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FEASIBILITY STUDIES OF NATURAL PLANTS COAGULANTS IN THE REMOVAL OF SELECTED WATER CONTAMINANTS

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ABSTRACT

The greatest public health concern about water is directed to its ever increasing number of contaminants. Public distribution systems, though accessible only to a limited population, mainly make use of chemicals in the treatment processes. Such water treatment systems overlay burden on the developing nation's financial resources. Moreover, reports states that such chemicals can cause severe health hazards. These points out the need for low-cost, replicable non-chemicals, which would be effective in the treatment of water contaminants. In the present study, treatment potentialities of vegetative parts of certain hydrophytic / mesophytic plants like *Lagenandra toxicaria Dalz, Aloe barbedensis Mill., Canna indica. L and Bacopa monnieri (L.) Wettst,* on Turbidity, Hardness, Iron and microbial count of contaminated water has been worked out.. Batch treatment has been followed and the performance evaluation of plants under varying concentration of plant materials and retention time has been worked out. Turbidity of water samples were monitored instrumentally (APHA, 1995), whereas hardness and iron content were assessed using EDTA titrimetric method (APHA, 1995) and thiocyanate method (Goswami and Kalita, 1988) respectively. Total coliforms and *E.coli* were estimated using pour plate method of NIO (1998). On an overall assessment, it has been noticed that the plants under experimentation showed differential responses to contaminants. *Lagenandra toxicaria* was noted to be effective in reducing turbidity at all concentrations of the plant material especially at higher retention time. The material was also noted to be effective in the removal of Iron and Total coliform content. Similarly *Aloe barbedensis* was found to be effective in the treatment of Turbidity. The decrease in turbidity was significant with increasing concentration and retention time. It was also noted to be effective in the treatment of iron and Total coliforms at initial stages. *Canna indica* was noted to be least effective in the treatment of selected water contaminants other than Total coliforms and E. coli. *Bacopa monnieri* was effective in the treatment of Iron content, Total coliforms and E. coli content.

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INTRODUCTION

Water resources all over the world are threatened not only by over exploitation and poor management, but also by ecological degradation. The greatest public health concern about water is directed to its ever increasing number of toxic substances including inorganic and organic chemicals and pathogens. Urban populations have more access to public distribution systems, which make use of aluminium sulphate (alum), calcium hypochlorite etc. in the treatment process. Such water treatment systems, even though effective, put pressure on the nations over burdened financial resources, thereby making treated water an expensive commodity. Apart from these, various research findings state that chemicals used for water purification can cause serious health hazards (Crapper *et. al.*, 1973; Miller *et al*., 1984). For example, chlorine is known to produce trichloromethane, a cancer precursor (Yongabi, 2004) while aluminium sulphate has been linked to Alzheimer's disease (Miller *et al.,* 1984).

In recent years there has been resurgence of interest in using naturally occurring alternatives to currently used coagulants for water treatment, even in developing countries (Jahn, 1988). This is mainly due to cost implications that are associated with organic chemicals, synthetic organic polymers and disinfectants used in the process (Shultz and Okun, 1984, Ndabigengesere and Narasiah, 1996). Studies have been conducted to evaluate the coagulation efficiency of many plant materials including *Prosopis juliflora*, *Cactus latifaria* (Diaz *et al*., 1999) and vegetable tannins (Özacar and Şengil, 2003). Tripathi *et al*. (1976) showed that the crude extract of Nirmali seed reduced 50-52% of bacteria after 30 minutes of settling time of turbid water coagulated by 0.5 mg/L of seed extract. The crude extracts of proteins of *Moringa oleifera* seeds have been reported to possess antimicrobial properties (Tripathi *et al*., 1976; Madsen *et al*., 1987; Suarez *et al*., 2003; Ghebremichael *et al*., 2005). The practice of using natural coagulant has the potential of replacing or supplementing pricey water treatment chemicals in poor countries. In addition, natural coagulants can overcome environmental issues that are associated with the use of water treatment chemicals (Crapper *et al*., 1973; Christopher *et al*., 1995; Kaggawa *et al*., 2001). The present study focuses on the efficiencies of four mesophytic / hydrophytic plants namely *Lagenandra toxicaria Dalz, Aloe barbedensis Mill., Canna indica. L* and *Bacopa monnieri (L.) Wettst* in the stabilization / treatment of certain water contaminants like Turbidity, Hardness, Iron and microbial count.

MATERIALS AND METHODS

For the present study plants like *Lagenandra toxicaria Dalz, Aloe barbedensis Mill., Canna indica. L and Bacopa monnieri (L.) Wettst,* were brought from pollution free environments and were maintained in the botanical garden for acclimatization. Description of the plants selected together with a description of the plant part used for the present study is given below.

***Lagenandra toxicaria* Dalz** (Common name: Neerkizhangu, Andavazha (malayalam)) belongs to the family Araceae. It is a rhizomatous herb seen along the streams and are widely distributed in all Districts of Kerala. It is a native of Asia and tropical Indian subcontinent. For treatment studies, rhizomes were cut into small pieces and crushed using kitchen blender (stone). These were then weighed separately and introduced into respective jars for treatment studies.

***Aloe barbadensis Mill.* (**Common name: Barbados Aloe or Curacao Aloe (English), Kattar vazha (Malayalam) Ghicadhur (Hindi) belonging to family Lilliaceae. It is a stoloniferous herb with leaves dense, aggregated, succulent, pale green and distant horny spines on margins. It is distributed throughout tropical and subtropical countries. Thick mucilaginous portion of the leaf was cut into small pieces and weighed pieces were crushed using a mortar and pestle (glass) and washed off and transferred to the respective jars for treatment.

***Canna indica* L (**Common name: Canna (English), Kattuvazha, Vazha chedi (Malayalam), Sarvajjaya (Hindi)) belongs to the family Cannaceae. It is an annual rhizomatous herb originated in Tropical and subtropical America and is widely grown as ornamentals. The starchy rhizome of most of the species is medicinal. For water treatment studies, the rhizomes were cut into small pieces and weighed. The weighed pieces were crushed using a mortar and pestle (glass) and washed off and transferred to the respective jars.

Bacopa monnieri* (L.) *Wettst, Bacopa (English), Neer brahmi (Malayalam) Brahmi (Hindi) belongs to the family Scrophulariaceae. It is an annual herb that grows in moist or damp areas. An infusion of the plant is used as a nerve tonic. It grows in almost all districts of Kerala. Entire plant was taken for assessing their efficiencies in water treatment. The twigs were cut into small pieces and macerated using a mortar and pestle (Glass). This was then washed off, filtered and transferred to respective jars for treatment studies. Batch treatment has been followed for evaluating the performance of plants under varying concentration of plant materials and retention time. Processed plant materials were used in definite quantities (0.5 g, 1.0 g, 2.0 g, and 4.0 g) to treat the polluted water samples at specific intervals of 1.5, 3, 6, 12 and 24 HAT (Hours After Treatment). Selected water quality parameters (physical, chemical and biological) were assessed at regular intervals to assess the treatment efficiency, using standard procedures. Turbidity of water samples were monitored instrumentally using a Nephelo-Turbidimeter (EI make), whereas hardness and iron content were assessed using EDTA titrimetric method (APHA, 1995) and modified thiocyanate method (Goswami and Kalita, 1998) respectively. Total coliforms and *E.coli* were estimated using pour plate method of NIO (1998).

RESULTS AND DISCUSSION

In the present study, an attempt has been carried out to assess the efficiencies of plants like *Lagenandra toxicaria* (rhizome), *Aloe barbedensis* (leaf), *Canna indica* (rhizome) and Baccopa monneiri (twigs) in the treatment of water contaminants like Turbidity, Total Hardness, Iron and E. coli. The percentage change in various physico-chemical and microbiological parameters over control, recorded at varying quantities of the plant materials like *Lagenandra toxicaria, Aloe barbedensis*, *Canna indica* and *Baccopa monneiri* at varying retention times are depicted in Table 1.

Table 1. Percentage changes in water quality parameters over control in treatment set containing *Lagenandra toxicaria*

	3 HAT	6HAT	12HAT	24HAT
Turbidity				
0.5g	-49.7	2.51	43.9	24.6
1.0g	-31.5	35.43	59.01	48.42
2.0g	0.25	19.5	56.69	52.61
4.0g	-45.1	13.63	46.22	36.9
Total Hardness				
0.5g	-9.0	-20	-23.8	-25
1.0g	-18.2	-25	-19	-25
2.0	-22.7	-35	-28.6	-40
4.0g	-36.4	-50	-28.6	-60
Iron				
0.5	48.7	-37.5	-12.5	-150
1.0	71.7	-150	-12.5	-37.5
2.0g	41.0	-37.5	0	0
4.0g	76.9	-12.5	-12.5	-37.5
E. coli				
0.5g	-243.3	100	100	50
1.0g	60	100	100	100
2.0g	100	100	100	100
4.0g	100	100	100	100

Positive values indicate % decrease and negative sign (-) indicate % increase with respect to control.

Table 2. Percentage changes in water quality parameters over control in treatment set containing *Aloe barbedensis*

	3 HAT	6HAT	12HAT	24HAT
Turbidity				
0.5g	33.09	55.64	79.23	63.02
1.0g	56.36	70.43	70	68.66
2.0g	22.91	52.92	68.85	77.81
4.0g	-80.4	47.08	80	11.26
Total Hardness				
0.5g	-16.7	-10.7	15.38	-18.18
1.0g	-12.5	-3.57	-15.4	-22.73
2.0g	-12.5	0	-7.69	-31.82
4.0g	-16.7	-14.3	-3.85	-31.82
Iron				
0.5g	-23.4	-28.1	37	82.54
1.0g	20.96	5.036	0	-9.524
2.0g	-10.2	-28.1	-8	11.11
4.0g	-58.1	-32.4	-8	-96.83
E. coli				
0.5g	-164.7	28.8	100	16.67
1.0g	-102.9	100	100	100
2.0g	100	-44	100	100
4.0g	100	100	100	100

Positive values indicate % decrease and negative sign (-) indicate % increase with respect to control.

Table 3. Percentage changes in water quality parameters over control in treatment set containing *Canna indica*

	3 HAT	6HAT	12HAT	24HAT
Turbidity				
0.5g	-47.1	-67.3	-3.91	-25.51
1.0g	-29.9	-52.4	-49.2	-92.86
2.0g	-28.7	-46.8	-32.8	-107.1
4.0g	-25.4	-43.2	63.28	-40.82
Total Hardness				
0.5g	13.04	0	-36.4	-15.38
1.0g	0	3.448	18.18	-3.84
2.0g	-8.7	13.79	-18.2	-23.08
4.0g	-17.4	17.24	-9.09	0
Iron				
0.5g	11.1	33.33	60	27.27
1.0g	68.25	-22.7	0	-81.82
2.0g	36.51	16	45	-254.5
4.0g	0	16	-150	-536.4
E. coli				
0.5g	65	100	36.36	100
1.0g	100	87.5	100	100
2.0g	100	100	100	100
04.0g	100	100	86.36	100

Positive values indicate % decrease and negative sign (-) indicate % increase with respect to control.

Studies with *Lagenandra toxicaria* rhizome showed that they are ineffective in the control of turbidity at initial stages of treatment. A general trend of increase in turbidity removal was noted with increase in time. Highest removal was noted in 1.0 gm treatment of the plant material at 12 HAT. As far as hardness removal is concerned, the plant material was noted to be ineffective at all stages of treatment. They are found to be effective in checking iron content of water at initial stages of treatment. Highest removal of 76.9% was noticed with the treatment set containing 4 gm of the plant material at 3 HAT. The plant material was also found to be effective in the control of *E.coli* at higher dosages of the material at all retention times.

Table 4. Percentage changes in water quality parameters over control in treatment set containing *Bacopa monnieri*

	3 HAT	6HAT	24 HAT
Turbidity			
0.5ml	-25	-57.3	19.44
1.0ml	-50	-91.01	33.33
1.5ml	-83.3	-124.7	-2.778
2.0ml	-108	-158.4	-94.44
2.5ml	-133	-180.9	-113.9
5.0ml	-233	-304.5	-36.11
Total Hardness			
0.5ml	10	10	0
1.0ml	0	10	0
1.5ml	10	0	0
2.0ml	0	0	0
2.5ml	0	0	0
5.0ml	0	0	-10
Iron			
0.5ml	96.4	96.25	96.96
1.0ml	100	100	100
1.5ml	100	100	100
2.0ml	100	100	100
2.5ml	100	100	100
5.0ml	100	100	100

E.coli			
Dosage	2HAT	6HAT	24HAT
0.5ml	62.5	12.2	33.33
1.0ml	100	100	100
1.5ml	100	100	100
2.0ml	100	100	100
2.5ml	100	100	100
5.0ml	100	100	100

Positive values indicate % decrease and negative sign (-) indicate % increase with respect to control.

Hence on an overall assessment, *Lagenandra toxicaria* is noted to be effective in the removal of turbidity, iron and *E.coli* at various concentrations of the plant material at various retention times. Consistent removal of turbidity was observed with *Aloe barbadensis* leaf at all concentrations of the plant material, except at 3HAT treated with 4g of the plant material. The highest value of 79.2% has been observed in the treatment set with 0.5g of the plant material at 12 HAT. In the present study, *A.barabedensis* showed no viability in checking hardness. Similarly iron removal showed variations but highest removal occurred at the coagulant dosage of 0.5g at 24 HAT. *A.barbedensis* showed bactericidal activity at concentration of plant material at higher retention times. In essence, *A.barbedensis* is effective in the treatment of all water quality parameters under study, except that of Hardness. *Canna indica* showed no signs of turbidity removal except at treatment set of 4.0g at 12 HAT.

Hardness removal was observed at initial stages but the activity got depleted at higher retention time. At initial stages of the treatment iron removal was effective and highest removal was observed at 3 HAT at a concentration of 2.0g. *C.indica* showed bactericidal activity at all concentrations of plant material and withholding time. It is evident from the results that *Canna indica* is inconsistent in removing Turbidity, Iron and Hardness. However it has showed effectiveness in the treatment of E.coli. *B.monnieri* was found to be promising in treating all the parameters under study except turbidity and hardness. Hardness removal was insignificant at all concentrations and retention time. Iron and *E.coli* removal was effective at all higher retention time and higher coagulant concentration. Of various plants attempted in the present study, *Lagenandra toxicaria* and *Aloe barbedensis* showed effectiveness in the treatment of Turbidity, Iron and E.coli content. They can be listed in the category of plants materials effective in water treatment like *Moringa oleifera* (Babu and Chaudhuri, 2005; Bhuptawat *et al*., 2007), Opuntia spp. (Miller *et al*., 2008; Zhang *et al*., 2006), Okra and Nirmali seeds (*Strychnos potatorum*) (Al-Samawi and Shokralla, 1996); Tamarind seeds (Bhole, 1995) etc. It is assumed that plant materials contain significant quantities of low molecular-weight water-soluble proteins, which when added to water, attains a net positive charge. The solution therefore acts as a natural cationic polyelectrolyte during treatment. When these natural coagulants are added to raw water, the net positive charges attributed by proteins acts like magnets, attracting the predominant negatively charged particles such as silt, clay and other toxic particles in water. The mixing action causes them to collide and stick to each other on a faster rate. The flocculation process occurs when the proteins bind the negatively charged particles, forming flocs, which are present in water. These flocs can be easily removed from the system by settling or filtration (Ndabigengesere and Narasiah, 1998; Ghebremichael *et al.,* 2005). The efficiency of removal of Turbidity, Hardness and Iron content by the plants can be attributed to these reasons. The metabolites release by the plants might be inhibitory to the growth of *E.coli*, resulting in their reduced numbers in treatment sets. Thus it can be concluded that of various plants under study, *Lagenandra toxicaria* and *Aloe barbedensis* can be effectively utilized for the treatment of selected water contaminants. However their resultant toxicity, if any, needs to be assessed before consumption of such treated water.

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