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Comparative Analysis of Raffia Palm Seeds Extracts and Duckweed as Disinfectant in Water Treatment

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ABSTRACT

This study compares Raffia hookeri seeds extracts and LemnaTrisulca (Duckweed) as disinfectant in water treatment. Raffiahookeri and duckweed were obtained within Makurdi, Nigeria. While the raw water samples were taken from River Benue for the study. Laboratory analysis was carried out using dosage, pH, temperature, initial concentration, and flocculation speed as variables. Filtrate and powder from Raffia hookeri and LemnaTrisulca were used. The result revealed that extracts from the filtrates at 0.3 ml concentration gave the optimum, removing 98.2% and 82.9 % of bacteria for Raffia hookeri and duckweed respectively. For the powder, optimum conditions with respect to bacteria removal were; Dosage = 0.2 ml, pH = 3, Temperature = 30 °C, Initial concentration = 633 FTU and flocculation speed =90rev/min with average percentage removal of 91.1 % and 83.7 % for Raffia hookeri and Duckweed respectively. In conclusion, filtrate obtained from Raffia hookeri gave a greater removal of bacteria for disinfection of water.

1. INTRODUCTION

Water as abundant natural resources is said to occupy over 60% or more of the earth surface. It naturally occurs as marine, fresh, estuarine, underground and rainwater. It is used for several activities such as domestic, industrial and agricultural. These natural sources of water may be polluted with domestic and industrial wastes hence containing microorganisms and dangerous elements which can endanger health and life [1, 2]. Water collected from natural sources needs treatment to avoid infections, and the nature of treatment depends on the source and water intended usage. Water for domestic usage needs thorough disinfection against disease-causing micro-organisms, with minimal level of dissolved calcium and magnesium (hardness) [3, 4].

Disinfection is a form of water treatment process that requires the elimination of pathogenic microorganisms or the partial destruction of disease causing organisms that are not completely destroyed during the treatment process [5]. The fact that not all the microorganisms are destroyed differentiates disinfection from sterilization which is the elimination of all microorganisms. Wastewater effluents when discharged into receiving waters has an adverse effect on the consumers because it be used for domestic or other purposes and needs bacterial reduction in order to minimize health hazards [6]. Different physical or chemical methods are used in the destruction of microorganisms under certain conditions [7, 8, 9]. Chemical disinfectants like chlorine, however, combine with natural organic matters (NOMs) that may be present in water to form trihalomethanes (THMs) which are carcinogenic and/or mutagenic by products [10, 11]. Other disinfectant like chlorine dioxide, is also associated with taste and odour [12, 13].There is interest in using naturally occurring disinfectants for water purification in developing countries due to the high cost of inorganic chemicals etc. [14, 15, 16].

Raffia palms belongs to a genius of about twenty species of palm native to tropical regions of Africa. They grow as high as 16m tall with remarkable pinnate leaves, the longest in the plant kingdom. They are used especially in the textile and construction industries. Apart from Raffia palm usage in the production of a wine; its fruits are eaten as food, while, oils are also extracted from the nuts for medicinal and other chemical usage [17]. Duckweed is the nomenclature given to the

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simplest and smallest flowering plant that grows ubiquitously on fresh or polluted water. They are usually tiny and very fragile too, commonly noticed as they float freely in the form of aquatic plants. There is series of research aimed at understanding its application in genetic biochemical interactions [18]. This study is aimed at comparing the effectiveness of raffia palm seeds extracts and duckweed as disinfectants in water treatment.

2. METHODOLOGY

The Raw water used for this obtained from River Benue in air tight containers of 20 litres and taken to the laboratory for analysis. Mature Raffia hookeri fruits were collected from Makurdi town. The peels and pulp were removed to obtain clean kernels. The fruits were not boiled before removing the peels and pulp because analysis has shown that the chemical composition of the fruit reduces upon boiling [17]. Some of the kernels were sun-dried for some days; after which it was crushed to powder using mortar and pestle.While, Duckweed was also obtained in Makurdi town of Benue State. Laboratory analysis was done using thermometer for measuring temperature, Hanna digital pH meter for pH and application of Standard plate count methods for total coliform bacterial test [19].

2.1 Preparation of the Disinfectants

2.1.1 Raffia Palm Kernels

The novel material was prepared by pounding the dried raffia palm kernels into a powder which was applied to the raw water directly for treatment. The Filtrate form of the disinfectant was prepared by smashing fresh seeds of the Raffai palm. The smashed seed where placed in a funnel with a filter and distilled water passed through it, and the filtrate was collected and used as the disinfectant.

2.1.2 Duckweed

This plant (Duckweed) was harvested and properly washed with distilled water. The disinfectant was prepared by pulverising duckweed and obtaining a filtrate by squeezing the sample with palms. A second portion of the harvested duckweed was properly sundried, then pounded and grinded using a blender to obtain fine particle sizes.

2.2 Application of *Raffia Hookeri*and *LemnaTrisulca (Duckweed)* As Disinfectant.

2.2.1 Effect of Dosage

A10 ml sterile pipette was used to inoculate 0.1 ml, 0.2 ml, 0.3 ml, 0.4 ml and 0.5 ml of Raffia hookeri and Duckweed filtrate each into eleven different 100 ml samples of raw water. The samples were flocculated for 20 minutes to ensure a proper mix of the content. After flocculation, the samples were allowed to stand undisturbed for 30 minutes. After the 30 minutes, the Bacteria load test was conducted on the treated water samples. With respect to powder, varying dose of 0.5g, 1g, 2g, 3g and 4g were added in the different beakers. Then flocculated for 10 minutes and allowed to settle for 30minutes. The beaker with the lowest bacteria load was considered as optimum dosage.

2.2.2 Effect of Flocculation Speed

Eleven different 100 ml samples of raw water were inoculated with the optimum doses of the Raffia hookeri and Duckweed filtrate. Ten of the samples (five from each) were flocculated for 20 minutes at 45 rev/min, 98 rev/min, 120 rev/min, 180 rev/min and 260 rev/min respectively in a flocculator while the eleventh sample was not flocculated. The samples were allowed to stand undisturbed for 30 minutes. After the 30 minutes, the Bacteria load test was carried out for each of the treated samples.The above procedure was repeated using Raffia hookeri and Duckweed powder.

2.2.3 Effect of Contact Time

The optimum dose was inoculated into 100 ml of raw water. The sample was flocculated at the optimum flocculation speed for 20 minutes after which it was allowed to stand undisturbed for 10 minutes. The sample was analysed at 10 minutes, 30 minutes, 1 hour, 1.5 hours and 2 hours after treatment with the filtrate and powder of both Raffia hookeri and Duckweed.

2.2.4 Effect of pH

100ml of raw water were measured in 5 beakers containing different prepared pH levels of 3,5,7,10 and 12 and flocculated for 10mins using both Raffia hookeri and duckweed filtrates and allowed to settle for 30mins. Bacterial load test was

carried out on each sample. The beaker that had the lowest bacteria load was found using the MPN technique and considered as the optimum pH. The above procedure was repeated using Raffia hookeri and Duckweed powder.

2.2.5 Effect of Temperature

Five 100 ml samples of raw water of temperature values of 20 ^{0}C, 25 ^{0}C, 30 ^{0}C, 35 ^{0}C and 40 ^{0}C were treated using Raffia hookeri and Duckweed filtrates and flocculated under the optimum conditions. The samples were analysed at the end of optimum contact time for bacterial load. The beaker with the lowest bacteria load was considered as the optimum temperature. This method was repeated using optimum Raffia hookeri and duckweed powders.

2.2.6 Effect of Particle Size

Varied particle sizes i.e. 150 mm, 300 mm, 750 mm,1mm,1.8mmof both *Raffia hooker*i and Duckweed each were poured into different 100 ml samples of raw water. The samples were flocculated for 20 minutes and then allowed to stand undisturbed for 30 minutes. After the 30 minutes, each of the samples was analysed for bacterial load. The particle size with the best bacteria removal was considered as the optimum.

3. RESULTS AND DISCUSSION

The result of the comparative study using Raffia hookeri and Duckweed in the treatment of raw water from River Benue is presented in Figures 1 – 11. The results reveal the variation of treatment conditions taking into consideration their effect on Bacteria Load.

3.1 Analysis of Filtrate Disinfectants

3.1.1 Effect of Dosage

Figure 1 shows that, the dosage of the Novel disinfectant applied had effect on bacteria load as there was a reduction in bacteria load as the applied dosage increased. 0.3ml was considered as the most economic and optimum dosage with 97% and 90% percentage bacteria removal using Raffia hookeri filtrate and duckweed filtrate respectively.

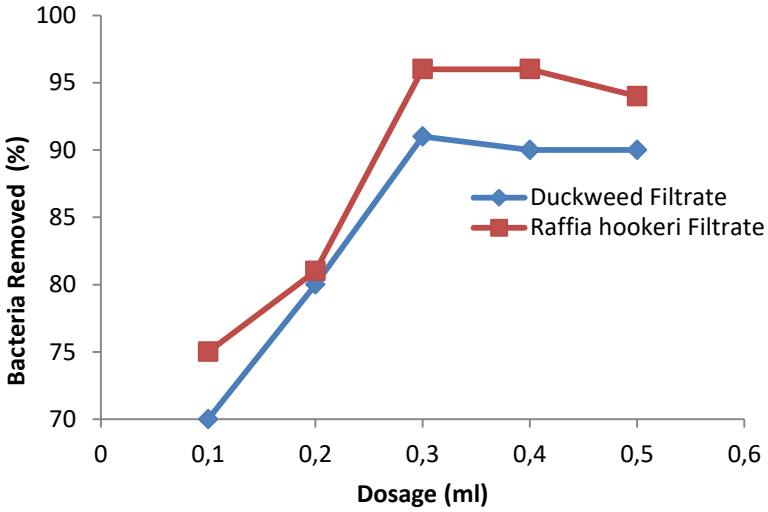

Fig1. Effect of dosage on bacteria removal.

3.1.2 Effect of Flocculating Speed

The effect of flocculating speed on Bacteria load removal is presented in Figure 2. The maximum percentage of Bacteria removal using Raffia hookeri filtrate and duckweed filtrate were 94.3% and 85.0% respectively. This shows that, the percentage of bacteria removal was high thereby reducing the pollution level of the raw water from 12 cfu/ml to 0 cfu/ml and 12cfu/ml to 1cfu/ml for Raffia hookeri filtrate and duckweed filtrate respectively. This was achievedat a moderate flocculating speed of 90 rev/min, which is very economical.

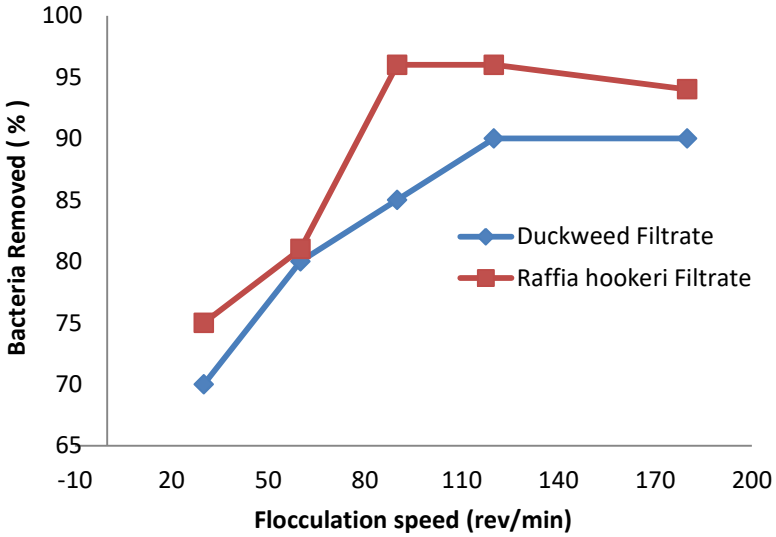

Fig 2. Effect of flocculation speed on bacteria removal.

3.1.3 Effect of Contact Time

The effect of contact time on the performance of filtrates from *Raffia hookeri*and Duckweed as disinfectant is presented in Figure 3. The figure shows that 90% bacterial removal was achieved within 10- 90 minutes and 82% within 10 - 30 minutes using *Raffia hookeri*filtrate and Duckweed filtrate respectively. But to save time and resources, 10 minutes is considered as the optimum contact time for disinfection.

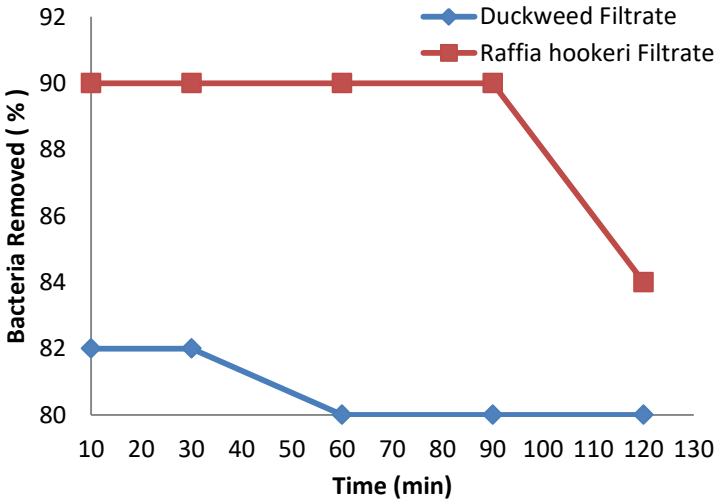

Fig. 3. Effect of Contact Time on Bacteria Removal.

3.1.4 Effect of pH

Filtrates of Raffia hookeri and Duckweedwere used to investigate the effect of pH on Bacteria removal from raw water as shown in Figure 4. It depicts that, slightly to the axis neutral pH is more effective for bacteria removal by these disinfectants. Average bacteria reduction at pH of 7 was 73 % and 52 % for Raffia hookeri and Duckweedrespectively.

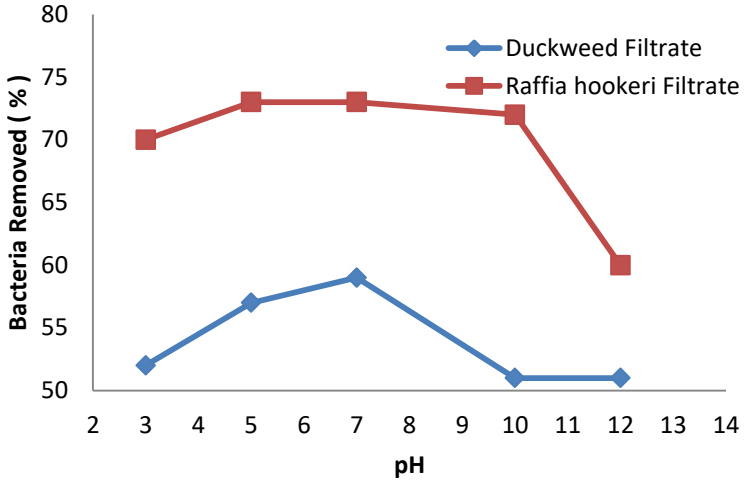

Fig. 4. Effect of pH on Bacteria Removal.

3.1.5 Effect of Temperature

The effect of temperature on bacteria removal from water is depicted in Figure 5. At temperatures of 20 °C, 25 °C, and 30 °C, bacterial removal was 84.1 % and 78 % by Raffia hookeri and Duckweedrespectively. The performance of raffia hookeri filtrate decrease after 30 °C though it was still better than that of duckweed. The Optimum temperature of 30 °C was chosen for both variations of the disinfectant.

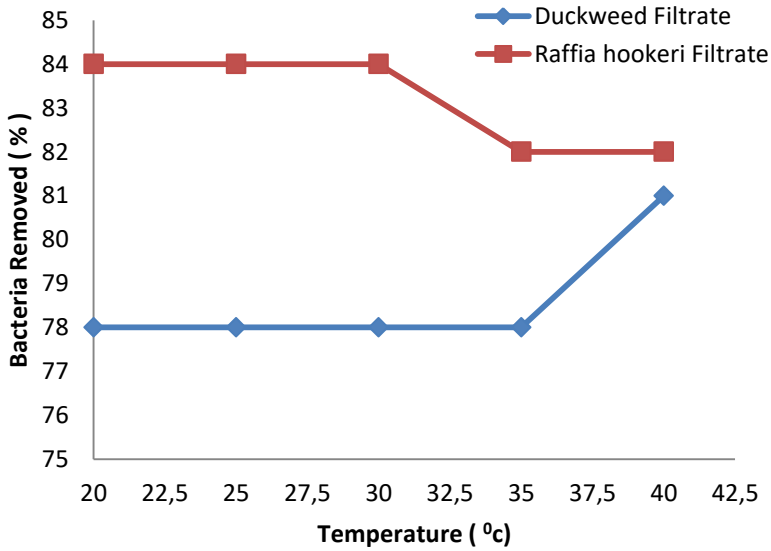

Fig. 5. Effect of Temperature of Water on Bacteria Removal.

3.2 Analysis of Powder Disinfectants.

The performance of Raffia hookeri and Duckweed powder disinfectants considering the effects of particle sizes, dosage, flocculating speed, contact time, PH, and temperature as variables is presented in figures 6 - 11.

3.2.1 Effect of Particle sizes:

The effect of different particle sizes is shown in Figure 6; it is obvious from the figure that more bacteria load was removed at a particle size of 0.3 mm with a removal of 78.2 %. The smaller particle size of 0.15 mm removed 65.5 %. In the same manner, particle sizes greater than 0.3 mm removed less than 78 % of bacteria load.It shows that the powder of particle size 0.3 mm gave optimum performance of 78 % bacteria removal.

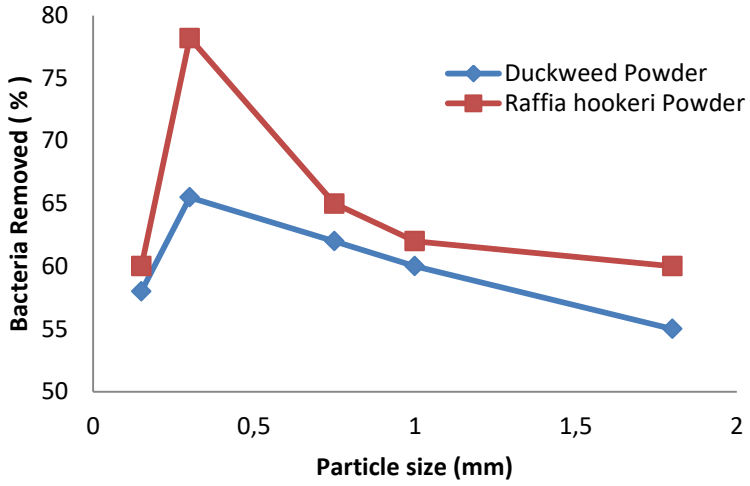

Fig. 6. Effect of particle size on bacteria removal.

3.2.2 Effect of Dosage

An increase in percentage bacteria removal was observed as shown in Figure 7 with increase in dosage. 83.5 % bacteria load was removed at doses of 2 g, 3 g and 4 g using Raffia hookeri powder, while, 80 % bacteria removal was observed using 5 g of Duckweed powder respectively. To obtain the best dose we look at the least amount of dosage that will still have the same effect on the removal of bacteria load. It is obvious that 2g of Raffia hookeri powder was considered as the optimum dosage to save cost.

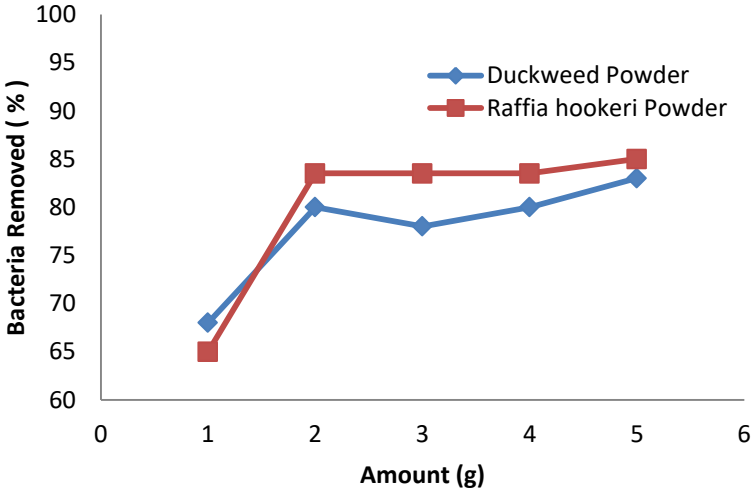

Fig. 7. Effect of dosage on bacteria removal.

3.2.3 Effect of Flocculation Speed

Flocculating speed has an effect on bacteria load using both Raffia hookeri powder and duckweed powder as disinfectants as shown in Figure 8. Increase in flocculating speed of the mixture brings about an increasing in the reactivity of the molecules thereby effecting more disinfectant-bacteria interaction. This results in bacteria load removal from 72.5 % to 84.3 % and 64 % to 76.5 %for Raffia hookeri and duckweed respectively. The optimum speed was obtained at 90rev/min same as in the filtrates variation of the novel disinfectants.

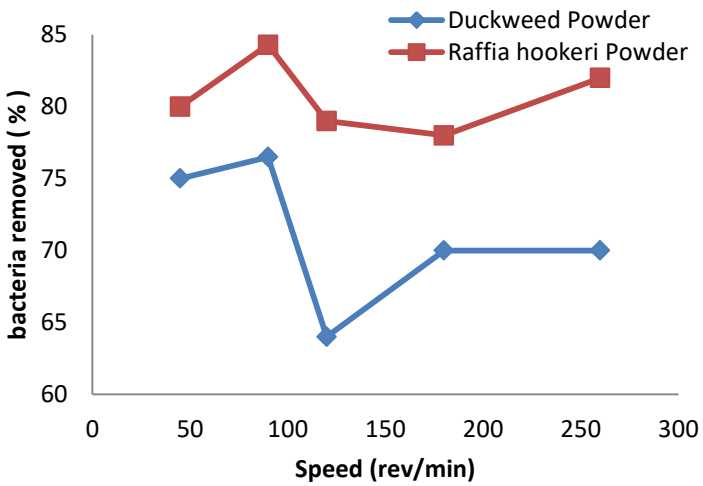

Fig. 8. Effect of flocculation speed on bacteria removal.

3.2.4 Effect of Contact Time

The result of the effect of contact time on the removal of bacteria from water is presented in Figure9. The figure shows that 81 % and 73 % bacteria removal was achieved at 10 minutes after treatment with Raffia hookeri powder and Duckweed powder respectively.

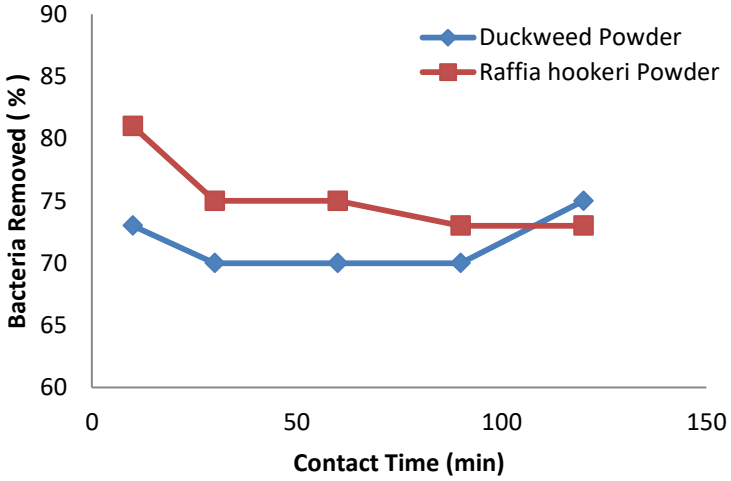

Fig. 9. Effect of Contact Time on Bacteria Removal.

3.2.5Effect of pH

From Figure 10, it can be seen that pH had an effect on the bacteria load using the disinfectants. The trend has no definite increase or decrease rate. pH of 7 had the highest recorded bacteria load while pH of 3 and 12 had zero bacteria load. But in the case of this study, pH of 3 is too acidic and pH of 12 is high in alkaline which makes the treated water dangerous to human health. In other words, it's inconsumable thereby considering the pH with the next least bacteria load which is 9 and has a percentage removal of 78.4 % as the optimum using Raffia hookeri powder.

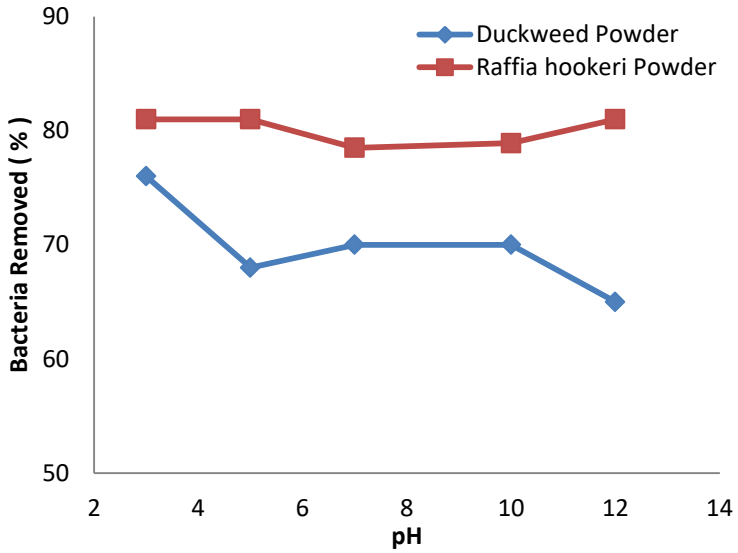

Fig. 10. Effect of pH of raw water on bacteria removal.

3.2.6 Effect of Temperature

Figure 11 represent the results of the effect of temperature of raw water on the performance of powder disinfectants. It indicates that percentage removed increased between temperatures of 30 °C, 35 °C and 40 °C while the least percentage removed was at temperatures of 25 °C and 45°C. The trend therefore shows that Raffia hookeri and duckweed powder disinfects better at temperatures between 30 °C and 40 °C. The optimum temperature was considered at 30 °C for economy, with 85.3 % and 79.1 % bacteria load removed for Raffia hookeri powder and Duckweed powder respectively.

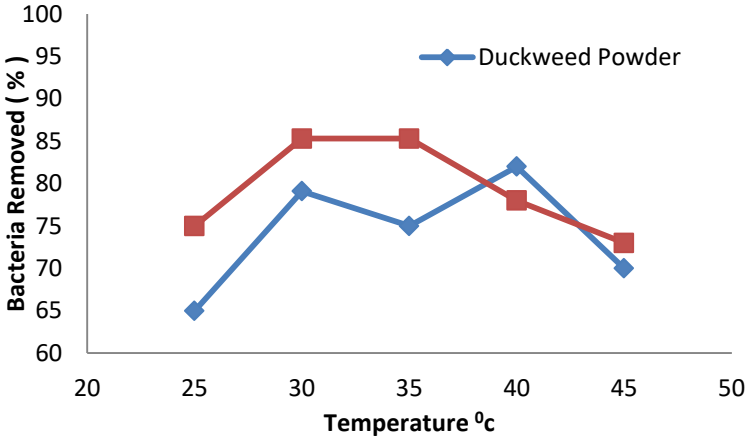

Fig. 11. Effect of Temperature on Bacteria Removal.

4. CONCLUSION

The research compares Raffia hookeri seeds extracts and LemnaTrisulca (Duckweed) as disinfectants in water treatment. Filtrates and powder form of Raffia hookeri seeds and LemnaTrisulca (Duckweed) were used as disinfectants. The number of bacteria present in the raw water was 900 per 100 ml. After treatment, the number of the bacterial dropped; ranging between 12 per 100 ml and 420 per 100 ml. Few bacteria were left after treatment using filtrates while larger number remained after treatment using their powder. These values are above the maximum value specified by WHO Standards for Drinking Water but the water is suitable for other uses. At 0.3 ml optimum concentration, the results revealed that the extracts from filtrates removed 98.2% and 82.9% of bacteria for Raffia hookeri and Duckweed respectively. For the powder, optimum conditions with respect to bacteria removal were; Dosage = 0.2ml, pH=3, Temperature = 30°C, Initial concentration = 633FTU and flocculation speed = 90rev/min with the highest percentage removal at 91.1% and 83.7% for Raffia hookeri and Duckweed respectively. The research recommends that, Water for domestic and other uses should be treated using filtrates of Raffia hookeri and Duckweed respectively, to remove bacteria in order to control and subsequently eliminate the problem of water borne diseases. Considering the cost and the health risks associated with the use of chemical and other forms of disinfection, the use of natural materials like Raffia hookeri filtrate, for water treatment should be encouraged and supported.

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