African Journal of Biotechnology Vol. 10(43), pp. 8625-8629, 10 August, 2011
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB10.1709
ISSN 1684–5315 © 2011 Academic Journals

Full Length Research Paper

Indigenous plant based coagulants/disinfectants and sand filter media for surface water treatment in Bamenda, Cameroon

K. A. Yongabi[1]*, D. M. Lewis[2] and P. L. Harris[2]

[1]School of Chemical Engineering, The University of Adelaide, 5005, South Australia, Australia.
[2]School of Agriculture and Wine, The University of Adelaide, South Australia, Australia.

Accepted 20 June, 2011

An Evaluation of plant- based coagulants and disinfectant-sand filter medium for surface water treatment in Bamenda, Cameroon using bacterial analyses and turbidity were carried out. 100L of very turbid surface water (Turbidity approx. 500NTU) was pretreated with 100 seeds of *Moringa oleifera*, and further filtered through a sand filter drum (120 L carrying capacity) made of fine, coarse sand, charcoal and gravel. The mean total heterotrophic bacterial counts, *Escherichia coli*, coliform, pseudomonas and yeast counts, as well as turbidity of untreated surface water significantly reduced by 85 to 95%. The results suggested that the mean values of the same parameters for sand filtered pond water alone was significantly lower than the corresponding mean values obtained for plant coagulant treated surface water. The findings from this study demonstrates strongly that a biocoagulant sand filter media (plant based coagulant-sand filter drum) could be applied to treat contaminated surface water, rendering it free from solids and pathogens.

Key words: Plant, coagulants, indigenous, surface, water, treatment, microbes, Cameroon.

INTRODUCTION

Water remains a strategic resource for the integration of economic, social and environmental concerns and it is the key to sustainable development. It sustains human productivity and livelihoods and plays a crucial role in integrating world's ecosystems. Water is under increasing and competing demands from agricultural, industrial and domestic uses with increasing pollution threatening this scarce resource. Approximately 1.6 million people are forced to use contaminated water globally. Uncontaminated water is rarely obtainable in rural Africa, Asia and especially in sub Sahara Africa (SSA). The prevalence of waterborne infectious diseases in SSA is rising (Yongabi, 2004; Yongabi et al., 2009). Water borne diseases contribute to the death of about 4 million children in the developing countries per annum. The world health organization has estimated that up to 80% of all diseases and sicknesses in the world is caused by inadequate sanitation, polluted water or unavailability of water (Pritchard et al., 2009). It is beneficial to treat water both for domestic use and safe disposal to the environment.

Water scarcity remains intractable in sub-Sahara Africa, especially in rural, semi-urban and even urban areas in these countries. There are also natural and artificial water bodies like ponds that contain a lot of nutrients that are unacceptable for consumption. Approximately 125 L of clean water is required per person per day, yet, many households cannot actually boast of 25 L of clean water per person per day (Pritchard et al., 2009) To this effect, water purification technologies would have to be considered with respect to efficiency and cost.

The need for simple, reliable and effective method of water treatment led to the application of plant materials, including seeds coagulants of *Moringa oleifera* (Eilert, 1978; Yongabi, 2004; Ghebremichael et al., 2009; Pritchard et al, (2009). Standard methods for the treatment of water include coagulation, flocculation, sedimentation, disinfection, membrane filtration, reverse osmosis

*Corresponding author. E-mail: kenneth. yongabi@ adelaide. edu.au.

and UV. These methods are often inappropriate in SSA due to prohibitive cost and scarcity of chemical coagulants and disinfectants. Dosage and technique pose some local challenges, and for this reasons, efforts to establish appropriate chlorination techniques for wells in rural communities is imperative. These technologies presently require high energy inputs (Fuglie,1999).

Most communities in sub Sahara Africa lack electricity and this makes it diificult to have a water treatment technology that depends on electricity. Water purification using seeds of *M. oleifera* plant has been reported extensively (Fuglie, 1999; Folkord et al., 2000). Bioactive coagulant proteins have been characterized (Ghebrimichael, 2009) and pretreated plant coagulants moringa and sand filtered water may overcome the limitations of both techniques. Little attempts to document and screen other plant based coagulants, other than moringa have been made.

This study was therefore designed to investigate the potential indigenous plant coagulants other than *M. oleifera* seeds and sand filter media for surface water treatment in Cameroon. The ultimate purpose of this study was to come up with a compendium of plant coagulants that could be used as a technology that is lowtech, effective and ecological. This report presents the potential results of integrating phytocoagulants using *Garcinia kola* and *Carica papaya* seed powder and sand filtered treated surface water.

MATERIALS AND METHODS

Plant collection and processing

Mature seeds of *G. kola* and *C. papaya* were obtained in Bamenda, Cameroon. 100 seeds were deshelled and pulverized in clean mortar using a pestle. The powder (from 100 seeds) was sprinkled onto 100 L of the dirty pond water in a 150 L capacity drum and stirred using a clean wood stirrer and the set up was allowed to stand for 30 min (Pollard et al., 1995). It was then filtered off using a muslin sack cloth and the filtered water was then passed through a sand filter drum. The materials used in the construction of the sand filter were locally gotten at a river bed and included: low strong (150 L carrying capacity) drum (plastic), 1½ yards of hose, four clips, three nipples, strainer or sieve, sharp river sand (coarse and fine), charcoal and gravel. All these materials (sand, gravel and charcoal) were carefully washed and rinsed repeatedly in clean water (Folkard et al., 1999).

The laying of the materials in the drum was done in the order: laying of perforated hose connected to the collector tank, then a layer of gravel, followed by a layer of charcoal, then coarse sand (2 mm in size) and two layers of fine sand (0.15 to 0.30mm size).

A test trial was carried out by flushing the set up repeatedly with clean water. The moringa pretreated water was then passed through the system. The filtered water was collected into the drum and three samples each were taken for analyses. Three water samples each (stream from Mile 6 mankon, Bambui and Storm water) were collected and subjected to all these treatments. The surface water was located in mile 6 Mankon, Bambui and Storm water. The surface water was shallow, very turbid and during the dry season, people sometimes fetch the water for household chores, stray animals, and cows drink from the source. Storm water was collected using sterile bottle from the drains after heavy rains.

Turbidity

The turbidity for each of the water samples was read before and after treatment using a turbidity meter (HACH DR, 2000).

Microbiological assessment of the surface water

The microbial analysis was carried out according to the protocols specified by Burns (1974), APHA (1983) and APHA and WEF (1995). The MPN technique was avoided due to the fact that it is time consuming, while the membrane filter technique was not considered because of certain limitations such as lack of facility for coliform counts and total aerobic bacterial counts etc, while the presumptive coliform test is also time consuming as limited in other microbial parameters.

A range of tests such as total heterotrophicc bacterial counts, *Pseudomonas aeruginosa* counts, as well as yeast counts were considered in addition to the traditional coliform and faecal coliform tests to explore the possibility of taking care of viable but non culturable bacteria. The traditional indicator tests do not always correlate well with certain groups of pathogens such as *Helicobacter pylori* and *Aeromonas* spp. and it was worthwhile considering this, especially in assessing the potential of newly constructed systems for water purification as well as screening for new phytocoagulants.

Culture tests

Three samples from each of the surface water samples were collected using sterile Maccathney bottles. 1 ml of the samples each was serially diluted with distilled water (9 ml) three fold up to 10^{-3} and 1 ml of each diluent of 10^{-1} and 10^{-3} were plated aseptically onto nutrient agar for total heterotrophic bacterial and pseudomonas counts, MacConkey agar for total coliform, eosin ethylene blue agar for *Escherichia coli* counts and potato dextrose agar for yeast/fungal counts (Cheesbrough, 1984). Incubation was carried out at 37°C for 24 h, and the plates were read following standard microbiological procedures. The bacterial counts were enumerated using Gallemp colony counter and recorded accordingly, while the yeast and pseudomonas colonies were picked, stained using methylene blue and gram stain, respectively. The average counts from 10^{-1} and 10^{-3} dilutions were recorded (Ellis, 1988; Yongabi, 2006; Yongabi et al., 2010).

RESULTS AND DISCUSSION

The results are presented in Tables 1 to 6. The findings suggest the combination of *G. kola* and *C. papaya* seeds with the sand filter outfit purified surface water. The raw data obtained from the surface water in Bamenda showed a very high total heterotrophic bacterial population and high faecal indicator bacteria, suggesting the presence of pathogens. This observation was observed in surface water in Malawi (Pritchard et al., 2009). Surface water is not usually consumed in Bamenda but during the dry season when there is acute water shortage, people fetch such water for other non potable domestic uses and occasionally boil it for drinking. In rural Cameroon there is water scarcity. The high *E.*

Table 1. Mean total bacterial and fungal counts of surface water in Cameroon before treatement.

Parameter	Stream 1 (mile 6 Mankon)	Stream 2 (Bambui)	Water source 3 (stormwater)
Coliform counts (cfu/ml)	357	780	96
Yeasts counts (cfu/ml)	1115	TNTC	114
Pseudomonas counts (cfu/ml)	105	196	0
E. Coli counts (cfu/ml)	102	307	73
Total heterotrophic bacterial counts (cfu/ml)	TNTC	TNTC	388
Turbidity (NTU)	27.3	33.5	119

TNTC, Too numerous to count.

Table 2. Mean total bacterial and fungal counts of surface water after treatment with *G. kola* seeds at one hour retention (residence) time.

Parameter	Stream 1 (mile 6 Mankon)	Stream 2 (Bambui)	Water source 3 (stormwater)
Coliform counts (cfu/ml)	92	215	9
Yeast counts (cfu/ml)	43	507	48
Pseudomonas counts (cfu/ml)	35	30	0
E coli counts (cfu/ml)	32	55	13
Total heterotrophic bacteial counts (cfu/ml)	515	611	80
Turbidity (NTU)	7.11	11.3	20

Table 3. Mean total bacterial and fungal counts of surface water after treatment with *Persea americana* seeds at one hour retention (residence) time.

Parameter	Stream 1 (mile 6 Mankon)	Stream 2 (Bambui)	Water source 3 (stormwater)
Coliform counts (cfu/ml)	98	323	18
Yeast counts (cfu/ml)	85	366	21
Pseudomonas counts (cfu/ml)	66	22	0
E. Coli counts (cfu/ml)	59	33	11
Total heterotrophic bacterial counts (cfu/ml)	823	516	95
Turbidity (NTU)	13.2	14.11	42.6

Table 4. Mean total bacterial and fungal counts of surface water after treatment with *C. papaya* seeds at one hour retention (residence) time.

Parameter	Stream 1 (mile 6 Mankon)	Stream 2 (Bambui)	Water source 3 (stormwater)
Coliform counts (cfu/ml)	82	296	13
Yeast counts (cfu/ml)	12	59	19
Pseudomonas counts (cfu/ml)	55	35	0
E. Coli counts (cfu/ml)	63	37	18
Total heterotrophic bacterial counts (cfu/ml)	428	315	110
Turbidity (NTU)	9.9	9.4	11.9

Table 5. Mean total bacterial and fungal counts of surface water after treatment with sand filter drum alone at one hour residence time.

Parameter	Stream 1 (mile 6 Mankon)	Stream 2 (Bambui)	Water source 3 (stormwater)
Coliform counts (cfu/ml)	298	663	89
Yeast counts (cfu/ml)	997	895	114
Pseudomonas counts (cfu/ml)	89	109	0
E. Coli counts (cfu/ml)	83	896	69
Total heterotrophic bacterial counts (cfu/ml)	TNTC	TNTC	279
Turbidity (NTU)	25.8	28.91	99.1

Table 6. Mean total bacterial and fungal counts of surface water after combined treatment with *G. kola* seeds and sand filter drum in 1 hour residence time.

Parameter	Stream 1 (mile 6 Mankon)	Stream 2 (Bambui)	Water source 3 (stormwater)
Coliform counts (cfu/ml)	25	31	18
Yeast counts (cfu/ml)	39	69	31
Pseudomonas count cfu/ml	15	12	0
E. coli counts (cfu/ml)	29	19	21
Total heterotrophich bacterial	425	291	112
Turbidity (NTU)	6.7	5.12	21.2

coli counts (102,307,73 CFU/ml) and coliform counts (357,780,96 CFU/ml) shows how unsafe the surface water was in Bamenda.This may be the first report on surface water quality in Bamenda, Cameroon. The use of the stream water for bathing could expose one's to skin diseases, especially if one has wounds or scratches on the skin. The presence and fairly high *P. aeruginosa* counts (105,196 CFU/ml) supports this. Pseudomoas species apart from causing urinary tract infections also causes skin infections (Cheesbrough, 1984). Surface water in Cameroon is heavily contaminated. This may be attributed to lot of human activities going on in the vicinity of these water bodies. The mean heterotrophic bacterial counts of the pond water when treated with *G. kola* seeds showed drastic reduction in bacterial counts from too numerous to 515,611,80 count of colony forming units per milliliter (Tables 1 and 2). However, despite a drastic reduction of *E. coli* and coliform counts (Tables 2, 3 and 4) of the surface water when treated with plant coagulant/ disinfectants seeds, the water was still not wholesome as suggested by the values, which are higher than the WHO recommended values. This however, suggests another round of treatment, without refuting the efficiency of three plant coagulants and disinfectants. It was in consideration of this that the integration of a sand filter media to Garcinia seeds treated water was carried out. When this was done, the total heterotrophic bacterial counts reduced to 425,291,112 CFU/ml, *E. coli* counts reduced to 29,19,21 CFU/ml, while coliform counts reduced to 25,31,18 CFU/ml. The values of heterotrophic bacterial counts were found to be in the WHO standard values for potable water (Table 6). The turbidity was drastically reduced for all the treatments (WHO, 1984) The results also indicated that the sand filter was efficient in turbidity removal (Tables 5 and 6). This is attributed to the fact that sand filter drum is made up of a number of layers of materials with different textures and filtering capacity: fine sand, coarse sand, charcoal and gravel (Yongabi et al., 2010).

Plant coagulant seeds are rich in nutrients which enter into the water and possibly serves as a substrate for bacterial re-growth (Ghebremichael et al., 2009). Water filtered through the sand filter media is stored for a longer time than with plant coagulant treated water. Despite the comparatively better water treatment potentials of the sand filter, it cannot quickly purify very dirty surface water (27.3,33.5 NTU). The sand filter drum has been very efficient in treating well water, borehole and deep stream water with low turbidity (NTU < 10NTU).

The option of pre-disinfection with phytocoagulants, particularly seeds of *Garcinia, Carica and Persea*, is not commonly practiced and require further studies. The analyses has shown that surface water can be treated effectively with plants coagulants/disinfectants and sand filter. In addition, the system may provide a greater volume of treated water at household level in a relatively shorter residence time than with just the bio sand filter system.

Conclusion

The benefits of disinfecting water with indigenous plant materials while filtering with slow sand filter drum are enormous; systems are dissolved, greater volume of treated water can be stored for a longer time, any form of dirty or wastewater can be treated and consumed within a relatively short residence time. Pathogenic microbes resistant to chlorine as well as the unpleasant effects of alum and chlorine can be taken care of without any energy inputs. The techniques are accommodating and the materials needed are cheap, and are all almost naturally available.

REFERENCES

APHA (1983). American Public Health Association standard method for the Examination of water and waste water 15th Ed.

APHA, AWWA, WEF (1995). Standard method for the Examination of water and waste water 19th edition pp 2-54.

Burns NM, Van Otterloo HR (1974). Standard method for Examination of water and waste water in American Health Association.

Cheesbrough M (1984). Medical laboratory Manual for Tropical Countries, Butterworths, pp. 1-79

Eilert U (1978). Antibiotic principles of seeds of Moringa oleifera plant. Indian Materials J. 39(235): 1013-1016.

Ellis WS (1988). Chlorination and disinfection of water. J. Am. Water Assoc. 366(4): 28-44.

Folkord GK, Sutherland J, Shaw R (2000). Water clarification using Moringa oleifera seed Coagulant http://www.iboro.ac.uk/well/resources/technical-briefs/60-waterclarification-using moringa-oleifera-seeds.pdf.

Fuglie LJ (1999). the miracle Tree Moringa oleifera: natural nutrition for the tropics. Dakar.

Ghebremichael K, Abaliwano J, Amy J (2009). Combined natural organic and Synthetic inorganic coagulants for surface water treatment. J. Water Supply, 58: 267-276.

Pollard SJT, Thampson FE, McConnachie GL (1995). Micro porous carbon from Moringa oleifera husks for water purification in less developed countries. Water. Res., 29(1): 337-347.

Pritchard M, Mkandawire T, Edmondson A, O'Neill JG, Kulunga G (2009). Potential of using plant extracts for purification of shallow well water in Malawi, Phy. Chem. Earth, 34: 799-805.

WHO (1984). Guidelines for Drinking water quality. Health Criteria and other supporting information, 2: 3-22.

Yongabi KA (2004). Studies on the potential use of medicinal plants and Marcofungi in water and wastewater purification. Proceeding of an e-seminar, IOBB; www.biotech.kth.se/iobb/news/kenneth04.doc.

Yongabi KA (2006). Studies on the potential use of medicinal plants and Marcofungi in water and wastewater purification.Tree life J. http://www.tfljournal.org/gateway.php?what=history&lid=20060310110308662(accessed,August 24,2010).

Yongabi KA, Harris PL, Lewis DM (2009). Poultry faeces management with a low cost plastic digester. Afr. J. Biotechnol. 8(8): 1560-1566.

Yongabi KA, Lewis DM, Harris PL (2010). Cheap Alternative Biocoagulant-Sand Filter System for Water Purification in Low Income Earning Countries, Accepted for presentation at the Chemical Engineering Conference (Chemeca) Adelaide, September 26, 2010.