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Original Research Article

Evaluating the Performance of Desert Date (*Balanite aegyptiaca*) as a Disinfectant in Raw Water Treatment

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ABSTRACT

This study evaluated the potential of using desert date (Balanite aegytiaca) seed kernel as disinfectant in domestic water treatment. Four different extracts were prepared from the kernel namely defatted powdered extract (DPE), defatted water extract (DWE), defatted filtered extract (DFE) and crude water extract (CWE). A jar test apparatus was used to determine the effect of different dosages (0.5, 1.0, 1.5, 2.0 and 2.5 g/l) of the extracts in raw water treatment obtained from river Ngadda, Maiduguri, Borno State, Nigeria. The performance of the extracts against total coliform and E. coli was assessed. The results show that the optimum dose used in reducing both total coliform and E. coli concentration in the water was 1.5 g/l using DPE with 72 and 100% efficiencies, while DWE achieved approximately 90 and 100% removal respectively. Interestingly, the optimum dose of 1.5 g/l of DFE achieved approximately 83% reduction in total coliform concentration. However, for E. coli, 1.5 and 2.0 g/l were the optimum doses used to obtain 100% performance using DFE. Similarly, CWE recorded 89% reduction in total coliform using an optimum dose of 2.5 g/l while 1.0 g/l achieved 100% E-coli removal. A remarkable zero bacterial count was achieved for E. coli inactivation using DPE at (1.5 and 2.0 g/l), using DWE at (1.5, 2.0 and 2.5 g/l), using DFE at (1.0 and 1.5 g/l) and using CWE at (1.0, 1.5 and 2.5 g/l). Overall, the performance of Balanite aegytiaca seed extracts disinfectant in water treatment is promising showing 100% reduction in some cases against E-coli.

1. INTRODUCTION

Water is essential to all living organisms as it is the most fundamental commodity used to sustain life (Muda *et al.,* 2020). Globally, many countries rely on surface water compared to groundwater for their domestic

usage. This necessitates the growing need to focus on utilization of surface water for drinking purposes (Iqbal *et al.,* 2019). In most rural communities in developing countries especially the sub-Saharan Africa, surface waters (rivers, streams and lakes) is mostly used as the main source of water for domestic purpose (Igwe *et al.,* 2017). Igwe *et al.*, (2017) added that there has been significant impairment of rivers with pollutants, as anthropogenic activities are fast degrading most water bodies. In this regard, the World Health Organization (WHO) estimates that 1.8 billion people in the World still do not have access to drinking water and more than 800,000 people are estimated to die of diarrhea due to lack of access to clean drinking water (Valverde *et al.,* 2018). The quality of water is of serious concern to man and his animals since it is directly linked to human health (Miah *et al*., 2016). Therefore, the use of water treatment is key to the removal of undesirable compounds and contaminants so that the water is safe to use for different purposes.

Water treatment entails the removal of suspended and colloidal particles, organic matter, micro-organisms and other substances that are deleterious to health. This may require low cost technologies, operation and maintenance and minimal environmental impacts to the surrounding (Jayalakshmi *et al.,* 2017). The removal of turbidity and pathogens are important steps in the treatment process and, generally, this is achieved using coagulation and chlorination (Muhammad, 2017; Yero *et al*., 2021). The later, that is the use of water disinfectant as a public health measure ensures microbiological quality and reduces the spread of disease (Collivignarelli *et al.,* 2017).

Many chemical disinfectants, if overdosed or used inappropriately can react with organic and inorganic precursors to form disinfection by-products (DBPs) with adverse health effect (Jones, 2017*;* Muhammad, 2017*;* Collivignarelli *et al.,* 2017*;* Mumbi and Fenting 2018*;* Jones and Bridgeman, 2018*;* Saleh *et al.,* 2019; Ascon, 2019). Another disadvantage is the high water treatment cost for developing countries making provision for clean water supply and water treatment difficult (Hoa*,* 2018). Therefore, developing countries need to explore suitable plant extracts that can be used for surface water treatment (Jones and Bridgeman, 2018; Iqbal *et al.,* 2019). Many studies on natural coagulants have been conducted using different extracts from plants (Jones and Bridgeman, 2015; Jones, 2017*;* Yero *et al.,* 2021). Others include Valverde *et al.* (2018) who used *Moringa oleifera* (MO) seeds as coagulant, Ridwan *et al. (2014)* used okra seeds, Jones and Bridgeman, (2016*)* used Hibiscus seeds while Mustard seeds was used by Bodlund *et al.* (2013) etc., In addition, the MO seeds contain antimicrobial agent and was found to be very effective against several bacteria and Fungi (Choudhary *et al*., 2017).

Balanite aegyptiaca (L.) Delile a drought tolerant perennial tropical ever green tree belongs to family of *Zygophyllanceac (Balanitaceac*) is commonly known as "Desert Date" (Heiglige in Arabic) (Al- Thobati and Abu Zeid, 2018*). Balanite aegyptiaca* is readily available in large quantity in Northern Nigeria with little information about the advantages that can be produced from its seeds which in most cases is considered as a waste (Muhammad, 2017). Also, Daya *et al.* (2011) reported that the phytochemical properties of desert date could contain anti-microbial properties, as major groups of phytochemicals which possess anti-microbial properties are phenolics and polyphenol (flavonoids, quinones, tannins, coumarins), alkaloid, lectins, polypeptide and saponin (Ferdes, 2018). The presence of saponin, alkaloid and tannin in Hibiscus seed was responsible for inactivation of *faecal bacteria* as acknowledged by *Jones and Bridgeman, (2018).* The antimicrobial property of *Balanite aegyptiaca* was investigated and found to be present in the seed kernel by Yero *et al.,* (2020). While the protein content in the seed kernel was believed to be responsible for coagulation as reported by Muhammad, (2017). The protein content in the seed kernel of *Balanite aegyptiaca* varied from 27 to 37% (Mariod *et al.,* 2017). Therefore, this study focused on the disinfection performance of the seed kernel extract prepared in different forms against total coliform and *E. coli* in water.

2. MATERIALS AND METHODS

2.1. Material Collection

Balanite aegyptiaca, desert date seed was obtained from Gamboru market in Maiduguri, Borno State, Nigeria. The seed pod was soaked in water for 5-6 hours to soften the husk and was washed thoroughly until

the seed was husk free. Thereafter, the moistened seed was dried under the sun for a day. The dried seed pod was then cracked using hammer to obtain the kernel. Further processing of the kernel involved selection of the matured kernel because immature kernels may not possess effective compounds. The selected kernel was ground to powder using kitchen blender and then sieved through a 1000 µm sieve. Surface water sample was collected from River Ngadda within Maiduguri metropolis. The water was collected in a 10 litre sterile plastic container and was delivered to the laboratory within 30 minutes. The collected samples were measured for the micro-organisms before and after treatment.

2.2. Lipid Extraction

The presence of lipid in the kernel could limit inter-particle bonding during water treatment as established in literature by Jones and Bridgeman, (2016). Therefore, 50 g of the sieved powder was loaded into a Soxhlet extractor for lipid extraction. Using laboratory grade hexane, extraction was run continually for 7-8 hours and the residue was air dried for 3 hours. The dried residue was then washed severally with deionized water to remove residual solvent. The washed residue was oven dried for 6 hours at 40 ^{o}C and then, the cake was ground again into fine powder using pestle and mortar. The fine powder was sieved through 300 µm sieve.

2.3. Preparation of Extracts

The processed material was used as disinfectant in four (4) different forms as shown.

1. The defatted powdered extract (DPE) was added directly in the raw water for the treatment.
2. Defatted water extract (DWE) was prepared by dissolving the defatted powder in 30 ml of deionized water and then poured into the raw water for the treatment.
3. Defatted filtered extract (DFE) was also prepared from the defatted powder by adding 100 ml of deionized water onto each of the various measured dosages (0.5, 1.0, 1.5, 2.0 and 2.5 g) of the defatted powder. The suspension was stirred vigorously on a magnetic stirrer for 30 min at room temperature. The suspension was filtered through Whatman No. 42 filter paper. The filtrate was used to treat the raw water.
4. The crude water extract (CWE) was also dissolved in deionized water and was used in the water treatment.

2.4. Jar Tests

Jar tests were conducted using a standard jar tester (Phipps & Bird 7790-900) comprising six, 1 litre beakers to determine effect of the extracts in water treatment. Varying dosages of 0.5, 1.0, 1.5, 2.0 and 2.5 g/l were dosed with beaker number 1 used as a control. For effective mixing, the water was rapidly mixed at 200 rpm for 1 minute for coagulation. The mixing speed was then reduced to 10 rpm for a further 30 minutes for flocculation to occur. The suspension was then allowed to stand for another 30 minutes after which a sample was taken by decantation for microbial analysis. The microbial analysis was carried out using a tenth fold dilution with normal saline. All experiment was conducted in triplicate and the results analyzed.

3. RESULTS AND DISCUSSION

The performance of desert dates kernel extracts as disinfectant in treating raw water against total coliform and E. coli were conducted and the results presented in the Tables. Table 1 shows the performance of DPE in raw water against total coliform count and E. coli bacteria. The results showed that DPE cause a remarkable reduction in total coliform count from 32×10^3 to 9×10^3 and 11×10^3 CFU respectively with an efficiency of approximately 72 and 66% using 1.5 and 2.0 g/l respectively. Interestingly, the highest removal efficiency of the extract against E. coli was achieved using same doses of 1.5 and 2.0 g/l. However, 1.5 g/l was observed as the most effective and optimum dose for both total coliform and E. coli reduction. It is believed that the major cause of the reduction in bacterial count was due to the presence of alkaloid, tannin and saponin in the kernel (Daya et al., 2017). Similar observation was reported by Jones and Bridgeman, (2018) and Shaheed et al. (2009) using Hibiscus seeds and Luffa cylindrica respectively.

Table 1: Performance of defatted powdered extract

Dose (g/l)	Total coliform count (cfu)	% Reduction	*E. coli* count (cfu)	% Reduction
0.0	32×10^3	-	2×10^3	-
0.5	37×10^3	-	4×10^3	-
1.0	27×10^3	15.63	7×10^3	-
1.5	9×10^3	71.88	0×10^3	100
2.0	11×10^3	65.63	0×10^3	100
2.5	36×10^3	-	4×10^3	-

Table 2 present the disinfection performance of DWE in raw water. After the treatment process, the optimum dose for both total coliform and *E. coli* reduction recorded was 1.5 g/l. The performance of the extract showed reduction in the concentration of total coliform bacteria from 48×10^3 to as low as 5×10^3 cfu at the 1.5 g/l dose with an efficiency of approximately 90%. Further increase in the dose increased the concentration of bacteria from 5×10^3 to 15×10^3 and 46×10^3 cfu (both below the zero dose concentration) at 2.0 and 2.5 g/l doses respectively. However, at higher dosages of between 1.5 – 2.5 g/l, the extract achieved 100% efficiency against *E. coli*. It is, however, clear from this results that *E. coli* bacteria are sensitive to DWE resulting in such a significant achievement. Thus, the use of this extract in water treatment could improve access to clean drinking water supply in developing countries.

Table 2: Disinfection performance of defatted water extract

Dose (g/l)	Total coliform count (cfu)	% Reduction	*E. coli* count (cfu)	% Reduction
0.0	48×10^3	-	8×10^3	-
0.5	33×10^3	31.25	4×10^3	50
1.0	14×10^3	70.83	7×10^3	12.50
1.5	5×10^3	89.58	0×10^3	100
2.0	15×10^3	68.75	0×10^3	100
2.5	46×10^3	4.17	$0v10^3$	100

Table 3 shows the performance of DFE. For total coliform bacteria, increase in concentration was observed at the 0.5 g/l. However, further increase in the dose from 1.0 to 1.5 g/l caused a reduction in the concentrations in both coliform count at 83% and 100% *E. coli* bacteria removal. Additionally, an increase in the dosage from 2.0 to 2.5 g/l caused an increased concentration while for *E. coli* the concentrations were below the zero dose concentration. A kind of resistance to the extract was observed at the 2.0 g/l for total coliform since the bacteria count increases further. It is noteworthy that for *E. coli*, 100% reduction was recorded at 1.5 and 2.0 g/l dose. There were inconsistencies in the results for the 3 extracts (DPE, DWE and DFE) against both bacteria. Their efficiencies in terms of bacterial reduction was optimal at different doses between.

Table 3: Disinfection performance of defatted filtered extract

Dose (g/l)	Total coliform count (cfu)	% Reduction	*E. coli* count (cfu)	% Reduction
0.0	48×10^3	00	8×10^3	00
0.5	51×10^3	-	4×10^3	50
1.0	17×10^3	70.83	3×10^3	62.50
1.5	8×10^3	83.33	0×10^3	100
2.0	23×10^3	52.08	0×10^3	100
2.5	46×10^3	4.17	5×10^3	37.5

Table 4 shows the performance of CWE against total coliform and E. coli in raw water. The results show that the extract was effective at higher doses of 2.0 and 2.5 g/l respectively against total coliform in which maximum removal efficiency of the bacteria was achieved using 2.5 g/l dose with approximately 89% reduction. In addition, at 1.0, 1.5 and 2.5 g/l doses, there was 100% removal of E. coli in water. This could be due to the presence of certain compounds in the seed that is very sensitive and effective against E. coli.

Table 4: Disinfection performance of crude water extract

Dose(g/l)	Total coliform count (cfu)	% Reduction	*E. coli* count(cfu)	% Reduction
0.0	47×10^3	-	22×10^3	-
0.5	97×10^3	-	7×10^3	68.18
1.0	72×10^3	-	0×10^3	100
1.5	68×10^3	-	0×10^3	100
2.0	11×10^3	76.60	53×10^3	-
2.5	5×10^3	89.36	0×10^3	100

4. CONCLUSION

This study investigated the potential of Desert date in water treatment as disinfectant. Desert date kernel showed some remarkable activities in this regard, against *total coliform* bacteria and *E. coli* in raw water. However, the defatted extract showed significant performance than the crude extract against *total coliform.* This is because there might be some compounds present in the kernel that could hinder the disinfection process which were ultimately removed during the oil extraction. This study might, however, be incomplete without making recommendation to investigate the disinfection potential of Desert date kernel against other bacteria commonly found in raw water such as shigella, and salmonella. Also, advance purification process should be adopted to obtain the disinfecting compounds in the seed.

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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