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The Role of Activated *Prosopis cineraria* Leaf Powder in the Removal of Ni (II) from WasteWater Stream

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ABSTRACT

The industries produce highly colored large volume of waste water, which is one of the major environmental problems. Such dye effluent is toxic and difficult to remove by conventional waste water treatment methods. Adsorption has evolved into one of the most effective physical processes for removal of dyes. Attempt has been made to study the Ni (II) adsorption capacity of *Prosopis cineraria* leaf powder from industrial waste water using batch adsorption technique. The effects of various parameters, such as temperature, pH, adsorbent particle size and initial chromium concentration on adsorption process have also been studied. The adsorption process of Ni (II) has been tested with Langmuir and Freundlich isotherm models. Adsorption data are well described by Freundlich isotherm with maximum adsorption capacity of 80% at 50°C, initial metal concentration of 50 mg/L and an adsorbent dosage of 0.5 g. The adsorption process follows pseudo-second order rate mechanism and rate constant is calculated at 30°C. This is called green remediation technology utilizing plant leaf powder, to biosorb pollutant wastewater basically Ni(II) and hence purifying water from Ni (II).

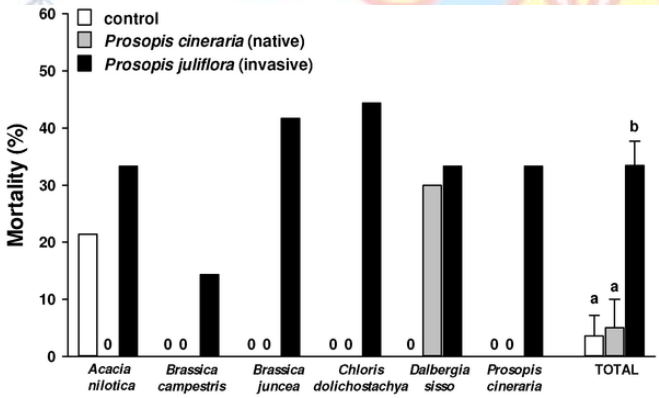
Keywords : Ni(II), *Prosopis cineraria,* leaf powder, pollutant, industrial, adsorption

INTRODUCTION

Heavy metals have been excessively released into the environment due to rapid industrialization and have created a major global concern. Ni (II) is basically found in industrial wastewaters, which originate from metal plating, mining activities, smelting, battery manufacture, tanneries, petroleum refining, paint manufacture, pesticides, pigment manufacture, printing and photographic industries, etc. Unlike organic wastes, heavy metals are non-biodegradable and Ni(II) can be accumulated in living tissues, causing various diseases and disorders;[14] therefore they must be removed before discharge. Research interest into the production of cheaper adsorbents to replace costly wastewater treatment methods such as chemical precipitation, ion-exchange, electroflotation,[1] membrane separation, reverse osmosis, electrodialysis, solvent extraction, etc.

Prosopis cineraria

are attracting attention of scientists. Adsorption is one the physico-chemical treatment processes found to be effective in removing Ni (II) from aqueous solutions.[15] An adsorbent can be considered as cheap or low-cost if it is abundant in nature, requires little processing and is a byproduct of waste material from waste industry. Leaf powders like *Prosopis cineraria* are inexpensive as they have no or very low economic value. Most of the adsorption studies have been focused on untreated leaf powders such as *Prosopis cineraria*.[2]

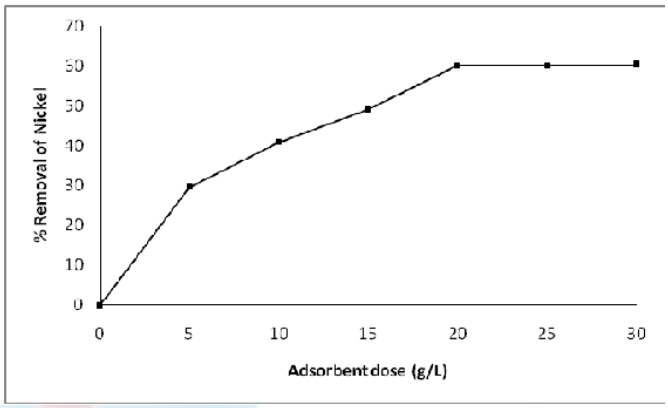


Community impact of *Prosopis cineraria*

However, the application of plant leaf powders as adsorbents such as *Prosopis cineraria* can also bring several problems such as low adsorption capacity, high chemical oxygen demand (COD)and biological chemical demand (BOD) as well as total organic carbon (TOC) due to release of soluble organic compounds contained in the plant materials. The increase of the COD, BOD and TOC can cause depletion of oxygen content in water and can threaten the aquatic life. Therefore, plant leaf powders such as *Prosopis cineraria* need to be modified or treated before being applied for the decontamination of heavy metals basically Ni (II).[3]

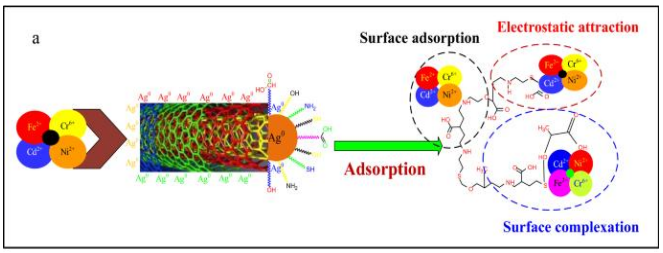
OBSERVATION

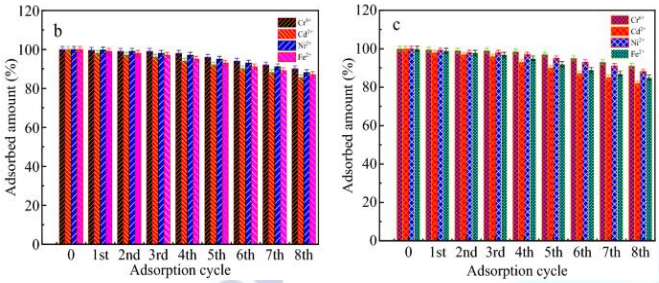
Two types of chemical modifications on leaf powder of *Prosopis cineraria* and their effectiveness in the removal of Ni(II) ions were reported .The first modification involved a monochloro triazine type reactive dye, Reactive Orange 13, which was covalently loaded to the cellulosic matrix of leaf powders of *Prosopis cineraria*. Another modification involved oxidation of hydroxyl groups of cellulose present in *Prosopis cineraria* to carboxyl group (a weak cationic ion-exchanger) by using hydrogen peroxide.[16]



Adsorption of Nickel ions

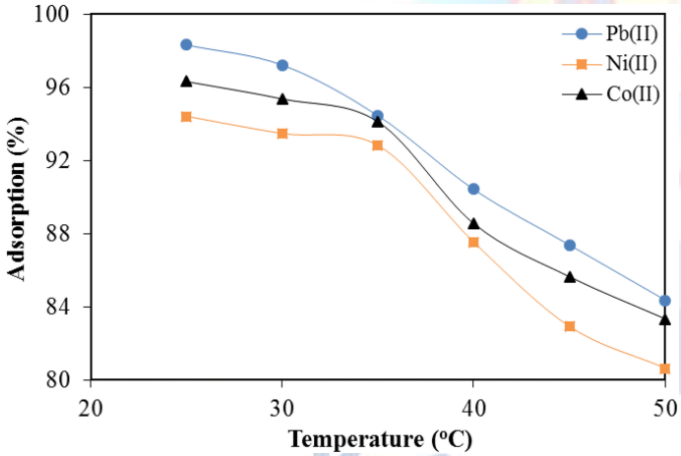
In the case of dye loaded *Prosopis cineraria*, the dye contains an azo linkage and hydroxyl groups (–OH), [4]a situation favourable for formation of six membered ring chelate with metal ions. The presence of sodium sulphonate groups of the dye molecules attached covalently to the adsorbent also enhanced the metal adsorption capacity. The mechanism of ion-exchange between Na+ of the dyed material and the heavy metal ion Ni (II) . For oxidized *Prosopis cineraria*, the high uptake of Ni (II) was due to the generation of carboxyl groups (–COOH).[17] The authors reported that oxidation process of *Prosopis cineraria* leaf powder was carried out under alkaline condition, therefore the carboxyl groups are in the form of carboxylate. The adsorption of Ni (II) ions could also take place by ion-exchange mechanism .[5]





Adsorption of different metal ions

Based on the Langmuir plots, maximum adsorption capacity for Ni (II) ion was achieved by dye loaded *Prosopis cineraria*, followed by oxidized *Prosopis cineraria* and unmodified *Prosopis cineraria*. However, for Ni(II) ions adsorption capacities were recorded by oxidized *Prosopis cineraria* leaf powder and the lowest was by unmodified *Prosopis cineraria*. Chemical modification of leaf powder to improve its removal performance and adsorption capacity for Ni(II) ions using ethylenediamine was conducted [6] .

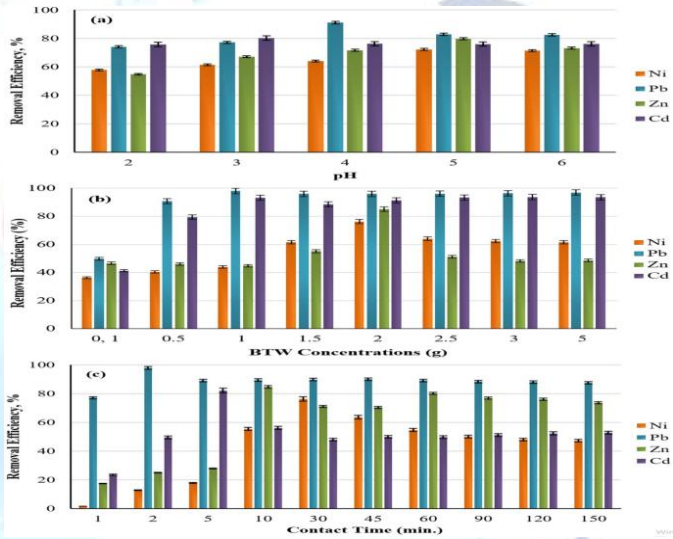


Adsorption of lead, nickel and cobalt by leaf powders of plants

Cellulose consists of active hydroxyl groups present on each monomeric unit of cellulose, therefore cellulose can react with carboxyl and amine groups of organic compounds. Based on the isotherm study, it was found that ethylenediamine modified cellulose content in *Prosopis cineraria* leaf powder adsorbed Ni(II) ions.[18] The modified adsorbent of *Prosopis cineraria* was also capable to adsorb metals 100 times more than unmodified cellulose leaf powder of *Prosopis cineraria*. Adsorption of Ni (II) ions occurred through complexation mechanism in which the amine (–NH2) groups of ethylenediamine take part in the chelation process. It is well known that adsorption of heavy metals by cellulosic wastes depends on the contact time and temperature. [7]

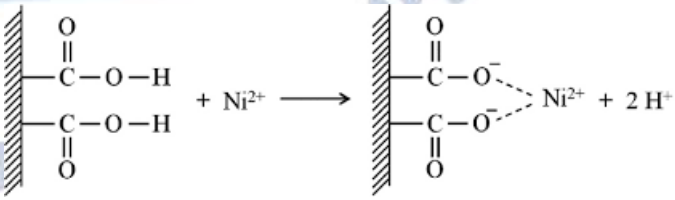
DISCUSSION

The study on chemically modified leaf powder of *Prosopis cineraria* for Ni (II) removal has attracted the attention of more scientists. A wide range of low-cost adsorbents obtained from chemically modified leaf powder of *Prosopis cineraria* has been studied and most studies are focused on the removal of Ni (II) ions.



Adsorption of heavy metal ions by plant fibres

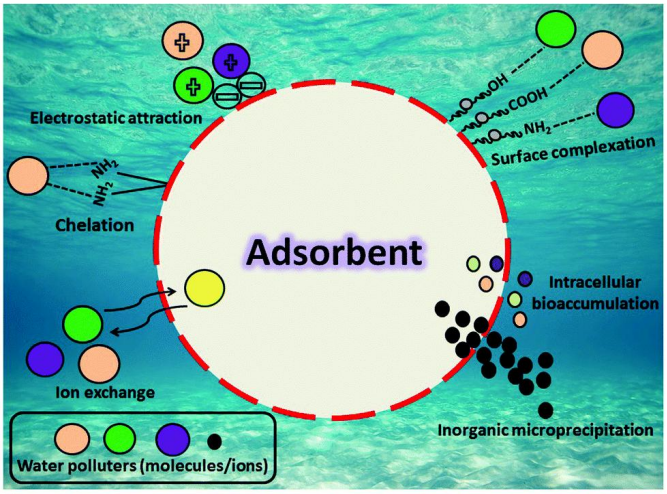
The most common chemicals used for treatment of leaf powder of *Prosopis cineraria* are acids and bases. Chemically modified leaf powder of *Prosopis cineraria* vary greatly in their ability to adsorb Ni (II) ions from solution. [19]



Nickel ion removal process

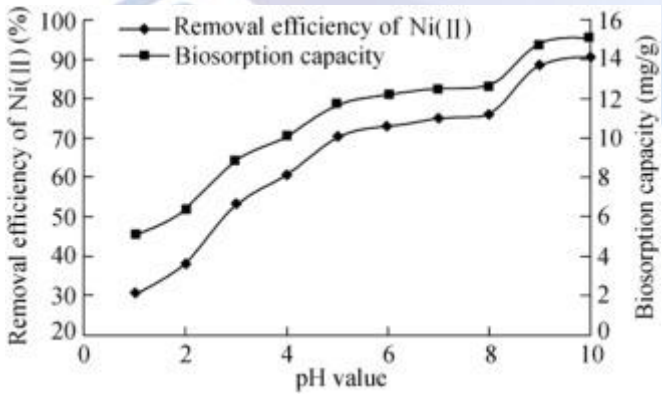
Chemical modification in general improved the adsorption capacity of adsorbents probably due to higher number of active binding sites after modification, better ion-exchange properties and formation of new functional groups that favours metal

uptake. Although chemically modified leaf powder of *Prosopis cineraria* can enhance [8] the adsorption of heavy metal ions, the cost of chemicals used and methods of modification also have to be taken into consideration in order to produce 'low-cost' adsorbents.



Adsorption process

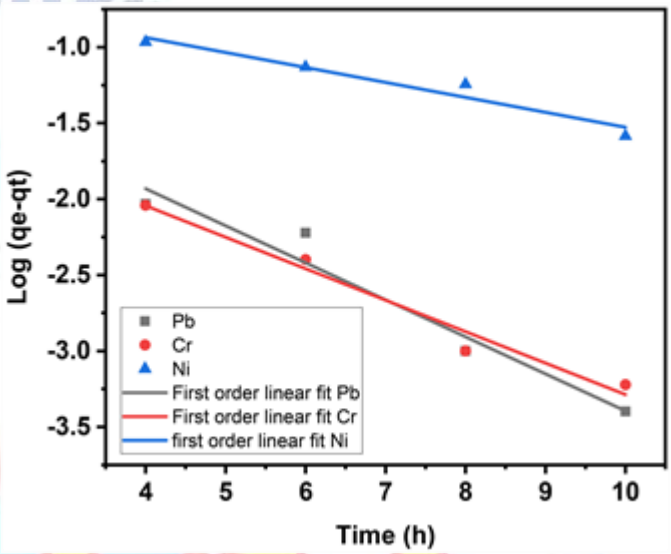
Since modification of adsorbent surface might change the properties of adsorbent, it is recommended that for any work on chemically modified leaf powder of *Prosopis cineraria*, characterization studies involving surface area, pore size, porosity, pHZPC, etc. should be carried out. Spectroscopic analyses involving [20] Fourier transform infrared (FTIR), energy dispersive spectroscopy (EDS), X-ray absorption near edge structure (XANES) spectroscopy and extended X-ray absorption fine structure (EXAFS) spectroscopy are also important in order to have a better understanding on the mechanism of Ni (II) adsorption on modified leaf powder of *Prosopis cineraria*.[9]



Removal efficiency of Nickel

RESULTS

Ni (II) and other heavy metal production units and industries have always had a pressing need for techniques that allow economical pretreatment for polluted waters. [21] The effectiveness of adsorption for Ni (II) removal from wastewaters has made it an ideal alternative to other expensive treatment options. The current paper hence deals with an investigation on modified leaf powder of *Prosopis cineraria* . Synthetic wastewaters prepared from commercial dyes and heavy metals containing Ni (II) were used in this study and the results showed high removals of Ni (II) . [10]



Metal ions removal shown graphically

CONCLUSION

This research absolutely contributes for economical alternatives. The most widely used and effective physical methods for adsorption in industry can be plant materials used such as modified leaf powder of *Prosopis cineraria* , with running costs cheap and ecofriendly. [22]

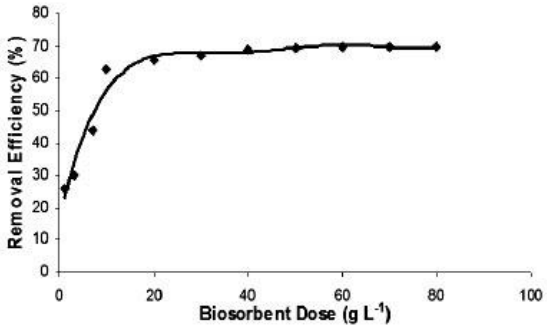


Fig. 2. Effect of adsorbent dose on % removal of Nickel. (Time=1hr, pH=5.6, Volume of solution=100mL, Initial Concentration=100mg L^{-1}, Temperature=33±1°C).

If the adsorbent material used cheaper cost with the additional pretreatment step, this method can be utilized further for other heavy metals besides Ni (II). Also, when we use natural adsorbents such as plants like *Prosopis cineraria* in present study, [11] it is readily

available there is no side effect. In spite of the scarcity of consistent cost information, the widespread uses of low-cost adsorbents in industries [23] for wastewater treatment applications today are strongly recommended due to their local availability, technical flexibility, engineering applicability, and cost effectiveness.[12] If low-cost adsorbents like *Prosopis cineraria* perform well in removing Ni (II) and other heavy metals at low cost, [24] they can be adopted and widely used in industries. It is not only to minimize the cost, but also to improve the profitability.[13, 25]

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