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COMPARATIVE STUDY OF ***MORINGA OLEIFERA*** AND ***CITRUS PARADISI*** AS DISINFECTANTS AND COAGULANTS FOR WATER TREATMENT

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Abstract. The coagulant and disinfectant qualities of *Moringa oleifera* and *Citrus paradisi* were investigated on various water samples acquired from sachet water (packaged water), borehole water, river water and well water. The results revealed that *Moringa oleifera* functioned adequately at settling time beyond 2 h in highly turbid river water but was more effective when combined with *Citrus paradisi*. *Moringa oleifera* or its combination with *Citrus paradisi* is less effective for turbid water treatment but effective for river water (sample) purification. The number of total *Coliforms* and *Escherichia coli* reduced with the increasing treatment time.

Keywords: *Moringa oleifera*, *Citrus paradisi*, water treatment, turbidity, disinfection, coagulation.

1. Introduction

The supply of hygienically safe and adequate drinking water is critical to the health and well-being of humanity. Water is an indispensable resource for human, animal and plant life as well as world economy. It is a vital environmental factor to all forms of life and plays a critical role in socio-economic development globally. From a local or global perspective, the problem of potable water shortage has become a cause for concern. It is estimated that over 2 billion people in over 80 countries of the world either lack access to clean water or experience water shortage [1, 2]. Population explosion, industrial expansion and the use of automobiles have greatly aggravated water pollution. Therefore, there is an urgent need to treat the water before consumption [3].

In Nigeria, many rural communities rely solely on self-water supply source. This requires households to depend on available water sources including rainwater, rivers, ephemeral streams, shallow wells and springs for domestic and industrial purposes. This is due to lack of modern water supply systems such as boreholes or pipe-borne water networks, however where such facilities exist, they are either completely broken down or malfunctioning. In Nigeria, numerous health problems, for example, an outbreak of cholera, typhoid fever, dysentery and other water-borne diseases have resulted from the inability to access modern and improved water supply systems. Presently, water corporations, public utility boards and local government councils in Nigeria are responsible for public water treatment and supply management [3].

Coagulation is a well-known process in water treatment used for removal of different organic substances from water for human consumption [4, 5]. It is also the most commonly used method for turbidity and particle removal during water treatment [6]. Coagulants are mainly classified into inorganic coagulant/inorganic polymer (for example, poly-aluminium chloride, PAC), synthetic organic coagulant (poly-aluminum silica sulphate, PASS and inorganic salt “alum”/aluminum salt) and naturally occurring coagulants (*Moringa oleifera*) [5, 7, 8]. Other classes of coagulants are mineral salts of polyvalent cations and iron salts [9]. Despite the popularity of these coagulants in a water treatment process, the cost, environmental and health effects are the major factors that hamper their continuous application in water treatment [5-7, 9, 10]. For instance, aluminium salts are often used as coagulants for treating wastewaters with different chemical and biological characteristics. However, aluminium has a strong carcinogenic property which induces Alzheimer’s disease [11-13]. Synthetic polymers such as acrylamide and epichlorohydrin also contain contaminant formulations comprised of residual/ unreacted monomers which are known to be carcinogenic [11-13]. Furthermore, aluminium causes neurological diseases and disrupts the natural alkalinity of water reducing pH, coagulation efficiency and sludge deposition

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during water treatment [5, 14]. Furthermore, poor chlorination may be partly to blame for the rise of deadly protozoan infection reported in Pakistan in 2014 [15].

Besides the health effects of chemical and synthetic coagulants, developing countries like Nigeria, are also confronted with many challenges in water treatment [16-18]. These challenges include turbidity, inefficiency and the high cost of water treatment chemicals which constitute about 35–70 % of recurrent expenditure [19, 20]. It has also been reported that the rising costs of water treatment chemicals are hampering the operations of water corporations in Nigeria [20]. Also, declining revenues, government funding and the inability of local supply of water treatment chemicals is a source of concern [21-23]. Hence, the quest for alternative coagulant from the natural material is influenced by the costs, health and environmental concerns associated with the use of synthetic organic polymers and inorganic coagulants in water treatment. Recent researches on the development of coagulant now focus on utilisation of readily available natural materials with excellent qualities that can compete with commercial coagulants [24, 25]. The discovery and utilisation of *Moringa oleifera* as an alternative source of coagulants is a sustainable alternative to existing coagulants [26-29].

Moringa oleifera is an excellent example of a "multipurpose" tree widely cultivated in the tropics for various applications. For example, its dry seeds are commonly used as a coagulant in water treatment in rural areas Sudan and disinfectant in Egypt to treat turbid Nile water. It is also used as a hard water softener, and its seed husks are raw material for synthesis of microporous activated carbon [10, 14, 30]. The seed cake from oil extraction has been used as a coagulant, flocculant and steriliser to treat water or as a fertiliser. The seeds of *M. oleifera* are widely available in Nigeria where its extracted oil is used as a lubricant, and for biodiesel production [31. 32]. Also, its raffinate is used as a coagulant and an environmentally friendly disinfectant in drinking water treatment [8, 26, 33]. This present study, therefore, focuses on comparative analysis of disinfection and coagulation activities of *Moringa oleifera* and *Citrus paradisi* seeds in different water samples treatment at varying time.

2. Experimental

2.1. Collection of Materials

Five samples of water were collected from different locations in Bosso town, Minna, Nigeria. Two water samples were obtained from two water wells: one located in Bosso (uphill) and the other near Julius Berger Company, Minna, Nigeria. One water sample was obtained from a river in Bosso city (uphill), another water sample was obtained from package water ("Supreme pure water"), and the final sample was from a borehole located at the Federal University of Technology, Minna, Nigeria. The water samples were collected on the same day within one hour (7:00 am – 8:00 am). The collection of water samples at this particular time of the day was to ensure that the rising sun does not affect the quality (parameters of interest) of the water to be investigated. The containers used for the collection of samples were empty and washed thoroughly with distilled water and rinsed with the specific sample to be collected. The dry *M. oleifera* pods were obtained from Minna, Nigeria, as the green pods do not possess any coagulation activity [8]. Next, the dry seeds of *M. oleifera* were selected from the pods that were collected as shown in Fig. 1. The seed coat and wings were mechanically removed before pulverisation and sieving using an analytical sieve (250 μm) according to the method reported in the literature [28].

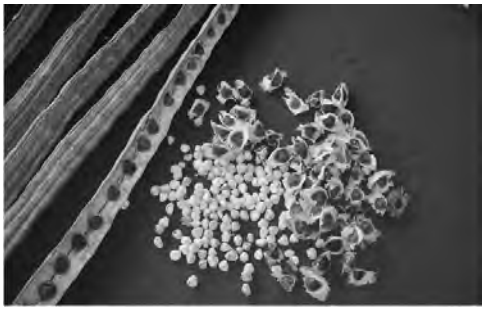

Fig. 1. *Moringa oleifera* pods and seeds [23, 27]

2.2. Extraction of Oil from *Moringa oleifera* Powder using Solvent Extraction Method

Oil extraction from *M. oleifera* seeds was performed in an electrothermal Soxhlet apparatus with ethanol as a solvent. A known weight (2.5 g) of *M. oleifera* seed powder was placed in the thimbles of electrothermal Soxhlet extraction chamber. Next 170 cm^3 of ethanol was added to the heating chamber. The process was conducted for 90 min in three equal 30-minutes cycles to ensure the extraction of oil from the seeds as signified by the change in colour of ethanol. After the oil extraction process, the seed cake was collected from the Soxhlet thimbles and dried in an oven over a period of one hour. The percentage yield of the oil extracted was then calculated. The oil content obtained was 35 % of the seed weight. The *M. oleifera* cake residue 65 % of the seed weight obtained after the oil extraction was used in this research work as coagulants to treat the water samples. *Citrus paradisi* was bought from Minna main market, Nigeria. The procedure for extraction of oil from *Citrus paradisi* seeds was similar to *M. oleifera*.

2.3. Salt Extraction of Bioactive Constituents from *Moringa oleifera* Residue Stock

Extraction of bioactive constituents was done by adding 1M of sodium chloride (NaCl). Five grams of *M. oleifera* cake residue stock were added to 1 l of 1M NaCl and mixed for 30 min using a magnetic stirrer. The solution was then filtered through a muslin cloth and Whatman filter paper number 1 to remove insoluble residue followed by applying the clear solution to microfiltration cartridge as reported in the literature [23].

2.4. Microfiltration

The samples extracted using NaCl were filtered using a microfiltration cartridge (CFP-2-E-3MA) (0.20 μm pore size, 1 mm ID), polysulfone type membrane (area 110 cm^2 and 30 cm nominal flow path length). "Protein assay method" was used to measure the protein concentration, and to determine the dosage of processed *M. oleifera* performing the Jar test. The permeate was collected and injected into the ultrafiltration cartridge according to the procedure reported in the literature [23].

2.5. Ultrafiltration

For bioactive constituents separation Xampler ultrafiltration cartridge (UFP-1-C-3M) with 0.5 mm ID fibre, 30 cm nominal flow path length, 1000 NMWC cut-off and 140 cm^2 polysulfone hollow fibre membrane area were used according to the procedure reported in the literature [23].

2.6. Freeze Drying

The filtrate was dried by freezing using LABCONCO, USA. The freeze drying of processed *M. oleifera* results in a white powder, which is totally soluble in water and has a high coagulation activity. This was done following the procedure reported in the literature [23].

2.7. Coagulant Solution Preparation

Moringa oleifera powder was dissolved in deionised water, and then the stock solution was diluted to the required strength. Coagulant solution was prepared using known concentrations.

2.8. Microbiological Analysis

In identifying the bacteria, there are four major approaches: molecular biological techniques, direct techniques, detection of microbial byproducts and culture techniques. To determine the number of bacteria in a sample, there is a variety of methods; including total population count, direct methods, total population count-indirect methods, viable counts, plate count procedure (pour plate, overlay plate and surface count plate methods) and turbidity measurements [34]. Several analytical methods are applied specifically to detect *Coliform* or *Escherichia coli* (at 317 K) as indicators of pollution. These include: mean probable number technique (MPN), multiple-tube fermentation technique (MTF), membrane filter technique (MF), and defined substrate technology (DST) Colilert® test. The MF is mostly preferred for the microbiological analysis since it is a reliable method that has been used to rapidly screen large volumes of water for indicator Coliforms. This method allows isolation and identification of colonies according to the references [35, 36].

The viable counts were adopted, and the procedure is as follows: an absorbent pad was placed inside empty sterile Petri dishes; sufficient membrane lauryl sulphate broth was aseptically added to saturate the pad. The medium was allowed to soak into the pad; the excess medium was poured off and discarded to avoid a confluent growth. With the aid of sterilised smooth forceps tip, the membrane filter was placed on the porous disk of the filter base. This was followed by placing sterilised funnel securely on the filter base. Firstly, a one-hundred-centimetre cube of water sample was pipetted into the funnel by pipetting a known volume and secondly it was made up to 100 cm^3. The water sample was then filtered slowly through the membrane filter. Immediately after filtering the water sample, the stop cork was closed to prevent air inlet through the membrane filter. After which it was carefully removed to one of the pads saturated with a membrane lauryl sulphate broth (Agar). It was ensured that no air bubbles were trapped between the membrane filter and the medium. The process was repeated with the second volume of water and for all the five water samples [35, 37].

Subsequently, Petri dishes were inverted and allowed to stay for 4 h before incubation at room temperature. A dish was then transferred into an incubator at 310 K for 14 h (for *Coliform* bacteria), and the other dish was transferred into an incubator at 317 K for 14 h (for *Escherichia coli*). After the total incubation period of 18 h, the membrane filter was examined under a bright light with a hand lens (colors are liable to change at cooling and standing). Hence, within 15 min of being removed from the incubator, all yellow colonies (however, fainted) were counted irrespective of size. The number of colonies counted on the membrane filter incubated at 310 K was regarded as the number of presumptive *Coliform* bacteria, and the number of colonies counted on the membrane filter incubated at 317 K was regarded as the number of presumptive *E. coli* [35, 37, 38].

Fig. 2 shows the flow diagram for the preparation of disinfectant and coagulant from *M. oleifera* seeds and its uses in the treatment of water samples.

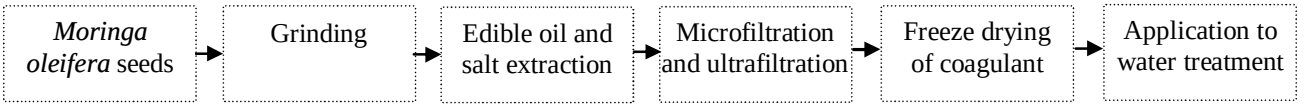

Fig. 2. Preparation of coagulant from *Moringa oleifera* and application to water treatment

3. Results and Discussion

The effectiveness of *Moringa oleifera* and *Citrus paradisi* as disinfectants and coagulants for water treatment was examined as presented in Tables 1-5. The results of the analysis of raw water samples collected from five different sources are presented in Table 1. The results indicate that pH of the raw water samples conforms to the standard of 6.5–8.5 set by the Federal Environmental Protection Agency (FEPA) of Nigeria except for the sample obtained from Supreme that had pH of 8.61. The pH value of water depends on its CO_2 content, and it has been reported that the pH value is lower when the concentration of CO_2 is higher [39]. Hence, the variations in the pH value of water samples can be attributed to the difference in water sources.

The temperature of the five water samples ranged within 293–296 K, which may be attributed to the time of the day the samples were collected. The river water sample had the lowest value of 293 K, Supreme water was 296 K, while the temperature of samples from FUT hand pump water, Berger water well and Bosso city water well were 294 K. Hence, the temperature of all water samples is within the set limit of ambient temperature set by the Federal Environmental Protection Agency (FEPA) of Nigeria [40].

The turbidity of water samples, which is a measure of the dissolved solids in water [41], was also measured. The results reveal that Supreme water had a turbidity of 0.6 NTU, FUT hand pump 0.40 NTU, Berger well-water 5 NTU, Bosso city water well 6 NTU, while the river water was 190 NTU. Regarding turbidity, it is important to note that samples water collected from Supreme water, FUT hand pump water and Berger well conforms to the set limit of 5 NTU, while the turbidity of water samples collected from Bosso well and River water is above the set limit [40, 42]. Also, the results indicate that the river water exhibited the highest value of turbidity (190 NTU) as expected since it is an open body of water with runoff from different sources.

Another parametric measure investigated was the conductivity of water samples. Conductivity is a measure of the ability of water to conduct electrical current; it depends on the movement of ions in water. Since conductivity is measured based on ionised substance in water, it can also be used as a measure of the total dissolved solid content of water. The results presented in Table 1 indicate that the conductivity of the water samples tested is in the range of 70–830 µs/cm. The lowest conductivity was observed for the river water sample at a conductivity of 70 µs/cm while Berger water well sample exhibited the highest level of conductivity with a value of 830 µs/cm.

The dissolved oxygen is an important feature of water quality that regulates both the chemical and biological activity in water. The value of dissolved oxygen can be influenced by the values of oxidizable substances such as fertiliser and agrochemical in the water samples. The dissolved oxygen of the five water samples ranged within 3–5 mg/l which is within the acceptable limit of 250 mg/l by the World Health Organization [42-44].

Other parameters tested were the total hardness; alkalinity and the chloride content of the water samples as presented in Table 1.

Table 1

Results obtained from the analysis of raw water samples

Parameters	Supreme water	FUT Hand pump	Berger water well	Bosso City water well	River water
Appearance	Clear	Clear	Cloudy	Clear	Highly turbid
Colour	Colourless	Colourless	Coloured	Colourless	Coloured
pH	9.00	8.00	8.00	8.00	8.00
Temperature, K	296	294	294	294	293
Dissolved oxygen, mg/l	5.00	8.00	5.00	3.00	3.00
Turbidity, NTU	0.60	0.40	5.00	6.00	190
Conductivity, µs/cm	130	210	830	400	70
Total dissolved substances, mg/l	90	140	600	270	50
Total hardness, mg/l	60	110	220	130	30
Alkalinity, mg/l	30	40	80	70	50
Chloride, mg/l	7	30	130	70	10
Total *Coliform*, viable count/ml	1	30	130	110	210
E. coli, viable count/ml	0	0	110	0	10

The results indicate that all the water samples except Supreme water failed the total *Coliform* test, which is an indication that the samples have either bacteria or faecal contaminations or both. Furthermore, the results in Table 1 indicate that there were negligible bacteria in Supreme water and FUT Hand pump water. While the Berger water well had 130 per ml of *Coliform* and 110 per ml of *E. coli*, Bosso City water well had 110 per ml, zero per ml of *Coliform* and *E. coli*, respectively. Results as presented also indicate that total *Coliform* in river water sample was 210 per ml while the *E. coli* was 10 per ml. Based on the results, it can be deduced that Berger water well, Bosso city water well and the river water samples did not conform to the standard value of zero *Coliform* per 100 ml of water set by the European Standard for drinking water [40, 43]. This can be attributed to contamination from adjoining septic tanks, soakage pits of the surrounding residential buildings. It can be inferred from the analysis conducted that Supreme pure water, FUT and Minna hand pump water are acceptable for drinking. Further screening of the water samples indicates that only Supreme pure water was almost 100 % safe for drinking.

Table 2 shows the results obtained when samples were treated with *M. oleifera* for a treatment period of 2 h; it can be seen from the results presented that the pH of the water slightly reduced after treatment. The results also show that the turbidity of the river water was significantly reduced after treatment, while that of the Supreme pure water, FUT hand pump water and Bosso City well water increased. This confirmed the established theory that *M. oleifera* is not very effective in treating already treated water (for instance, Supreme pure water) or water that is less turbid [17, 45]. Also, the turbidity of the water samples was higher after treatment compared to the set limit of 5 NTU [40, 42]. Regarding *E. coli* and *Coliform*, the results indicate that treatment of water with *M. oleifera* reduced bacteria contents of treated water. This suggests disinfectant and coagulation properties and activities of *M. oleifera* contributed immensely to getting some treated water acceptable in colour and appearance.

The results for the treatment effect of the mixture of *M. oleifera* and C*itrus paradisi* for two hours are presented in Table 3. The results show a little reduction in pH of the treated water, sample results also show that treatment of the water samples using the combination of *Citrus paradisi* and *M. oleifera* greatly reduced the turbidity of the raw water after treatment. Also, the Berger well-water sample reduced by 93 %, River water sample reduced by 69 %, but others increased slightly above what was obtained when the samples were treated with *M. oleifera* only. It can be seen from the results that the number of total *Coliforms* and *E. coli* reduced suggesting that *M. oleifera* and *Citrus paradisi* possess disinfectant and coagulant properties.

The results from the raw water samples treated with *M. oleifera* for 22 h are presented in Table 4. The results indicate a reduction in pH of the raw water samples after treatment within the permissible level of 6.5–8.5. Regarding turbidity, the result revealed that the Berger well-water sample increased by 99 %, River water sample reduced by 96 %, while other samples changed as follows: Supreme pure water sample reduced by 4 %, FUT borehole water sample reduced by 51 % and Bosso City well-water sample reduced by 48 %. Also, a slight reduction was noted in the number of total *Coliforms* and *E. coli* compared to Table 3 further suggesting that *M. oleifera* and *C. paradisi* can possess disinfectant and coagulant properties.

Table 5 shows the results of water qualities obtained when the five water samples were treated with the mixture of *M. oleifera* and *C. paradisi* for 22 h.

Table 2

Results from the analysis of samples + *Moringa oleifera* powder after 2 h

Parameters	Supreme water	FUT Hand pump	Berger water well	Bosso City water well	River water
Appearance	Less clear	Less clear	Less clear	Less clear	Less turbid
Colour	Colourless	Colourless	Less cloudy	Colourless	Less colour
pH	9.00	8.00	8.00	8.00	8.00
Temperature, K	297	295	297	297	297
Dissolved oxygen, mg/l	4.00	4.00	4.00	4.00	4.00
Turbidity, NTU	19.00	22.00	19.00	19.00	53.00
Conductivity, μs/cm	140	230	870	455	98
Total dissolved substances, mg/l	95	155	584	305	66
Total hardness, mg/l	390	380	670	570	400
Alkalinity, mg/l	90	170	130	150	140
Chloride, mg/l	75	230	330	446	125
Total *Coliform*, viable count/ml	0	13	201	156	25
E. coli, viable count/ml	0	0	15	6	1

Table 3

Results from the analysis of samples + *Moringa oleifera* powder + *Citrus paradisi* powder after 2 h

Parameters	Supreme water	FUT Hand pump	Berger water well	Bosso City water well	River water
Appearance	Less Clear	Less Clear	Less Clear	Less Clear	Less Turbid
Colour	Colourless	Colourless	Less Cloudy	Colourless	Less Coloured
pH	8.00	8.00	8.00	8.00	8.00
Temperature, K	25	26	25	25	25
Dissolved oxygen, mg/l	4.00	4.00	5.00	3.00	3.00
Turbidity, NTU	23.00	24.00	37.00	22.00	59.00
Conductivity, µs/cm	173	278	914	502	127
Total dissolved substances, mg/l	116	186	612	336	85
Total hardness, mg/l	180	100	330	70	130
Alkalinity, mg/l	64	88	150	70	80
Chloride, mg/l	99	90	160	90	135
Total *Coliform*, viable count/ml	0	11	179	133	21
E. coli, viable count/ml	0	0	13	5	0

Table 4

Results from the analysis of samples + *Moringa oleifera* powder after 22 h

Parameters	Supreme water	FUT Hand pump	Berger water well	Bosso City water well	River water
Appearance	Clear	Clear	Clear	Clear	Clear
Colour	Colourless	Colourless	Colourless	Colourless	Colourless
pH	7.00	8.00	8.00	7.80	7.60
Temperature, K	297	297	297	297	297
Dissolved oxygen, mg/l	2.70	2.00	2.60	3.00	2.00
Turbidity, NTU	5.00	11.00	6.00	10.00	7.00
Conductivity, µs/cm	143	220	808	438	94
Total dissolved substances, mg/l	96	147	541	293	63
Total hardness, mg/l	530	530	510	520	410
Alkalinity, mg/l	130	100	90	100	80
Chloride, mg/l	50	80	140	240	80
Total *Coliform*, viable count/ml	0	9	137	112	17
E. coli, viable count/ml	0	0	8	3	0

Table 5

Results from the analysis of samples + *Moringa oleifera* powder + *Citrus paradisi* powder after 22 h

Parameters	Supreme water	FUT Hand pump	Berger water well	Bosso City water well	River water
Appearance	Clear	Clear	Clear	Clear	Clear
Colour	Colourless	Colourless	Colourless	Colourless	Colourless
pH	7.00	8.00	8.00	7.00	7.00
Temperature, K	294	294	293	280	296
Dissolved oxygen, mg/l	5.00	3.00	3.60	3.90	7.00
Turbidity, NTU	5.00	4.00	2.00	5.00	5.00
Conductivity, µs/cm	156	216	754	403	74
Total dissolved substances, mg/l	105	145	55	270	70
Total hardness, mg/l	260	200	400	200	160
Alkalinity, mg/l	80	140	200	100	120
Chloride, mg/l	69	73	115	74	100
Total *Coliform*, viable count/ml	0	5	116	108	12
E. coli, viable count/ml	0	0	6	2	0

The results showed no significant difference in pH when *Citrus paradisi* was introduced in comparison with the results obtained when the water sample was treated with *M. oleifera* alone over the same treatment period of 22 h. Furthermore, the turbidity of the raw water samples reduced significantly after the treatment period of 22 h. The turbidity of the five water samples reduced by these trends: Berger well-water sample 99 %, Bosso City well water sample 17 % and River water sample 98 %, but, Supreme pure water sample and FUT borehole water sample generally increased from 0.64 to 5.18 NTU making 81 %, FUT borehole water sample increased from 0.36 to 4.27 NTU making an increment in turbidity of 12 %. Also, between the treatment period of 2–22 h the pH value reduced to a more acceptable level. Further decrement in the number of total *Coliforms* and *E. coli* was observed which confirms the very possibility that *M. oleifera* and *C. paradisi* possess disinfectant and coagulant properties. It can be inferred from the results of various analyses conducted in this study that both *M. oleifera* and *C. paradisi* are good water coagulants that can be used in place of commercial coagulants.

4. Conclusions

After 22-hours treatment time *Moringa oleifera* and *Citrus paradisi* caused 99 and 99.4 % reduction in turbidity of samples, respectively. The turbidity of sachet water sample increased from 0.64 to 5.18 Nephelometric Turbidity Unit (NTU) representing 809 % increment, while the borehole water sample increased from 0.36 to 4.27 NTU representing an increment of 11.86 %. The comparative analysis of the disinfectant and coagulant properties of *Moringa oleifera* and *Citrus paradisi* seeds for the treatment of different water samples showed that although *Moringa oleifera* is not effective in treating already treated or less turbid water, the bacteria (*Escherichia coli* and *Coliform*) content was reduced. Also, it contributed significantly to improving the colour and appearance of water. In this study, comparative analysis of *Moringa oleifera* and *Citrus paradisi* as the coagulant and disinfectant was also conducted. The results indicated that the water samples examined are unsuitable for consumption and treatment time positively affects the disinfectant qualities and water quality of *Moringa oleifera* and *Citrus paradisi*. Thus, *Moringa oleifera* and *Citrus paradisi* possess coagulation properties for application as coagulants in water treatment.

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ПОРІВНЯННЯ *MORINGA OLEIFERA* ТА *CITRUS PARADISI,* ЯК ДЕЗІНФІКУЮЧИХ ТА КОАГУЛЮЮЧИХ РЕЧОВИН ДЛЯ ОБРОБЛЕННЯ ВОДИ

Анотація. *Досліджено коагулюючі та дезинфікуючі властивості Moringa oleifera (Моринга маслянистa) та Citrus paradisi (грейпфрут) на зразках, отриманих з пакетованої води, води із свердловин, річкової та колодязної води. Показано, що Moringa oleifera адекватно функціонує після 2 годин відстоювання сильно мутної річкової води, і є більш ефективним у поєднанні з Citrus paradisi. Встановлено ефективність такої комбінації для очищення річкової води. Число загальної кількості Coliform та Escherichia coli (коліморфних бактерій та кишкової палички) знижується зі збільшенням часу оброблення.*

Ключові слова: *Moringa oleifera, Citrus paradisi, оброблення води, мутність, дезінфекція, коагуляція.*