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NATURAL COAGULANTS FOR WATER PURIFICATION: AN ECOFRIENDLY APPROACH

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ABSTRACT

From ancient times plants are used for the treatment of different types of diseases. Plants are also have ability to purify waste water. Water is indispensable for human health and well-being; there can be no life on Earth without water. However, that same water can do harm to our body if not purified. This review was aimed at examining natural plant extracts in order to develop inexpensive ways for rural communities to purify their drinking water. The study involved creating an inventory of plant extracts that have been used for water and waste water purification. Locally available seeds and leaves used for water purification. Treatment with these natural coagulants helped in the coagulation of the heavy metals like Lead, Nickel, Copper, etc. present in the raw water samples. The study reveals that seeds and leaf extracts were also more effective in clearing and in sedimentation of suspended organic and inorganic matter present in water sample. In general, other plants should be studied in order to solve the problem of water quality especially in developing countries. In such a case plant species can contribute to advancing the goal of sustainable water treatment technologies that are themselves sustainable. This work suggests the use of these plants for water purification, which are an economical and eco-friendly approach.

KEYWORDS: Coagulants, Heavy metals, Water purification, Water.

INTRODUCTION

Water is the basis of life on earth. Water is most important for human survival. About 75% of the body weight is made up of water. WHO estimates that about 85% of the rural population facing lack potable drinking water. In developing countries 15 million infants die every year due to contaminated drinking water, poor hygiene and malnutrition. About 80% of illness in

developing countries are directly connected with contaminated drinking water (WHO). Ground water, surface water and rain water are often the major sources of water availability in a community. Potable water, which is safe for drinking must be free of pathogenic organisms, toxic substances and an excess of minerals and organic pollutants. It must be colourless, tasteless and odourless in order to be attractive to consumers (Yongabi, 2010). World population increasing year to year and reaching 7 billion in 2012 whereas an access of getting pure water remains a problem especially for people who live in developing countries. The severity is much observed in rural dwellers who is their source of drinking is surface water which is not purified and this results for transmission of waterborne diseases (Megersa et.al., 2014). Water get polluted from various sources. Number of chemical coagulants and disinfectants used for waste water. Unfortunately, there are indications that a number of water borne pathogens are growing resistant to Chlorine- Alum and lime treatment. Chlorine or Halogen compounds used in disinfecting water has been tagged a precursor for cancer, as it forms tetrahalomethane compounds and lead to hormone mimics. Beside aluminium sulphate is generating dementia in young and elderly. There is a need to probe into indigenous knowledge in waste water purification. There is a lot of indigenous knowledge and plants that has remained unexploited due to lack of adequate science and technology. Historically, there is evidence to suggest that communities in the developing world have used plant based materials as a strategy for purifying drinking water (Miller et al., 2008). Recently a number of effective coagulants have been identified of plant origin treatment table 1 (Megersa et.al., 2014). Of the large number of plant materials that have been used over the years, the seeds from Moringa oleifera have been shown to be one of the most effective primary coagulants for water treatment especially in rural communities (Ndabigengesere and Narasiah, 1998; Ali et al. , 2010; Sotheeswaran et al., 2011; Yahya et al., 2011). In coagulation and disinfection, a substantial number of active compounds have been isolated from various parts of plant species. The active coagulating component can be extracted from the plant parts and used in pure or semi-pure form, thus decreasing the total amount of organic material added to the treatment process which may resulting in the possibility for undesired and increased microbial activity (Gebremichael et al., 2005; Miller et al., 2008). Plant extract also have ability to reduce the inorganic pollutants such as metals, present in waste water (Ida, 2013). This review evaluates the use of plants, which are non-toxic, economical and easily available.

Natural Coagulants

Moringa oleifera (Drumstick)

Moringa oleifera is the most widely cultivated species of a monogeneric family, the Moringaceae, that is, native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan (Alo et al., 2012). Moringa oleifera seeds are used as a primary coagulant in drinking water clarification and wastewater treatment due to the presence of a water-soluble cationic coagulant protein able to reduce turbidity of the water treated (Mangale et al., 2012). Moringa oleifera leaves is used for Cadmium (II) removal from waste water (Ali et al., 2015). Moringa seeds are much more effective in water purification in terms of adsorption of metals. The percentage removal by Moringa seeds were 90% for copper, 80% for lead, 60% for cadmium and 50% for zinc and chromium (Nand et al., 2012). The seed has been found to have antimicrobial activity against bacteria, moulds and fungi. Both Gram positive and Gram negative bacteria removed by using Moringa seeds (Kurup et al., 1954). Laboratory investigations confirm the seed to be highly effective in the removal of suspended solids (Berger et al., 1984). Moringa seeds have capability to clean the low and high turbid water (Ali et al., 2010; Mangle et al, 2012).

Table: 1 List of plant species used as coagulants and disinfectants.

Scientific name	Family	Genera	Plant parts	Habit	Uses
Moringa oleifera Lam.	Moringaceae	Moringa	Seed	Tree	Coagulation and disinfection
Phaseolus vulgaris L.	Fabaceae	Phaseolus	Seed	Herb	Coagulation
Opuntia ficus indica (L.) Mill.	Cactaceae	Opuntia	Leaves	Shrub	Coagulation and
Dolichos Lablab L.	Fabaceae	Lablab	Fruit	Herb	disinfection
Senna alata (L.) Roxb.	Fabaceae	Senna	Leaves	Shrub	Coagulation
Castanea sativa Mill.	Fagaceae	Castanea	Seeds	Tree	
Aesculus hyppocastanum L.	Sapindaceae	Aesculus		Tree	
Quercus robur L.	Fagaceae	Quercus		Tree	
Q. rubra L.	Fagaceae	Quercus		Tree	
Quercus cerris L.	Fagaceae	Quercus		Tree	
Coccinia indica (L.) Voight	Cucurbitaceae	Coccinia	Fruits	Vine	Coagulation
Cicer arietinum L.	Fabaceae	Cicer	Seeds	Herb	Coagulation and disinfection
Phoenix spp.	Arecaceae	Phoenix	Seeds	Tree	Coagulation
Azadirachta indica A.Juss.	Meliaceae	Azadirachta	Fruit	Tree	Coagulation
Luffa cylinderca M.Roem.	Cucurbitaceae	Luffa	Fruit	Vine	Coagulation
Aloe barbadensis Mill.	Alloaceae	Aloe	Seeds	Herb	Coagulation and disinfection
Jatropha curcas L.	Euphorbiaceae	Jatropha	Seeds	Tree	Coagulation and

					disinfection
Citrus aurantifolia	Rutaceae	Citrus	Fruit	Tree	Coagulation and disinfection
Swingle					
Hibiscus sabdarifa L.	Malvaceae	Hibiscus	Calyx	Herb	Coagulation and disinfection
Garcinia kola Heckel	Guttiferae	Garcinia	Seeds	Herb	Coagulation and disinfection
Carica papaya L.	Caricaceae	Carica	Seeds	Tree	Coagulation and disinfection
Mangifera Indica L.	Anacardaceae	Mangifera	Fruit	Tree	Coagulation
Parkinsonia aculeata L.	Fabaceae	Parkinsonia	Seed	Tree	Coagulation and disinfection
Vigna unguiculata (L.) Verdc.	Fabaceae	Vigna	Seed	Herb	Coagulation
Trigonella foenum-graecum L.	Fabaceae	Trigonella	Seed	Tree	Coagulation
Strychnos potatorum	Loganiaceae	Strychnos	Seed	Tree	Coagulation and disinfection
Cuminum cyminum L.	Apiaceae	Cuminum	Seed	Herb	Coagulation
Cyamopsis tetragono	Fabaceae	Cyamopsis	Seed	Herb	
Zea mays L.	Poaceae	Zea	Seed	Herb	Coagulation
Abelmoschusesculentus(Moench)	Malvaceae	Abelmoschus	Gum	Herb	Coagulation
Calotropis Procera (Aiton) W.T.Aiton	Aclepiadaceae	Calotropis	Flower	Shrub	
Manihot esculenta crantz	Euphorbiaceae	Manihot	Root	Shrub	Coagulation and disinfection
Ocimum sanctum L.	Lamiaceae	Ocimum	Leaves	Shrub	Disinfection
Triticum aestivum L.	Poaceae	Triticum	Leaves	Herb	
Phyllanthus emblica L.	Phyllanthaceae	Phyllanthus	Leaves	Tree	
Cactus latifaria	Cactaceae	Cactus	Leaves	Shrub	Coagulation
Prosopis juliflora (Sw.) DC.	Fabaceae	Prosopis	Pod	Tree	
Pisum sitavum L.	Fabaceae	Pisum	Seed	Herb	
Corchorus tridens L.	Malvaceae	Corchorus	Leaves	Herb	
Solanum incunum L.	Solanaceae	Solanum	Leaves	Shrub	Coagulation and disinfection

Water Melon Seed (Citrullus lanatus)

Watermelon (Citrullus lanatus var. lanatus) is a vine-like (scrambler and trailer) flowering plant of Cucurbitaceae family. Water melon seed have potential to remove turbidity of water. When watermelon seed cake was used in combination with chemical coagulant such as alum higher colour and turbidity removal were observed, going as high as 100% clarification of colour. However the recommended ratio for the combined coagulant dose was 80% watermelon seed powder and 20% alum as best water treatment was obtained. This therefore establishes that watermelon seed powder as a natural coagulant can be more effective when used with 20% alum as a coagulant mix. The study reveals that, watermelon seed has been

found to be a potential natural coagulant for surface water treatment (Muhammad et.al., 2015).

Lime juice (Citrus aurantifolia)

Lemon juice used as disinfectant. Lemon juice has been mixed directly into a bucket of turbid water for purification. A number of communities adopted and used this in the past to treat dirty water apart from making dirty water fairly clear, it has a greater disinfective property. The acidity in lime juice is responsible for its disinfective property. Adding lime juice to water (1-5% final concentration) to lower the p^H bringing it to 4.5 will reduce Vibrio cholerae by 99.99% in about 120 minutes (Yongabi, 2010).

Plantago ovata (Seed)

A biocoagulant was successfully extracted from Plantago ovata by using an $FeCl_3$ - induced crude extract (FCE). The potential of FCE to act as a natural coagulant was tested for clarification using the turbid water of a river. FCE removed more than 95.6% of all initial turbidity concentrations (50-300 NTU). High bacteriological quality was achieved in the treated water. FCE as an eco-friendly biocoagulant was revealed to be a very efficient coagulant for removing turbidity from waters (Ramavandi, 2014).

Ocimum sanctum

The powder of leaves and ashes of O. sanctum plant have been found to have strong affinity towards Chromate at low P^H values. The % removal of Chromates is found to be: 85.5% to 91.6% with the leaves powder of Ocimum sanctum and 77.3% to 92.5% with their ashes. Plant have ability to remove Chromium (VI) from polluted waters (Veni and Ravindhranath, 2012).

Zea mays (Corn)

The investigation have confirmed the seeds of Zea mays highly effective in the removal of suspended solids from water containing medium to high initial turbidities. The turbidity reduction (81.0%) was achieved with 1g of Z. mays for one hour treatment (Okoli et al. , 2014). Treatment with Zea mays showed the significant decreased up to 92% in the reduction of microbial counts (Chauhan et al., 2015). Z. mays seed also have ability to remove heavy metals from polluted water (Nand et al., 2012).

Jatropha Curcas (physic nut)

The seed powder of physic nut (Jatropha curcas) is very useful in wastewater treatment. This plant belongs to the family Euphorbiaceae. Reports on the potentials of this plant in wastewater treatment exist (Yongabi, 2004). Activated carbon from the husk adsorbs heavy metals from contaminated water. Generally, the seed biomass is made up of about 35% oils rich in cosmetic value and equally used as lubricant oils for engines.

Some other Plants

Previous studies have screened a number of plants used as a coagulant and disinfectant for water treatment. Opuntia and other cactus species including Cactus latifaria have been successfully used as natural coagulant (Vijayaraghavan et al., 2011). The Phaseolus vulgaris seeds act as a natural coagulant (Sciban et al., 2006). Moringa concanensis, Ficus racemosa, Annona sqamosa showed phytocoagulant activity in water purification (Godhani et al., 2014). Locally available seeds such as Cumin, Mahaleb, Anise and Cress were used for water purification (Khairia M. Al- Qahtani, 2015). Dolichos lablab with alum shows high efficiency of removing turbidity from the synthetic water and lake water (Hayder and Rahim, 2015). The waste water is treated for the removal of turbidity by use of natural coagulants (Prodanovic et al., 2013; Mukheled al-Sameraiy, 2012). The simultaneous waste water purification by photocatalytic degradation of organic/hazardous waste materials and seed germination is possible (Sawant et al., 2013). Protein extracted from natural coagulants is used for turbidity removal in water (Muthuraman et al., 2013). Arachis hypogaea, Vigna unguiculata, Vigna mungo are used as heavy metal and microbes removal from waste water (Chauhan et al., 2015).

CONCLUSION

This review work conclude that application of seeds and leaves extract of plant can be highly recommended for waste water purification, and this technique can be applied for water purification in developing countries and rural communities, where people are used to drink contaminated turbid water. Various experiments has been examined that seed and leaves extract of plants are more effective in clearing and in sedimentation of suspended organic and inorganic matter present in water sample. The data obtained showed that Moringa oleifera seeds were much more effective in water purification in terms of reducing microbial numbers and adsorption of metals. It is recommended that more natural sources should be investigated for potential coagulation and disinfectation abilities, which contribute to advancing the goal

of sustainable water treatment technologies that are themselves sustainable and ecofriendly. It will also improve the both health and wealth of the country.

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