Bull. Chem. Soc. Ethiop. **2007**, 21(2), 205-211. ISSN 1011-3924
Printed in Ethiopia

STUDIES ON THE EFFICACY OF *BRIDELIA FERRUGINEA* BENTH BARK EXTRACT FOR DOMESTIC WASTEWATER TREATMENT

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(Received May 13, 2005; revised January 26, 2007)

ABSTRACT. The efficacy of *Bridelia ferruginea* Benth bark extract in wastewater treatment was investigated. Chemical analysis found the bark to contain potassium, sodium, calcium, magnesium, zinc, manganese, iron and copper. Phytochemical tests revealed the bark to contain tannins, phlobatannins, saponins, alkaloids, and steroids. Comparative studies using varying concentrations (0.5, 1.0, 2.5 and 5.0% w/v) with alum and ferric chloride showed that the bark extract was effective in the clarification and sedimentation of total solids in the waste water sample. The optimum dose achieved was 2.5% w/v with a minimum of 24 hours contact time. The total bacteria counts were reduced by 46% after 24 hours when the extract was used whereas ferric chloride achieved 50% reduction and alum achieved 55% reduction under similar conditions. The feasibility of using the bark extract as an additional coagulant is therefore discussed.

KEYWORDS: *Bridelia ferruginea*, Sedimentation, Total bacteria count, Wastewater treatment

INTRODUCTION

The history of wastewater treatment revolves around the development of system to deal with those concerns. The first set treatment methods dealt primarily with the aesthetics of water, making it pleasing in taste, colour and odour. Later, as a connection was found between water and disease, the greater concern became making water safe for human consumption. [1, 2]

While the physical availability of water to each country is unique and usually constant, demand for water will continue to increase. The problem is how to balance demand and supply. Water pollution already is a serious problem in the majority of the developing countries. A high proportion of domestic and industrial effluents are untreated and discharged directly to water courses, irrigation canals, and drainage ditches. Allowed to continue, this increased pollution will reduce the amount of water available for use in the future [2].

Producing high quality reclaimed water from wastewater treatment plants required a paradigm shift for operators. The initial success of reuse projects will be sustained only if the public perceives that the reuse of wastewater is healthy and necessary [1]

The main constituent in domestic wastewater is human excreta with smaller contributions from food preparations, personal washings, laundry and surface drainage [3]. A large number of enteric bacteria and viral pathogens may be excreted by infected individuals and may therefore be present in untreated domestic wastewater [4]. Sedimentation/precipitation is the first major stage of treatment following preliminary treatment, which usually involves the removal of settleable solids, which are separated as sludge [5]. Not until the 1960s, however, was the use of chemicals considered an effective solution to a new set of modern water quality issues – stricter water quality standards and toxic industrial pollutions entering wastewater treatment plants [6].

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Bridelia ferruginea Benth bark is the commonest savannah *Bridelia.* It is usually a gnarled shrub which sometimes reaches the size of a tree in suitable condition and the down curved tip of the leaf is destructive. It's common names are Kirni, Kizni (Hausa); Mareni (Fulani); Iralodan (Yoruba), Ola (Igbo), Kensange abia (Boki) [7]. The bark extract of the plant has been used for the coagulation of milk and also lime juice for the formulation of a traditional gargle "Ogun efu" [8]. The roots of the plant are used as chewing sticks and in Togo, the root bark is used for intestinal and bladder disorders, as well as skin diseases [9]. An aqueous extract of the leaves of the plant has been shown to have hypoglycemic activity [10, 11]. Also the plant has been shown to have molluscidal activity [12]. It is also used as a purgative and a vermifuge [14].

Further research into it's efficacy in waste water treatment is desirable so that it may be employed in recycling and providing easy and safe means of portable water.

EXPERIMENTAL

Plant material

Bridelia ferruginea bark was collected from the tree of *Bridelia ferruginea* Benth family Euphorbiaceae from the residential quarters of the University of Ilorin, Nigeria. A voucher sample was deposited at the Plant Biology Herbarium of the University.

Preparation of the bark extract

The bark pieces were cut into small pieces and dried in an oven at 40 ^oC for 48 hours (Gallenkamp Oven BS Size two). The dried pieces were then pulverized using the laboratory mill (Christy and Morris Limited, machine type 8), the powder obtained were sieved using 100 mesh sieve and the sieved samples were stored as stock from which appropriate amounts were taken for experiment. Two hundred grams of the powdered bark were dissolved in solvent combination of water and ethanol in the volume ratio of 1:2 at room temperature for 48 hours. The suspension was then decanted and filtered using sterile Whatman Paper No. 1. The filtrate was concentrated to dryness at 45 ^oC in a rotary evaporator. The residue obtained served as the bark extract [15].

Chemical analysis of the bark extract

Exchangeable cations were extracted with normal neutral ammonium acetate. Sodium and potassium in the extract were analyzed by the flame photometric method while calcium and magnesium were determined by the versenate titration method [16].

Phytochemical screening

The screening procedures were adapted from those of [17]. The extract was screened for presence of alkaloids, tannins, phlobatannins, glycosides, flavonoids, saponins, and anthraquinones.

Effects of Bridelia ferruginea bark extract on sedimentation of total solids

A clean platinum evaporating dish was dried in the oven at 103 ^oC and cooled in the dessicator for 1 h, until a constant weight was obtained. A 250 mL volume of domestic wastewater was thoroughly mixed and 100 mL of the sample was dispensed into the evaporating dish and evaporated in the oven for 1 h at 103 ^oC. This was then cooled in the desiccators and weighed.

To test the comparative effects of alum, ferric chloride and *Bridelia ferruginea* powder; 0.5 g, 1.0 g, 2.5 g, and 5.0 g of each substrate were weighed into 1 L of the wastewater and thoroughly mixed. The total solids content at 0, 24, 48, 72, and 96 hours were determined as described below by using 100 mL from the treated wastewater sample.

$$\text{Total solids (mg/L)} = \frac{\text{Weight of sample after heating}}{\text{Volume of sample used}} \times 100$$

Effects of Bridelia ferruginea bark extract on coagulation (jar test)

0.5 g, 1.0 g, 2.5 g and 5.0 g of the coagulants were weighed and were each dissolved in the wastewater sample (100 mL). The wastewater was treated with varying amount of the coagulants i.e. 0.5, 1.0, 2.5, and 5.0% w/v by using a six-place multiple stirring equipment thermolyne model number SL-7225, the treated sample were agitated at 210 rpm for two minutes using the magnetic stirrer to ensure coagulation followed by slow agitation at 28 rpm for 15 minutes to ensure thorough flocculation. The flocculated samples were then allowed to settle overnight and the pH, colour and turbidity values of the supernatant liquor were determined. The colour and turbidity were determined using the spectrophotometer Dr. 2010 (Hach 1997 model) and the pH was determined using the pH meter Suntex SP-701.

Effect of Bridelia ferruginea bark extract on total bacteria counts

Total bacteria counts of the wastewater were estimated by serial dilution using the plate count method [18]. One milliliter of a 10^{-4} dilution was plated on nutrient agar (oxoid) and incubated at 37 ^{o}C for 48 hours. At 0, 24, 48 and 96 hours, 1 mL was carefully measured from the treated portion of the wastewater serially diluted and enumerated on the same media. The same procedure was followed for the alum and ferric chloride treated wastewater. Experiments were conducted in duplicates.

RESULTS AND DISCUSSION

According to the standard procedures recommended by American Public Health Association (APHA) on the analysis of public water, investigations were carried out on the crude extract of the bark of *Bridelia ferruginea*. The accuracy of our results is in line with the recommended standard method. The results of analysis of the chemical composition and phytochemical screening of the crude extract solution are represented in Tables 1 and 2. The non-toxic levels of the plant extract in comparison with the recommended values [19] limits for substances acceptability of water for domestic purposes is represented in Table 3.

Table 1. Determination of the metallic contents of *Bridelia ferruginea* extract.

Metals	Value (mg/L) ± standard error mean (SEM)
Potassium	200 ± 0.5
Sodium	200 ± 0.5
Calcium	105 ± 0.5
Magnesium	37 ± 0.5
Zinc	2.11 ± 0.01
Manganese	0.54 ± 0.01
Iron	0.34 ± 0.01
Copper	0.01 ± 0.001

Table 2. Phytochemical screening of the crude extract solution.

Active constituents	Amounts/levels
Tannins	++
Saponins	+
Alkaloids	++
Phlobatannins	++
Steroids	+

Key: ++ = strongly positive, + = positive.

Table 3. Limits for substances affecting the acceptability of water for domestic purposes [19] (concentration mg/L).

Substances	Maximum permissible
Copper	1.5
Iron	1.0
Manganese	0.5
Zinc	15
Magnesium	150
Calcium	200

Note: WHO limits is being adopted as FEPA guidelines.

Table 4. Effect of coagulants on the sedimentation of total solids of wastewater.

Contact time (h)	% Concentration (w/v)	% Reduction		
		Bridelia ferruginea	Ferric chloride	Alum
Zero	Raw sample	-	-	-
24	Raw sample	3.84	3.84	3.84
	0.5	66.39	66.13	69.33
	1.0	70.65	69.32	70.37
	2.5	79.80	75.06	82.81
	5.0	69.23	54.72	65.33
48	Raw sample	8.14	8.14	8.14
	0.5	70.23	68.73	71.10
	1.0	75.54	70.66	72.97
	2.5	83.96	78.62	85.14
	5.0	70.50	68.75	70.53
72	Raw sample	10.65	10.65	10.65
	0.5	71.24	70.94	73.20
	1.0	77.78	76.13	76.59
	2.5	86.67	81.33	87.55
	5.0	76.29	71.85	75.67
96	Raw sample	10.97	10.97	10.97
	0.5	71.26	71.11	73.33
	1.0	77.89	76.59	77.78
	2.5	87.17	82.06	87.64
	5.0	76.55	72.40	76.21

Significant degree of clarification and sedimentation of total suspended solids were effected by the *Bridelia ferruginea* bark extract, comparative to alum and ferric chloride. After a holding time of 96 hours; a higher percentage reduction was achieved with 2.5% w/v dose of bark extract compared to alum and ferric chloride. This is illustrated in Table 4. The results of the coagulation test on the wastewater sample are represented in Table 5.

Also, the bacterial load of wastewater treated with the optimum dose of bark extract, alum and ferric chloride were reduced after 96 hours contact time. This is illustrated in Table 6. The greater the amount of the coagulants for the treatments, the more the acidity and the more the reduction in bacterial load until an optimum dose is achieved.

Table 5. Coagulation (jar) test (wastewater plus coagulants: initial pH of wastewater = 8.46, initial colour of wastewater = 16 (PtCOAPHA), initial turbidity of wastewater = 18.5 (FAU), contact time = 24 hours).

Coagulants (% w/v)	pH	Colour (PtCOAPHA)	Turbidity (FAU)	Reduction in turbidity (%)
0.5 Alum	3.36	5	1.70	90.81
1.0 Alum	3.21	6	1.90	89.73
2.5 Alum	3.00	9	2.60	85.95
5.0 Alum	2.98	16	4.00	78.38
0.5 $FeCl_3$	4.60	16	2.90	84.32
1.0 $FeCl_3$	3.49	18	3.20	82.70
2.5 $FeCl_3$	3.26	22	5.60	69.73
5.0 $FeCl_3$	3.24	26	7.20	61.08
0.5 Extract	5.12	12	3.20	82.70
1.0 Extract	5.00	15	3.80	79.46
2.5 Extract	4.23	19	4.50	75.68
5.0 Extract	4.20	23	6.20	66.49

Table 6. Effect of coagulants on the reduction of total bacterial count of wastewater.

Contact time (h)	% Concentration (w/v)	% Reduction on total bacterial count		
		Bridelia ferruginea	Ferric chloride	Alum
Zero	Raw sample	-	-	-
24	Raw sample	2.97	2.97	2.97
	0.5	34.65	36.63	47.52
	1.0	40.59	43.56	51.49
	2.5	45.54	49.50	54.46
	5.0	28.71	32.67	36.63
48	Raw sample	7.00	7.00	7.00
	0.5	46.53	50.50	59.41
	1.0	48.51	59.50	59.41
	2.5	51.49	54.46	60.40
	5.0	34.65	36.63	39.60
72	Raw sample	22.77	22.77	22.77
	0.5	53.47	54.46	61.39
	1.0	56.44	59.41	62.38
	2.5	60.40	61.39	66.34
	5.0	45.54	46.53	49.50
96	Raw sample	31.68	31.68	31.68
	0.5	56.44	58.42	61.39
	1.0	59.41	60.40	63.37
	2.5	62.38	63.37	69.31
	5.0	48.51	50.50	51.49

The interest shown in the second half of the nineteenth century in chemical methods for treating wastewater is being revived in recent years. Alum and ferric chloride is the notable coagulants conventionally used in wastewater treatment [6]. One of the most important steps in wastewater treatment is coagulation/sedimentation to remove hardness and reduce bacterial load. The efficiency of a coagulant is determined by its ability to remove suspensions, bacteria and any resulting colour in the wastewater before the final treatment with chlorine (disinfectant).

In addition to domestic wastes, the products and by-products of our modern technology lead to discharge of different kinds of wastewaters containing various impurities of various magnitudes. By their nature, the wastes arising from food, beverages and soft drinks processing industries promote fast growth of various kinds of organisms including the pathogenic ones. Discharge of these wastes into any river, stream, or any kind of water-body will lead to the quick deterioration of the water qualities. Pre-treatment of such wastes prior to discharge will save the situation. In history, outbreak of epidemics and infectious diseases arose from polluted waters. Examples are the outbreak of infections hepatitis in 1955-1966 in New Delhi, India where 30,000 cases were reported [20].

This study is aimed at reducing the total organic carbon content and bacterial load using easily available coagulants such as *Bridelia ferruginea* bark extract which will help to accelerate and improve the effectiveness of the final treatment with chlorine (disinfectant) so as to render the water re-useable. In this work, the coagulating properties of *Bridelia ferruginea* Benth bark have been established and found to compare favourably with other coagulants such as ferric chloride and alum. This study also shows that *Bridelia ferruginea* bark contains tannins as one of its major bioactive constituents while other active agents includes alkaloids, steroids and saponins (Table 2). This observation agrees with the result obtained [2]. Tannins are natural substances with a molecular weight of between 500 and 3,000, possessing a number of free phenol hydroxyl groups. They are used in tanning leather [15].

The non-toxic nature of the plant extract has been shown by the results of the chemical analysis of the bark (Table 1), which is in consonance with [19] standards (Table 3). This result is in consonance with that obtained [2]. The ability of the bark extract to reduce the bacterial load of wastewater can be explained in two ways; one, it made the water acidic, thereby assisting in the removal of sizeable percentage of the bacteria. Also, the cations form complexes with the bacteria, which caused further reduction in the bacterial population. The percentage removal of the bacteria was appreciable even at lower doses of the coagulants. This agrees with the results of [20] who explained the removal of bacteria from sewage through chemical coagulation and flocculation.

The significant sedimentation of total solids recorded in this work is in consonance with the work done by [21] using *Moringa oleifera* seeds in water purification. The results are also in consonance with the work done by [2] using the bark of *Bridelia ferruginea* in river water purification. These encouraging findings support the recommendation of the bark extract of *Bridelia ferruginea* as an additional coagulant in domestic wastewater-treatment.

ACKNOWLEDGEMENT

Special appreciation to Mr. Olu Bodunde of Niger River Basin, Kwara State, Nigeria for assess to Niger Basin Laboratory and equipments.

REFERENCES

1. James, L. *History of Water: World of Water*, World of Water International Ltd.: Manitoba, Canada; **2000**; pp 9-20.
2. Kolawole, O.M.; Olayemi, A.B. *Nigeria J. Pure Applied Sci.* **2003**, 18, 1387.

3. Gray, N.F. *Biology of Water Treatment*, Oxford Scientific Publications: United State; **1989**; pp 124-828.
4. Samuel, R.F.; Bulton, G. *J. Applied Environ. Microbiol.* **1983**, 45, 174.
5. Fair, G.M. *Element of Water Supply and Waste Disposal*, 2nd ed., John Wiley and Sons: New York; **1983**; pp 94-410.
6. Pamela, W. *History of Wastewater: World of Water*, World of Water International Ltd.: Manitoba, Canada; 2000; pp 26-36.
7. Rashid, M.A.; Gustafson, K.R.; Cardellina, J.H., II; Boyd, M.R. *Nat. Prod. Let.* **2000**, 14, 285.
8. Orafidiya L.O.; Lamikanra, A.; Adediji, J.A. *Phytotherapy-Research* (*United Kingdom)* **1990**, 4, 189.
9. De Bruyne, T.; Cimanga, K.; Pieters, L.; Claeys, M.; Dommisse, R.; Vlietinck, A.J. *Nat. Prod. Let*. **1997**, 11, 47.
10. Ampofo, O. *Some clinical observations of the treatments* in: *Perspective in Mechanical Plant Research Today, Drug Research and Productions Unit*, Ofafemi Awolowo University, Ile-Ife: Ile-Ife, Nigeria; **1977**; pp 35-45.
11. Iwu, M.M. *Fitoterapia (Italy)* **1983**, 54, 243.
12. Iwu, M.M. in Proceedings of 4th Annual Conference of Nigeria Society of Pharmacognosy, University of Nigeria, Nsukka. In: The State of Medicinal Plant Research in Nigeria, Abayomi Sofowora, (Ed.); **1984**; p 57.
13. Adeoye, A.O.; Abadu, A.M.; Owumi, C.J.; Olukoya, D.K.; Antimicrobial activity of *Bridelia ferruginea* in: *Book of Abstract of the Symposium on Drug Production from Natural Products Drug Research and Production Unit*, Obafemi Awolowo University, Ile-Ife: Ile-Ife, Nigeria; **1988**; p 24.
14. Cimanga, K.; De Druyne, T.; Apers, S.; Pieters, L.; Totte, J.; Kambu, K.; Tona, L.; Bakana, P.; Van ufford, L.Q.; Beuke Iman, C.; Labadie, R.; Vlietinck, A.J. *Planta Med.* **1999**, 65, 213.
15. Orafidiya, L.O.; Lamikanra, A.; Akueme, I.D. *Phytotherapy-Research (United Kingdom)* **1996**, 10, 266.
16. Association of Official Analytical Chemists *A.O.A.C. Official Methods of Analysis*, 13th ed., Association of Official Analytical Chemists: Washington, D.C.; **1980**.
17. Sofowora, E.A. *Screening Plants and Traditional Medicine in Africa*, John Wiley and Sons: New York; **1977**; pp 142-144.
18. American Public Health Association (APHA) *Standard Methods for the Examination of Water and Wastewater*, APHA, New York. **1971**.
19. Federal Environmental Protection Agency (FEPA) *Guidelines and Standard for Environmental Pollution Control in Nigeria*, Federal Environmental Protection Agency: Federal Press; Lagos, Nigeria; **1991**.
20. Ademoroti, C.M.A. *Effluent Water Treatment J.* **1980**, 20, 12.
21. Olayemi, A.B.; Alabi, R.O. *Studies on Traditional Water Purification using Moringa oleifera Seeds*, *Africa Study Monographs*, Vol. 15, Center for African Area Studies, Kyoto University: Japan; **1994**; pp 135-142.