



NATURAL COAGULANTS- AN ALTERNATIVE TO CONVENTIONAL METHODS OF WATER PURIFICATION



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Abstract

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Water is used for several purposes by humans but the level of purity of the water being consumed is very crucial since it has a direct effect on health. Safe drinking water should generally be free from heavy metals, turbidity, organic compounds and pathogens. Conventional treatments of water often include coagulation, flocculation, sedimentation, filtration and disinfection. Among the coagulating agents used in water treatment, ferric sulphate or alum (aluminium sulphate) is some of the most widely used salts. Aluminium is strongly neurotoxic and may be involved in the development of Alzheimer's disease. It is a well known fact that most of the chemical disinfectants used for antibacterial activity generate various unwanted chemicals known as disinfection by products (DBPs) in water. These DBPs are associated with harmful effects on humans such as hemolytic anemia, cancer risk, nervous system effect and liver effects. Addressing these problems calls out for a tremendous amount of research to be conducted to identify robust new methods of purifying water at lower cost and with less energy, while at the same time minimizing the use of chemicals and impact on the environment. Here in this review article we highlight some of the Natural herbals like *Strychnos potatorum* (nirmali), *Moringa oleifera* (drumstick tree), that have been used by humans throughout history in treating drinking water.

INTRODUCTION

Water is that chemical substance which is essential for every living organism to survive on this planet. Water is needed by every cell of the organism's body to perform normal function. Water covers 71% of the Earth's surface, mostly in oceans and other large water bodies, with 1.6% of water below ground in aquifers and 0.001% in the air as vapor, clouds and precipitation (U.S. Geological Survey 2000).

Clean, fresh drinking water is essential to human and other life. Some observers have estimated that by 2025 more than half of the world population will be facing water-based vulnerability, a situation which has been called a 'water crisis' by the United Nations (Kulshreshtha, 1998). A recent report (November 2009) suggests that by 2030, in some developing regions of the world, water demand will exceed supply by 50 % (Charting Our Water Future 2009).

Water pollution

Pure uncontaminated water does not occur in nature. Water pollution is any undesirable change in the state of water, contaminated with harmful substances. It is the second most important environmental

issue next to air pollution. Any change in the physical, chemical and biological properties of water that has a harmful effect on living things is termed as 'water pollution' (WHO 1997).

There are also various micro-biological agents that include bacteria, viruses and protozoa which can also cause water pollution and may cause various water-borne diseases. The earliest recorded attempts to find or generate pure water date back to 2000 B.C. Early Sanskrit writings outlined methods for purifying water (Early Water Treatment 2009). These methods ranged from boiling or placing hot metal instruments in water before drinking it to filtering that water through crude sand or charcoal filters.

Conventional methods of purification

Water is used for several purposes by humans but the level of purity of the water being consumed is very crucial since it has a direct effect on health. The conventional method of water purification using aluminium sulphate (alum) and calcium hypochlorite puts pressure on the nation's over-burdened financial resources making treated water very expensive in most

developing countries and beyond the reach of most rural folks. Hence, they resort to sources such as dams, dug outs, streams, rivers, and lakes. Water from these sources is usually turbid and contaminated with microorganisms that cause many diseases including guinea worm and bilharzia. According to Postnote (2002), waterborne diseases are one of the main problems in developing countries; about 1.6 million people are compelled to use contaminated water and more than a million people (of which two million are children) die from diarrhea each year.

Health hazards due to chemicals

Earlier research findings of Crapper *et al.*, (1973) and Miller *et al.*, (1984) showed that the chemicals used for water purification can cause serious health hazards if an error occurs in their administration during the treatment process. These reports suggested that a high level of aluminium in the brain is a risk factor for Alzheimer's disease. Also, studies by workers (Letterman and Driscoll, 1988; Mallevialle *et al.*, 1984; Miller *et al.*, 1984) have raised doubts about the advisability of introducing aluminium into the environment by the continuous use of

aluminium sulphate as a coagulant in water treatment.

Chlorine, which is applied to water at various points in a water treatment for disinfection, combined with naturally occurring organic matter (NOM) to generate DBPs in general and halogenated DBPs is particular [Clark *et al.*, (1998)]. So, there is need to find alternative method for antibacterial activity [Schoenen, (2002)].

New and Economical ways to purify drinking water

UNICEF has discovered that one of the best ways of getting clean drinking water without wasting any energy is keeping the water in glass bottles on sunny roofs for 24 hours, where the sun kills 99.9% of the deadly *E. coli* bacteria. The research continues, and the turn of the decade may witness a new epoch in potable drinking water.

In India, the majority population still lives in village and small towns. These rural / tribal communities do not have access to public water supplies. This population obtains their water supply from unprotected sources such as open dug wells or small streams and ponds which are

polluted. The disinfection of water in these rural / tribal areas has a unique problem. Therefore, there is an urgent need for development and widespread promotion of simple disinfection techniques for rural /tribal areas.

There is therefore the need to investigate the use of non-chemicals which would be available locally in most developing countries. The use of natural materials of plant origin to clarify turbid water is not a new idea. Natural polyelectrolytes of plant origin have been used for many centuries in developing countries for clarifying turbid water (Schulz & Okun 1984). For home water treatment, the materials have to be used in the form of powder or paste, 90% of which consists of substances other than the polyelectrolytes. Even under such conditions, a few plant seeds make effective coagulants (Jahn, 1988).

It's time to re-discover India's ancient and traditional water-purifying methods using herbs and seeds, which cleanse the water while retaining its natural benefits. Our country is rich in a broad variety of seeds and herbs like *Nirmali*, *Sahjana*(*Moringa oleifera*), *Khas-khas* and *Elaichi* which can

provide us pure drinking water right at home. Even lotus leaves have been discovered to check water-borne diseases like dysentery and diarrhea that kill thousands of children year after year.

The major population of our country is living in rural/tribal area, where these natural herbs are easily available. Disinfection of water by using natural herbs can also help to generate employment facility for the peoples living in this area.

Moringa oleifera

Moringa (botanical name "*Moringa oleifera*") also called Drumstick tree is a versatile tree useful not only for human beings but also for animals and also in various industrial applications. People in India have been using it as an item of their daily food for nearly 5000 years. The Moringa plant originated initially in the Northern part of India some 5000 years back and soon moved into the Southern parts as well, where it was known as 'Murungai keerai' (Moringa leaves) and 'Murungai kaai' (Moringa vegetable). The Moringa tree had spread to most part of Asia, nearly the whole of Africa, South America, southern part of North America

and some pockets in Europe. It has been found useful in nutrition, agriculture, soil control, water purification, industrial applications, cattle feed etc and also for treating various types of illnesses in humans and livestock.

Moringa oleifera Lam (Moringaceae) is a highly valued plant, distributed in many countries of the tropics and subtropics. It has an impressive range of medicinal uses with high nutritional value. Different parts of this plant contain a profile of important minerals, and are a good source of protein, vitamins, beta-carotene, amino acids and various phenolics. The *Moringa* plant provides a rich and rare combination of zeatin, quercetin, beta-sitosterol, caffeoylquinic acid and kaempferol.

Various parts of this plant such as the leaves, roots, seed, bark, fruit, flowers and immature pods act as cardiac and circulatory stimulants, possess antitumor, antipyretic, antiepileptic, antiinflammatory, antiulcer, antispasmodic, diuretic, antihypertensive, cholesterol lowering, antioxidant, antidiabetic, hepatoprotective, antibacterial and antifungal activities, and are being employed for the treatment of

different ailments in the indigenous system of medicine, particularly in South Asia.

The leaves of *Moringa oleifera* have been reported to be a valuable source of both macro- and micronutrients, rich source of β -carotene, protein, vitamin C, calcium, and potassium and act as a good source of natural antioxidants; and thus enhance the shelf-life of fat-containing foods (Dillard and Bruce German, 2000; Siddhuraju and Becker 2003)

Seeds for water clarity

Moringa oleifera seeds contain a natural cationic protein (MOCP) that can be used as an antimicrobial flocculant for water clarification. The natural flocculant found in *Moringa oleifera* is present in 6 of the 14 species of *Moringa oleifera* growing in Africa, Madagascar, India and Arabia. Knowledge that *Moringa oleifera* seeds can purify water is not new; the seeds have been used for water treatment for generations in countries like India and Sudan. For example, the women of Sudan have used the seeds from the *Moringa oleifera* for water treatment since the beginning of the 20th century through a technique that comprehended the swirling

of seeds in cloth bags with water for a few minutes and let it settle for an hour.

Recent research has identified proteins of sizes ranging from 3 to 60 kDa, all possessing coagulating ability. The protein(s) act as a cationic polyelectrolyte, which attaches to the soluble particles and creates bindings between them, leading to large flocs in the water. Stirring and mixing accelerates the electrostatic flocculation, and the flocs condense the contaminants (Gottsch, 1992).

Strychnos potatorum

S. potatorum (nirmali) is a moderate-sized tree found in Southern and central parts of India, Sri Lanka and Burma, used predominantly as a traditional medicinal extract. Seeds of *S. potatorum* are used in dysuria, polyuria, urolithiasis, also in epilepsy. The seeds, leaves and trunk bark gave diabolin (major alkaloid) and acetyldiabolin. Seeds have also gave brucine, strychnine, novacine, icajine, oleanolic acid and its glycoside. Leaves and bark gave isomotiol, stigmaterol, campesterol and sitosterol. Diabolin exhibits hypotensive activity. A decoction of seeds is given to treat stammering. The seeds resemble

those of *Nuxvomica* but are non-poisonous. The ripe seeds are used for clearing muddy water. Sanskrit writings from India reported that the seeds were used to clarify turbid surface water over 4000 years ago which indicated that they were the first reported plant-based coagulant used for water treatment. Most studies concerning its use as coagulant seem to be limited within the Indian subcontinent.

The nuts of this species of *Strychnos* are very largely used in some parts of India for clearing muddy water. The fruit is also employed by the native practitioners of Hindostan, under the name of nirmali, as an emetic and in dysentery. In clearing water, one of the dried nuts is rubbed hard for a short time around the inside of the earthen water pot; on settling, the water is left pure and tasteless. The seeds contain a large quantity of an albuminous principle, upon which their virtues probably depend. The tree, which grows to a very large size, produces a shining, black, one-seeded berry.

Seed coagulant

Nirmali seed extracts are anionic polyelectrolytes that destabilize particles in

water by means of interparticle bridging. Previous studies have established that the seed extracts also contain lipids, carbohydrates and alkaloids containing the –COOH and free –OH surface groups which enhance the extracts' coagulation capability. A mixture of polysaccharide fraction extracted from *S. potatorum* seeds contained galactomannan and galactan capable of reducing up to 80% turbidity of solution. In all cases, the galactomannans are made up of a main chain of 1,4-linked d-mannopyranosyl residues bearing terminal d-galactopyranosyl units linked at the 0–6 position of some mannose residues.

Although the specific coagulation mechanism associated with nirmali seed extracts has not been extensively investigated, one can surmise that the presence of copious amount of –OH groups along chains of galactomannan and galactan provides weakly but abundant adsorption sites that ultimately lead to the aforesaid coagulant interparticle bridging effect.

In laboratory and field studies, seeds of *S. potatorum* have shown promise as coagulant in the clarification of turbid water (Sen & Bulusu, 1962; Dhekane *et al.*, 1970;

Tripathi *et al.*, 1976; Sutherland *et al.*, 1990, 1994; Folkard *et al.*, 1995; Al-Khalili *et al.*, 1997; Folkard & Sutherland, 2002). In laboratory tests, direct filtration with *S. potatorum* seed as coagulant appeared effective in clarifying low turbidity water (Abu-Ghararah, 1983).

CONCLUSION

Growing population, increased economic activity and industrialization have not only created an increased demand for fresh water but also resulted in severe misuse of natural resource. Water resources all over the world are threatened not only by over exploitation and poor management but also by ecological degradation. According to a survey conducted by United Nation Environment Programme (UNEP), 20% of world's population lacks access to safe drinking water and 50% lacks access to safe sanitation. Polluted water is estimated to affect the health of about 1200 million people and contributes to the death of 15 million children (per year) under the age of five.

The use of plant materials as natural coagulants to clarify turbidity of water is common practice since ancient times.

India's ancient and traditional water-purifying methods using herbs and seeds can be used to treat the water which cleanse the water while retaining its natural benefits. India is rich in a broad variety of seeds and herbs like which can provide us pure drinking water right at home.

Seeds of *Strychnos potatorum* (*S. potatorum*) and *Moringa oleifera* (*M. oleifera*) have shown promising result as the source of natural coagulant in the clarification of turbid water. Direct filtration with *S. potatorum* seeds as coagulant appeared effective in clarifying turbid water. This property is attributed due to the presence of polyelectrolytes, proteins, lipids, carbo-hydrates and alkaloids containing the -COOH and free -OH surface groups in the seed. Among the other plant materials investigated, seeds of *M. oleifera* were found to be one of the most effective sources of primary coagulant for water treatment.

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