand.

The containers used should be cleaned after each use, so as to remove insoluble elements from the seeds. Although seeds and kernels can be stored for long periods of time, the dough should be renewed with each water treatment [9].

1.5 Bacteriological analyzes.

Bacteriological analyzes of water consist of the detection and enumeration of the following germs: total germs (GT), total coliforms (CT) and fecal (CF), faecal streptococci (SF), *Escherichia Coli* (*E. coli*) as well as sulfite-reducing clostridium (CSR). Bacteriological analysis is not only quantitative but also qualitative [10].

Due to the fact that the soil science laboratory does not have the material and human resources to carry out the bacteriological analyzes, the latter were carried out in the units of the Laboratory of the Société d'Exploitation des Eaux du Niger (SEEN) which is located in Goudel (Niamey).

The analyzes were mainly and specially focused on the determination of indicators of fecal contamination such as total and fecal coliforms, bacteria, fecal streptococci, Sulphito-reducing, and 44°C for *Escherichia coli*. Chromocult® Coliform Agar from Merck, a selective and differential culture medium was used for their detection by the surface spreading technique. The spreading of the samples on the culture medium was done using small autoclavable

plastic beads [11]. Before cultures, Chromocult was prepared according to the manufacturer's instructions, then sterilized at 121°C for 15 minutes in an autoclave and poured into Petri dishes. After plating the samples were incubated at 37°C for 24 hours.

- They were made in several stages:
- Sterilization of the jars in the Raypa STEAM STERILIZER brand autoclave at 121°C for 20 minutes;
- Water intake by rinsing the jars three times with water from the pond;
- Dose and start the coagulation and flocculation operation;
- Decant the water in 1L jars and store it in a refrigerator (PHARMACEUTICAL REFRIGERATOR) at 4°C for 24 hours ;
- Inoculate the culture media through a suction shaft to suck up the water passing over the medium and the fire to avoid contamination by foreign germs;

we use :

- ✓ 100 ml of water on Tergitol medium for *Escherichia coli*;
- ✓ 100 ml of water on Azide medium for Streptococci;
- ✓ 2 ml of water on Meat-Liver Agar medium for sulfite-reducing agents;
- ✓ 1 ml of water on Standard medium for total germs;
- Incubation for 24 h in incubators at 37°C for bacteria, faecal streptococci, sulphito-reducing, total and faecal coliforms and 44°C for *Escherichia coli*;
- Observation and reading of media

2.5 Physical Analysis

2.5.1 Determination of organic matter

The method used for the determination of organic matter is that of the "permanganate index" test, which consists in measuring in an acidic medium the quantity of oxygen used for the reduction of potassium permanganate by the oxidizable materials contained in water. The operating mode consists of:

- Take 100 ml of the sample in a graduated cylinder and pour it into a 250 ml conical flask suitable for the heating system used ;
- Acidify the sample by adding 3ml of sulfuric acid;

- Then bring the solution on a hot plate to keep the samples at a temperature of 98°C ($\pm 2^\circ\text{C}$) until boiling;
- Add 15 ml of potassium permanganate (titrated solution) and keep boiling for 10 minutes (± 15 seconds): during this phase, the potassium permanganate will be consumed by the oxidizable materials.

2.5.2 Determination of total residues

After the treatment and after 2 hours of settling, the pasty deposits were collected in porcelain containers, dried in an oven at 50°C for 24 hours. The dry deposits were then weighed using an Adventurer Pro brand 0.001 g precision scale.

2.5.3 Measuring the color of the water

The color of the water is a benchmark of quality for drip irrigation water. It is a parameter reflecting an aesthetic nuisance which can have an origin: natural (presence of iron and manganese in deep water, humic substances in surface water), be one of the consequences of the eutrophication phenomenon (excessive development of algae and plankton) in lakes, ponds, dams, etc. and finally have a chemical industrial origin (dyes from tanneries and the textile printing industry and dyes) [12]. The color of the water is measured using a spectrophotometer while taking the color of distilled water as a reference color. It is expressed in cobalt.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Bacteriological parameters

In the present study, the effectiveness of *Moringa oleifera* powder in reducing four groups of bacteria was tested. These are *Escherichia coli*, Faecal Streptococci, Total and Sulphite-reducing bacteria.

3.1.1.1 *E. packages*

The raw water from the study pond was of poor bacteriological quality and contained approximately 23 germs per 100 ml. *Moringa oleifera* almond powders dried at respective temperatures of 25,40 and 50°C with a dose of 100 mg /L were used for the treatment of this water, samples of the supernatants were taken and analyzed. The results of this analysis show a

total reduction in *Escherichia coli* total (100%) regardless of the drying temperature considered.

3.1.1.2 Faecal streptococci

The results on the determination of the Streptococcus group germs from raw water from the pond show that this water does not contain any individuals of this type of germs / were found in the raw water. After the treatment of the same water was made with *Moringa oleifera* almond powder with the dose of 100 mg /L and the results confirm that this water does not contain any faecal streptococci. This proves the good bacteriological quality of the treated water due to the absence of these germs from the fecal streptococcus group. However, the absence of these germs was a handicap to be able to evaluate the effectiveness of the powder of the seeds of *Moringa oleifera* in the elimination of faecal streptococci.

The 0 faecal streptococci results recorded in the case of our sample comply with the WHO directive which is 0/250 ml [13] and the French standard which is 0/100 ml [14].

3.1.1.3 Total germs

One of the bacteriological analyzes consisted of looking for total germs in the samples of raw water and water treated with almond powder. The results of the raw water analysis show that it contains approximately 132 germs per ml. As for the treated water, the microbiological analysis of the supernatants showed significant elimination of these germs which reduced this population to 1 germ / ml, 2 germs / ml and 2 germs / ml with powders dried respectively at 25°C, 40°C and 50°C. That is a reduction in the rate of total germs 99.24% for the dose at 25°C and 98.48% for those at 40 and 50°C.

3.1.1.4 Sulphite-reducing

The raw water used has a high level of Sulfite-reducing bacteria of 124 germs per 2 ml. The treatment of this water with the powder considerably reduced this number. The results of the study show that only the water treated with the powder dried at 50°C contains 1 germ / 2 ml of sulfite-reducing bacteria and no presence was reported in the treated raw water samples. by powdered almonds from *Moringa oleifera* dried at respective temperatures of 25 and 40°C. So, here the reduction of the bacteria genus Sulfo-reducing is 100% for the dose of 100 mg /L at 25 and 40°C and about 99.19% for the temperature of 50°C.

The first two are therefore in accordance with the French standard [15] and the EU [13].

3.1.2 Physical parameters

3.1.2.1 Organic material

Unlike the previous parameters, the initial organic matter content of the raw water (3.85 mg/L significantly increased by 52.59, 55.84 and 57.14% after the water treatment with 100 mg/L of *Moringa oleifera* powder dried at 50, 40 and 25°C respectively Fig. 1.

- **Total Residues** : With a turbidity of around 640 NTU, the raw water used has a high content of suspended elements. The Total Residues (RT) at the initial state are estimated at 0.5 mg /L Fig. 2.
- **Color** : The color of raw water is 4202 cobalts. The colored water was treated with almond powders of the dried *Moringa oleifera* seeds at the respective temperatures of 50°C, 40°C and 25°C for an application rate of 100 mg /L. After only 2 hours of settling time, the color of the water dropped rapidly leading to a drop of 97.62%; 97.858% and 98.167% respectively for 50°C, 25°C and 40°C (Fig. 3A). Then, this decrease becomes slower and slower in 24 hours to bring the color of the treated water back to the percentages of 99.167%, 99.286% and 99.309% respectively at drying temperatures of 50°C, 40°C and 25°C. (Fig. 3B). The color changed a little after 72 hours to give the percent reduction of 99.619%, 99.69% and 99.738% at the respective known temperatures (Fig. 3C).

3.2 Discussion

Water treated with Moringa almond powder at temperatures of 25, 40 and 50 ° C shows a total reduction of *Escherichia. coli* total (100%) regardless of the drying temperature considered. These results comply with the WHO guideline value of 0/100 ml and disagree with those of [16] and [17] who found that Moringa treatment does not remove 100% of the water pathogens. *Escherichia coli* is considered the most appropriate indicator of faecal contamination [18].

The treatment of pond water with *Moringa oleifera* almond powder at a dose of 100 mg /L shows a considerable reduction in the rate of total germs 99.24% for the dose at 25°C and

98.48% for those at 40 and 50°C. Our results corroborate those found by [19] for which, Moringa removes 90 to 99.9% of impurities from water such as total germs. On the other hand, our results are different from those obtained by Bernardin [20] in Madagascar who obtained a 50% reduction in total germs. This difference would be due to the initial turbidities of the treated water (638NTU for the water in our study and 16.5NTU for the water studied by Bernadiv) but also to the doses applied which are completely different and which are respectively 100 mg /L and 60 mg /L. But despite the good results recorded, they do not comply with the WHO 0/250 ml directive [13] and the French standard which is 0/100 ml [14].

As regards organic matter, an increase of 52.59, 55.84 and 57.14% respectively at temperatures of 25, 40 and 50°C was recorded. This increase in the organic matter content of the treated water is thought to be linked to the organic nature of the flocculant proteins of *Moringa oleifera* [21]. Our results are consistent with those of two teams of researchers, in this case that of [22] and in Burkina Faso the team of [23] They found an increase of the organic matter content of water treated with *Moringa oleifera* powder from 102% to 104% and 30 to 100%, respectively. These rates are all above the guideline value of I WHO which is 5 mg /L. The increase in organic matter levels that we obtained is thought to be due to the fact that the seeds of *Moringa oleifera*, being rich in protein, probably diffuse organic matter as well as other ions such as nitrate and sulfate into the treated water [22].

The existence of suspended solids in large quantities in raw water can be explained by the presence of the phenomenon of massive proliferation in this water.

After treatment of this water with almond powders, the amount of total residues did not vary much depending on the respective drying temperatures and this slight difference is not statistically significant. This gives the total residues of 0.4965 mg /L, 0.4785mg/L and 0.4875 mg /L respectively at temperatures of 50, 40 and 25°C, i.e. a slight reduction of 0.7%, 4.3% and 2.5%. The determination of these residues makes it possible to assess the load carried by the water. This load can, in certain cases, lead to rapid clogging of the filters. It can be interesting to know the clogging power of water [13] especially when it is intended for certain irrigation methods such as drip or

sprinkling. Regarding the color of the water treated with almond powder, a decrease of 99.167%, 99.286% and 99.309% respectively at the drying temperatures of 50°C, 40°C and 25°C was recorded. Statistical analysis revealed significant differences at all measurement dates. At 2 hours (Fig. 3A) and 24 hours of settling (Fig. 3B), the colors of the treated water are homogeneous with each other but different from the Control.

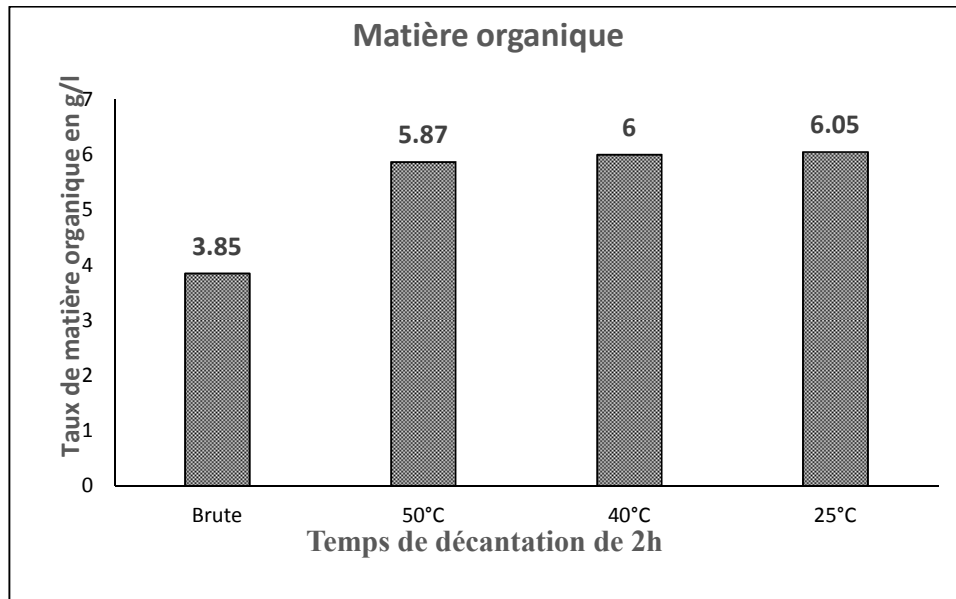


Fig. 1. Evolution of the organic matter of water as a function of the drying temperature of the *Moringa oleifera* powder and of settling time

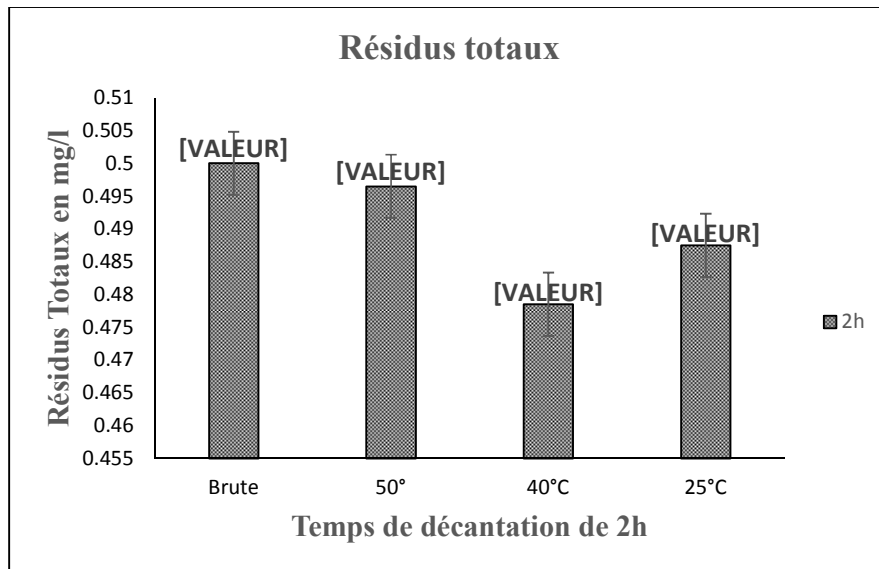


Fig. 2. Evolution of total water residues as a function of the drying temperature of the *Moringa oleifera* powder and of settling time

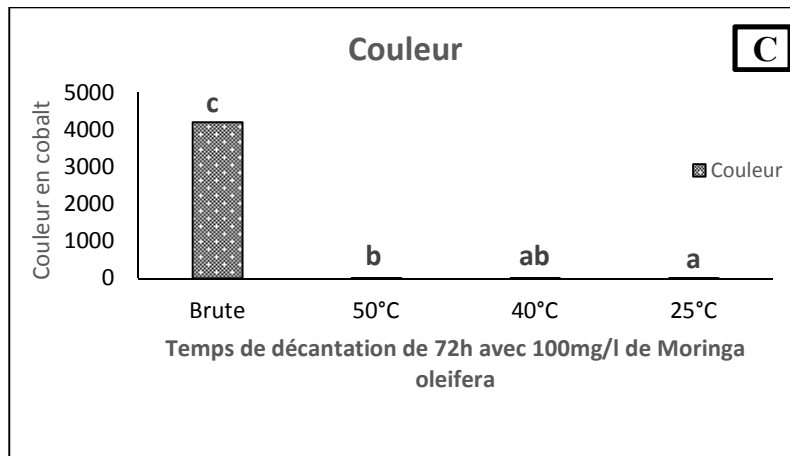
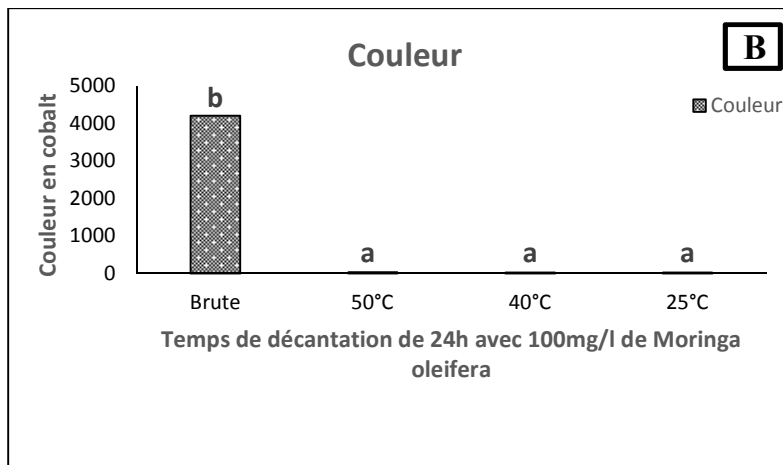
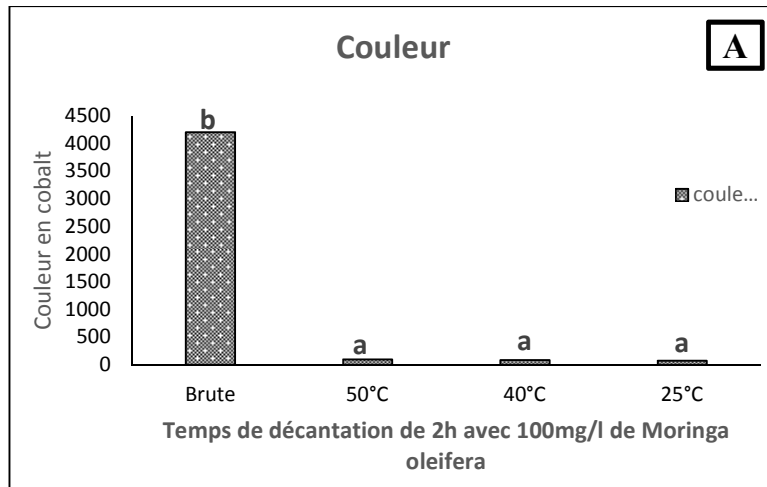


Fig. 3. Evolution of the color of the water as a function of the drying temperature of the *Moringa oleifera* powder and of the settling time

While at 72 hours, the color of the water treated with the dose of 100 mg /L dried at 25°C is better than the Control and that at 50°C. But the water treated with this dose at 25°C is homogeneous with that at 40°C (Fig. 3C). Water intended for drip irrigation should have an

acceptable appearance and be free from any abnormal changes [25]. If it is colorless, it is more reassuring for drip irrigation without any fear of clogging of the drippers. The water obtained after treatment is suitable for use in drip irrigation without any problem.

4. CONCLUSION

The tendency of *Moringa oleifera* seeds to decrease microbial levels shows that they contain antimicrobial substances and therefore play an important role in the purification of polluted water. The results obtained within the framework of this study touch more closely on the role that *Moringa oleifera* can play in water treatment. The results obtained in this study allow us to confirm the hypothesis according to which it is possible to replace chemical coagulants by natural coagulants (seeds of *Moringa oleifera*). In addition, the seeds of *Moringa oleifera* being rich in protein probably diffuse organic matter in the treated water. The seeds of *Moringa oleifera* can be used to reduce raw water concentrations of metals. Regarding the parameters observed, two evolving trends have emerged. This is the strong drop off of about 99.25% color, 100% *Escherichia coli*, 98.86% of total Germs, 99.99% of Sulfo-reducers, and 55.19% increase in organic matter, 8.19% of TDS, 24.99% of calcium on the other hand . The water resulting from the treatment meets the standards for irrigation water in general and drip irrigation in particular for most of these parameters. Based on these promising results, it will be interesting to expand research on methods of reducing residual organic matter in treated water in order to stabilize the treated water and extend shelf life.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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