

Water Purification with a Natural Product

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Due to the scientific and technological progress, toxic metal and organic contamination is a serious problem threatening human health. Heavy metal ions such as Pb(II), Cd(II), Hg(II) and Ni(II) are toxic and carcinogenic at even relatively low concentrations. They are not biodegradable and can accumulate in living organisms causing various diseases and disorders. Therefore, these heavy metals can be considered as one of the most toxic pollutants for water and wastewaters. Heavy metals are generally discharged to the environments via automobile emissions, mining activities, battery industry, fossil fuels, metal plating and electronic industries with diverse routes. Many industries generate great quantities of wastewater containing heavy metals at concentrations usually too low to be treated/removed by standard methods. The main techniques that are commonly used for the recovery of metal ions from industrial effluents include precipitation, coagulation, flotation, adsorption, ion-exchange, reverse osmosis, electrochemical treatments, membrane separation, hyperfiltration, evaporation, oxidation and solvent extraction. These techniques suffer diverse drawbacks. For example, precipitation processes cannot guarantee the metal concentration limits required by regulatory standards and produce wastes that are difficult to treat. On the other hand, ion exchange and adsorption processes are very effective but require expensive adsorbent materials for the removal of heavy metals from dilute aqueous streams. In developing countries, the quality of drinking water is often insufficient and hazardous to health. Aluminum salts are the most commonly used coagulants in water and wastewater treatment. However, many researchers have pointed out serious drawbacks of such salts; for example, Alzheimer's disease and similar-health related problems have been associated with residual aluminum in treated water. To date, several coagulants such as iron salts, polyaluminum chloride, polyferric chloride and synthetic organic polymers, have been suggested as alternatives to aluminum salts. Although these materials enhance coagulation processes, health and environmental safety is still not guaranteed. Furthermore, there is the issue of cost which is often a hindrance especially for developing countries. The use of low-cost and waste materials of biological origins, i.e., natural organic coagulants, has shown to provide economic solutions through reduction of exorbitant costs for water treatment to this global problem and is being advocated for as a sustainable technology for water treatment. Just like in case of fighting malnutrition, *Moringaoleifera* (MO) tree could be the answer to water treatment problems. The seeds have been found to be effective in removing turbidity, heavy metals and bacteria from water in a sustainable and environmentally friendly way.

Treatment of water to render it fit for human consumption is an immense challenge in all countries. In developing countries, the quality of drinking water is often hazardous to human health. Studies have identified that a protein extract from MO seeds is an effective flocculent/coagulant to aid purification and, as mentioned above, can replace aluminium and iron salts, and synthetic polymers that are commonly used but can be hazardous to health. The protein, apart from being non-toxic, has further great advantages because it is entirely biodegradable, significantly reduced volume of sludge and lack of effect on the pH and conductivity of the water. Furthermore, there are useful products extracted from seeds. The residual solids can be used as animal feed and fertiliser and the shell of the seed can be activated

and used as an adsorbent. Ultimately, the coagulant protein for water treatment is obtained at extremely low or zero cost.

Apart from the advantages as a flocculent mentioned earlier, the protein extracted from Moringa seeds has been observed that the amount of protein required depends on amount of impurities. Furthermore, the flocculent is removed with impurities. In contrast, precipitation with ions e.g. FeCl_3 and $\text{Al}_2(\text{SO}_4)_3$, leaves material in the water. The protein activity in water treatment is not affected by pH (pH range 4-9) and ionic strength (up to 0.5M). Neutron reflection was used to measure quantitatively structure and composition of the adsorbed protein films. The proteins adsorbed strongly on silica (SiO_2), sapphire (Al_2O_3) and polystyrene. Neutron reflection data shows that the MO protein binds to silica and sapphire in a dense multimolecular layer even at low concentrations. The protein does not come off rinsing with either H_2O or D_2O . Rinsing with anionic surfactant sodium dodecyl sulphate (SDS) solution results in the co-adsorption of the surfactant forming a denser protein/surfactant layer. However, rinsing with cationic surfactant cetyltrimethylammonium bromide (CTAB) causes the protein to come off the surface suggesting a way of regenerating or cleaning the biofilter. Small-angle scattering shows similar adsorption to heterogeneous surface of organic particles, e.g. 0.5 % wtpolystyrene latex. Strong adsorption of protein in combination with the tendency for the protein to associate suggests a mechanism for destabilizing particulate dispersions to provide cleaned water. The protein from seeds of MO show some surface activity, i.e. it's effective in reducing surface tension of water from 72 mN/m, to about 30-40 mN/m. The onset of surface activity in the concentration range studied of the Moringa proteins compared to 3 common proteins bovine serum albumin (BSA), lysozyme and frog foam protein is of the order: frog foam > BSA > MO > lysozyme. The weak surface activity is important in water treatment because if very surface active, then one would require to get to high concentrations before getting the protein molecules in the bulky to start the water purification process. It, however, important to point out that surface activity isn't enough in determining whether or not the protein has water pollutant removal properties. It is, however, important to point out that surface activity isn't enough in determining whether or not the protein has water pollutant removal properties.

Surface activity at the air-water interface of the mixtures with anionic surfactants at low concentrations has been investigated by surface tension measurements of the protein with anionic SDS, cationic sodium bis (2-ethyl-1-hexylsulfosuccinate) (AOT), cationic

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hexadecylpyridinium chloride (HDPC), non-ionic Triton X-100 (TX-100) and zwitterionic N-dodecyl-N,N-dimethyl-3-ammonio-1-propanesulfonate (DDAPS). The order of interaction, i.e., deviation of the protein/surfactant mixtures surface tension vs concentration curves from that of the protein alone, varied as follows: anionic>cationic>non-

ionic and zwitterionic. In fact, the curves of mixtures with either TX-100 or DDAPS nearly overlapped that of the protein alone indicating minimal interaction. In other words, the zwitterionic surfactant, though charged, behaves like a non-ionic surfactant because it is overall neutral.