Influence of Plant-Based Coagulants in Waste Water Treatment

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Abstract **- Coagulation and flocculation by adding chemicals are the methods that are usually used for water treatment. These types of treatment facilities are difficult and also expensive. So there is an increased demand for the innovative, low maintenance and energy efficient technology for water treatment. This study is concerned with the coagulation activity of extracts of various plant-based coagulants such as "Moringa Oleifera", "Tamarindus Indica". The aim was to ascertain the above mentioned plant-based coagulants in the influence of coagulation activity. The results indicated that Moringa Oleifera Seed Powder showed better influence in removal of physico-chemical parameters such as turbidity, pH, alkalinity, hardness etc., whereas Tamarindus Indica seed powder is better in removal of heavy metals from waste water when compare to Moringa Oleifera Seed Powder. Application of this low cost plant-based coagulants are recommended for eco-friendly, nontoxic, simplified water treatment where rural and peri-urban people living in extreme poverty are presently drinking contaminated water.**

Keywords- **Moringa Oliefera, Tamarindus Indica, water purification, coagulation, Physico-chemical parameters, heavy metals.**

I. INTRODUCTION

Environmental pollution is currently one of the most important issues facing by humanity. It was increased exponentially in the past few years and reached alarming levels in terms of its effects on living creatures. Increased industrial, agricultural and domestic activities have resulted in the generation of large amount of waste water containing number of toxic pollutants which are polluting the available fresh water continuously. Industrial pollution continuous to be a potential threat affecting the water due to the discharge of non-biodegradable heavy metals such as cadmium, nickel, copper, chromium, zinc, etc. into water stream. Consumption of such polluted water causes various health problems. Thousands of chemicals have been identified in drinking water supplies around the world and are considered potentially hazardous to human health at relatively high concentrations as they are carcinogenic [20].

Cadmium pollutants in water may occur from industrial discharge and mining waste [8]. Cadmium contamination is caused by its release in wastewaters and contamination from fertilizers and air pollutants. Cadmium is more toxic than lead and chromium. Cadmium at extreme levels causes itai-itai disease and at low levels over prolonged periods causes high blood pressure, sterility among males, kidney damage and flu disorders[2]. Hence, cadmium removal in water using natural polyelectrolytes such as Moringa seeds would be an advantage [14].

Chromium is widely distributed in the earth's crust and is used in metal plating [5]. In general, food appears to be the major source of chromium intake and on the basis of guideline value, there are no adequate toxicity studies available to provide long-term carcinogenicity study [17]. In epidemiological studies, an association has been found between exposure to chromium (VI) by the inhalation route and lung cancer [20].

Zinc is an essential trace element found in virtually all food and potable water in the form of salts or organic complexes [20]. Zinc is found in industrial waste and used in metal plating. Therefore, sources of zinc in water are mainly from industrial discharge and natural sources [21]. The removal of zinc is important for water treatment processes in producing good quality water [6].

Many conventional methods for heavy metal removal from aqueous solution were found which includes chemical precipitation, reverse osmosis, solvent extraction, and ion-exchange. The major disadvantage that we come across with these conventional processes is that the processes are expensive and not eco-friendly. Other disadvantage includes incomplete metal removal, high reagent and energy requirements generation of toxic sludge and other waste products that require careful disposal. Local Seed powders have proved to be a boon for developing economic and eco-friendly waste water treatment process in removal of heavy metals [18]. The advantage of plant based coagulants as water treatment materials are apparent as they are economically feasible, easily available and easy to store. Hence the present study is on the available resource materials – Moringa Oleifera, Tamarindus Indica seed powder. The main objective of the work is use of natural coagulants for the treatment of waste water which is an economically feasible and eco-friendly technology. This would provide potable water by means of natural treatment especially for under developed communities.

II. MATERIALS AND METHODS

As a precautionary exercise, standard procedures were followed for sample handling and collection [1].

A. Collection of water sample

The water sample used for this study was collected from a residential area of Tekkali nearby the industrial area of Ravivalasa in Srikakulam District.

B. Preparation of Moringa Oleifera Seed powder

The Moringa seeds were de-shelled and dried at ambient temperatures (23 to 25^0C) for a period of five days before milling. The white kernels were milled into a fine powder using mortar and were sieved through a small mesh to get the fine powder. The powder were collected into a sterile bottle with cap and stored in the refrigerator at 3^0C for seven days.

C. Preparation of Tamarindus Indica Powder

Plant materials obtained from different places was sun dried (23 to 25^0C) for five days and dried in Hot Air Oven at 60^0C for an hour, then ground in a grinder and sieved to get the fine powder.

D. Physicochemical analysis of the water sample

The water sample physicochemical parameters were determined prior and after treatment with the above said two different natural coagulant seed solutions using standard methods [1]. The mixing of two powders in water can be done by using Jar Test Apparatus. Jar test is the most commonly used method for determining the efficiency of a coagulant, since it is easy to perform [15].

E. Determination of turbidity

The turbidity of the water sample was determined using Nephelometer. The Nephelometer was switched on and then calibrated with distilled water. 5 mls of the water sample was poured into a cuvette holder with the vertical line on the cuvette aligning with the horizontal mark on the instrument. The value of the turbidity was then read on the CLD (Crystal Liquid Display).

F. Determination of Hardness

The determination of the total hardness of water is based on a complexometric titration of calcium and magnesium with an aqueous solution of the disodium salt of EDTA at pH value of 10.

G. Determination of Heavy metals

All cleaned glassware were soaked in 10% HNO_3 overnight for metal analysis and washed with distilled and deionised water before they were used. The analysis of the samples were carried out soon after collected and stored in a refrigerator for further analysis. The calibration standards of metals were prepared according to the Standard Methods for Examination Water and Water analysis [1]. The conditions for the Atomic Absorption Spectrophotometer (AAS) were optimized according to the recommended setting for each of the metals of interest with background correction using high purity grade acetylene fuel. The concentrations of metals were prepared in the linear range [16]. For specific metal analysis, standard solutions of known concentrations were used and the effect of the additions of Moringa and Tamarindus Indica Seed powder on metal adsorptions was tested. The seed paste of Moringa and Tamarindus Indica seeds were prepared by taking approximately 0.1g of the seed powder with the muslin cloth and the strainer to the water samples that were to be purified. All experiments were conducted at room temperature and after being allowed to stand for two hours, the samples were analysed using the AAS.

The absorbance of the standard was measured and a graph of net absorbance against the concentrations of the element in the standard solutions was plotted to get the calibration plots. From the calibration graphs, the concentrations of the metals Chromium, Cadmium and Zinc adsorbed by Moringa and Tamarindus Indica seeds were determined.

III. RESULTS AND DISCUSSIONS

The primary factor for water purification by Moringa Seeds is due to the action of Seed proteins. The Moringa Seed Kernel contains about 37% of proteins [15]. Moringa flocculants show that the basic polypeptides are the main causes of clarifiers along with that the main functional groups in the side chain amino acids of Moringa Oleifera Seed proteins also contribute in water purification. The mechanism of coagulation with seeds of Moringa Oleifera consists of adsorption and neutralization of the colloidal positive charges that attract the negatively charged impurities in water. At a pH below 10, the Moringa Oleifera Seed proteins are positively charged and thus the seeds when added to water samples bind to the negatively charged particles if any in the samples [15], [9].

In this study Moringa and Tamarindus Indica Seeds were used as coagulants and their ability to aid metal removal from water sample was investigated.

TABLE I
PERCENTAGE REMOVAL OF HEAVY METALS WITH PLANT-BASED COAGULANTS

Natural coagulant	Cr (%)	Cd (%)	Zn (%)
Tamarindus Indica	62	73	70
Moringa Oleifera	58	70	65

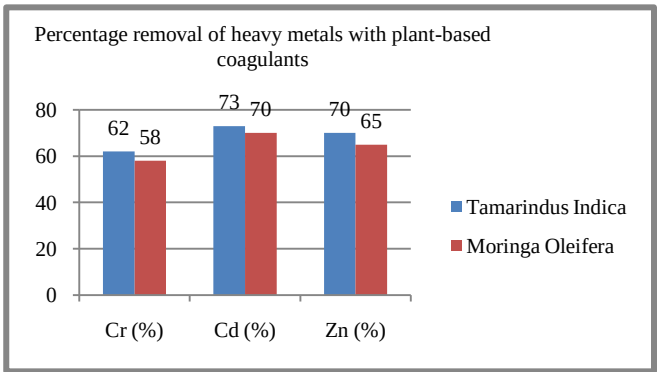

Fig.1 Percentage removal of heavy metals with plant-based coagulants

Table-1 and Figure-1 depicts the percentage removal of heavy metals from the sample water when two different natural coagulants were used. Table-1 shows that Tamarindus Indica Seeds have high percentage removal of heavy metals compared to Moringa Oleifera. Tamarindus Indica shows 73% of metal removal and the highest percentage removal was achieved for Cd whereas Moringa Oleifera shows 70% of metal removal for Cd. Adsorption describes attachment of ions and molecules from seed protein by means of specific mechanisms and adsorption is one of the processes affecting speciation, migration and biological availability of trace elements in natural water [3]. Metal ions in coagulation react with proteins and destroy them in water [7]. The adsorption of metals using Tamarindus Indica is limited to the adsorption surface. Heavy metals and solids that have high charges than Tamarindus Indica colloidal surface will remove high percentage of metals compared to other seeds. The Tamarindus Indica seeds showed adsorption of metals for which the percentage adsorption for Cadmium was 73% and Chromium, Zinc were about 62% and 70% respectively.

TABLE II
REMOVAL OF TURBIDITY WITH PLANT-BASED COAGULANTS

Natural coagulants	TURBIDITY (in NTU)	
	Before Treatment	After Treatment
Tamarindus Indica	3.5	3.0
Moringa Oleifera	3.5	1.8

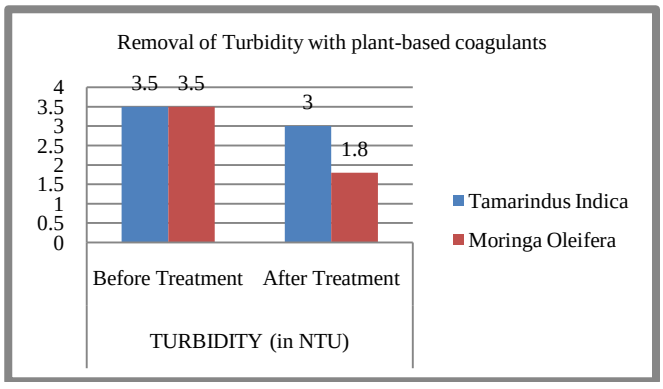

Fig.2 Removal of Turbidity with plant-based coagulants

Table-2 and Figure-2 shows that the effect of treating turbid water samples with two different seeds. It was observed that compared with original turbidity (3.5 NTU) of the water sample (Figure-2), Moringa was more effective than Tamarindus Indica in turbidity removal (1.8 NTU). It was observed that the turbidity was slightly decreased when Tamarindus Indica is added (3.0 NTU).

After treatment, Moringa seeds were observed to reduce the turbidity levels effectively in the water sample. The flocculations of particles by Moringa seeds apparently involves charge neutralization and inter particle bridging between the negatively charged proteins in seeds that brings about floc formation [4], [22].

TABLE III
PERCENTGE REMOVAL OF HARDNESS WITH PLANT-BASED COAGULANTS

Natural coagulants	% Hardness Removal
Tamarindus Indica	10%
Moringa Oleifera	34%

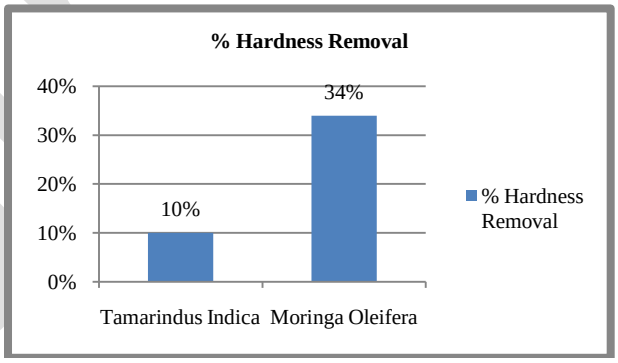

Table-3 and Figure-3 shows that the total hardness removal of water using Morigna seeds and Tamarindus Indica. The percentage removal of hardness for Tamarindus Indica and Moringa Oleifera seeds was 10% and 34% respectively. However, Moringa seeds showed a higher percentage of hardness removal compared to Tamarindus Indica. Hardness removal is considered to be due to the types of the proteins that are present in the seeds and the adsorption due to chelations of the metal ions to these proteins.

IV. CONCLUSION

Locally available seeds such as Moringa Oleifera and Tamarindus Indica were used for water purification. This paper evaluates Moringa Oleifera and Tamarindus Indica can be used as water purifiers and it would be possible to develop an eco-friendly method of water purification. This will show the way to improve the quality of drinking water in the rural areas. This paper also reports the use of other locally produced seeds such as Tamarindus Indica that have almost similar types of cationic polyelectrolytes as in Moringa seeds and compares their effectiveness in purifying drinking water. It

was concluded that when compared with Tamarindus Indica, Moringa Oleifera is highly effective in removal of the physico-chemical parameters whereas Tamarindus Indica is highly effective in metal removal. Plant-based coagulants show higher efficiency and it may be used alternative coagulant for water treatment. The results obtained in the study were good agreement with the previous study on natural coagulants. Plant-based coagulants also control and regulate turbidity and hardness and this study helps to detect the problems of heavy metals in drinking water in developing countries where purchase of coagulants is expensive and operating costs are high.

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