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RESEARCH ARTICLE

Invitro REMOVAL OF NICKEL (II) BY *Allium cepa* SKIN AS AN ABSORBENT

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Abstract

Nickel is a naturally occurring heavy metal that is commonly used in industrial processes. The long time exposure of Nickel (II) causes significant adverse health effects to humans. Biosorption is one of the major techniques for the removal of heavy metals from various sources and it is a cost-effective means for the treatment of metal-bearing water. In the present study, biosorption was conducted under different conditions such as varying pH (2, 4, 6, 8, 10), shaking velocity (100, 150, 200 rpm), concentration (100, 150, 200 mgL^{-1}) and biosorption dosage (0.75, 1.25, 1.75, 2.25, 2.75 g) for the biosorption of Nickel (II) by *Allium cepa* skin.

INTRODUCTION

The presence of heavy metals in the environment is a major concern due to their toxicity to many life forms. A heavy metal is a metallic element which with a specific gravity greater than about 5.0. It is a member of an ill-defined subset of elements that exhibit metallic properties, which would mainly include the transition metals, some metalloids, lanthanides, and actinides. It occurs naturally in the ecosystem with large variations in concentration. Living organisms require varying amounts of "heavy metals". It includes metals such as Zinc, Iron, Nickel, Molybdenum, etc., whereas certain metals such as mercury, lead, and plutonium are toxic which have no known beneficial effect on humans

Nickel is a silvery white, malleable and ductile metal. It is an abundant natural element. It possesses good thermal and electrical conductivity, moderate strength, and hardness. Although nickel can achieve oxidation states from –1 to +4, compounds of the +2 state are most common. Nickel compounds have no characteristic odor and taste.

Heavy metals can be toxic to living things at certain levels. Although they occur naturally, they come from many different sources including mining industries, burning of fossil fuels, like coal, burning garbage or tobacco and even forest fires release heavy metals into the environment. Most heavy metals are cations, meaning that they carry a positive charge. Zinc and copper, for instance, both carry a 2+ charge. Soil particles and loose dust also carry charges. Most clay minerals have a net negative charge. Soil organic matter tends to have a variety of charged sites on their surfaces, some positive and some negative. The negative charges of these various soil particles tend to attract and bind the metal cations and prevent them from becoming soluble and dissolve in water. Solubility is considered as an important factor in determining the toxicity of a metal. Water soluble nickel compounds do not enter cells readily whereas water insoluble nickel compounds enter cells through phagocytosis and are carcinogenic. Carcinogenicity is related to DNA protein binding, oxidation and DNA protein cross linking by nickel.

Nickel is a widely used metal in industrial and commercial applications, being both workable and highly resistant to corrosion. Nickel is widely used in many applications such as in combination with other metals to form coins, jewellery, stainless steel, etc. It is also used for electroplating, to color ceramics, and in battery production. Certain nickel compounds are known to be highly carcinogenic to humans with long time exposure. The physical properties of nickel, such as corrosion resistance, high strength and durability over a wide range of temperatures, pleasing appearance, good thermal and electrical conductivity, and alloying ability are the main advantages (Moore and Ramamoorthy, 1984).

Nickel salts are carcinogenic. Ni^{2+} is a highly reactive complex than other forms of nickel. It includes complexes such as nickel (II) chloride, nickel (II) carbonate, nickel (II) sulfate, etc.,

The general population can be exposed to nickel via inhalation, oral, and dermal routes of exposure. Major source of nickel exposure occurs through food and other sources including nickel that is involved in production, processing and its use. Foods that are naturally high in nickel concentration include chocolate, soybeans, nuts, and oatmeal. The amount of nickel that enters our blood stream depends on the size of the particle. Smaller nickel particles enter easily into the blood stream than larger particles (Szyczewski et al., 2009). Adverse respiratory effects have been reported in humans and animals exposed to nickel compounds at concentrations much higher than that typically found in the environment. High concentrations of nickel occur as dust that is released into air from stacks during processing that gets settles on the ground. It is one of the metals that occur in most of the toxicity tests – it appears stuck onto DNA, stuck on translocation proteins and is often present in blood at high levels (Khalid et al., 2000). Hence it is essential to remove nickel from industrial waste waters.

Pure nickel carbonates are reported to be product of aqueous nickel salts and alkali metal hydrogen carbonate. Nickel carbonate occurs in nature as hexahydrate or as hydroxyhydrate. It reacts with acid to give out carbon dioxide. It is prepared by reacting sodium carbonate with nickel (II) chloride or nickel (II) sulfate.

The common health hazards of nickel include allergic skin reactions in those who are sensitive to nickel and the other major effects include chronic bronchitis, reduced lung function, lung cancer and nasal sinus. These have occurred in people who have breathed dust containing certain nickel compounds. Nickel compounds $NiSO_{4,}$ $NiCl_2$, $NiCO_3$, $NiNO_3$ have been classified as carcinogen class I (by inhalation), reproductive toxicants class II (may cause harm to unborn children (Holan and Volesky, 1994).

Removal of nickel and other heavy metals from aqueous solutions can be accomplished by different methods. Precipitation of hydrous oxides is one of the most commonly used methods due to simplicity and low cost. However this method produces large volume of sludge that is costly and hazardous to dispose of and may not reduce the heavy metal content sufficiently. Adsorption is another method that can be used for nickel removal (Galun et al., 1987; Fourest and Roux, 1992; Brady et al., 1994; Wilhelmi and Duncan, 1995; Suhasini et al., 1999).

Thus, an increase in the level of the heavy metal presents series of threats to living organisms and the ecosystem

MATERIALS AND METHODS

Sample collection

The skin of *Allium cepa* was collected from house hold wastes in Hosur, Krishnagiri dist, Tamilnadu, India.

Preparation of biosorbent

The mature *Allium cepa* skin was collected. The brown skin was washed with distilled water to remove dust and adhering particles. The skin was dried under sunlight for few days until it turned crispy. Then the dried skin was crushed and blended to form powder. It was then stored in an airtight plastic container for future use to avoid contact with the atmospheric moisture.

Preparation of nickel (II) stock solution

Stock solution of 1000 MgL^{-1} was prepared by dissolving 2.022g Nickel carbonate in one liter of distilled water with small amount of dilute Hcl. The working solution was prepared by diluting the stock solution.

Preparation of dimethylglyoxime

0.5% of Dimethylglyoxime was prepared by dissolving 0.5g of Dimethylglyoxime in 100ml ethanol.

Nickel analysis

Nickel content was analyzed by using Spectrophotometric method, as described in the Standard methods for the Examination of Waste and Wastewater, to measure the concentrations of the Ni. The reaction between Ni and Dimethylglyoxime results in the formation of water insoluble red colored complex. The mixture of the complex and crystals is dissolved in chloroform, and then the results were read in spectrophotometer at 375 nm (Masatada Satake, 1979).

Biosorption studies

An aqueous stock solution of $NiCo_3$ in a concentration of $100 mgL^{-1}$ of Ni (II) was used in all experimental runs. Calculated quantities of this stock solution were measured and used for further experimental solution preparation. The pH of solution is adjusted with HCl and NaOH. Deionized water is used for all experiments. A known quantity of the dried biosorbent was added into the metal bearing solution of a given concentration in Erlenmeyer flasks. The biosorption medium was stirred at a constant speed for 1 hr at 37^{O} C. The samples were taken at definite time intervals and filtered immediately to remove biomass and Ni (II) concentration in the remaining solution was analyzed. The unabsorbed Ni (II) in the adsorption medium was determined with a spectrophotometer (SYSTRONICS 2201).

Effect of shaking velocity

1g of *Allium cepa* skin powder was added in a conical flask containing 50 mgL^{-1} of $NiCO_3$ solution. Flasks were maintained at different rpm such as 100 rpm, 150 rpm, and 200 rpm in an orbital shaker. All experiments were run in duplicate. Ni (II) concentration was measured by using spectrophotometer. The absorbance value obtained by analysis and their respective calculated concentrations are given in Table 2.

Effect of pH

1g of *Allium cepa* skin powder was added in a conical flask containing 50 mgL^{-1} of $NiCO_3$ solution. Flasks were maintained at different pH such as 2, 4, 6, 8 and10 in an orbital shaker at a speed of 200 rpm. All experiments were run in duplicate. Ni (II) concentration was measured by using a spectrophotometer. The absorbance value obtained by analysis and their respective calculated concentrations are given in Table 3.

Effect of concentration

1g of *Allium cepa* skin powder was added in a conical flask containing different $NiCO_3$ concentrations such as $200 mgL^{-1}$, $150 mgL^{-1}$, 100 mgL^{-1} in an orbital shaker at a speed of 200 rpm. All experiments were run in duplicate. Ni (II) concentration was measured by using a spectrophotometer. The absorbance value obtained by analysis and their respective calculated concentration are given in Table 4.

Effect of biosorbent dosage

0.75g, 1.25g, 17.5g, 2.25g and 2.75g of *Allium cepa* skin powder was added to each conical flask containing $50 mgL^{-1}$ of $NiCO_3$ and kept in an orbital shaker at a speed of 200 rpm. All experiments were run in duplicate. Ni (II) concentration was measured by using a spectrophotometer. The absorbance value obtained by analysis and their respective calculated concentrations are given in Table5.

Result and Discussion

Effect of shaking velocity

Biosorption studies were carried out by varying the shaking velocity (rpm) from 1 to 6 hours. The absorbance values were recorded by using spectrophotometer analysis and their respective concentrations are calculated (Table 2 and Figure 1). It was observed that with an increase in the rpm, removal of Ni (II) also increases and it is observed to be maximum at 150 rpm.

Table 1: Physical and Chemical Properties of Nickel Carbonate ($NiCO_3$)

Molar mass	118.70 g/mol
Appearance	Light Green Powder
Density	4.39g/cm3
Melting point	56-57 °C
Water solubility	Insoluble in Water; soluble in dilute acids

Table 2: Biosorption of Nickel (II) at 375nm
(Concentration – 50 mgL^{-1}, pH – 6, Biosorbent dosage – 10gL^{-1})

Time(hr)	Shaking velocity (rpm)		
	100	150	200
0	0.372	0.603	0.475
1	0.591	0.531	0.680
2	0.251	0.732	0.518
3	0.401	1.162	0.735
4	0.482	0.947	1.837
5	0.579	0.486	0.926

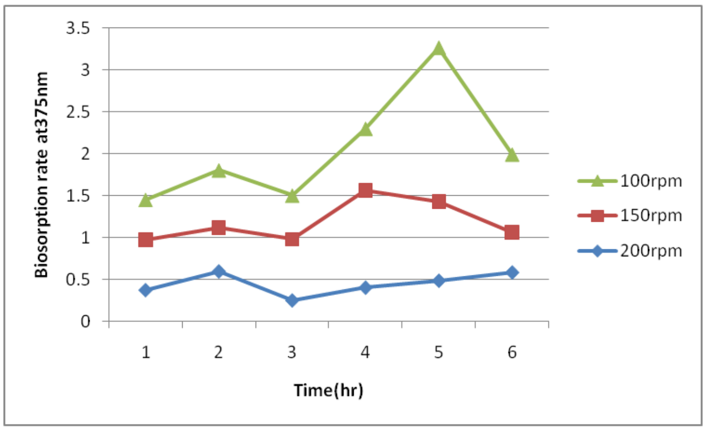

Figure 1: Effect of shaking velocity

Effect of pH

Biosorption studies were carried out by varying the pH for 1 to 6 hours. The absorbance value obtained by using spectrophotometer analysis and their respective concentrations are calculated (Table 3 and Figure 2). It was observed that with an increase in the pH, removal of Ni (II) also increases and it is observed to be maximum at pH 2.

Table 3: Biosorption of Nickel (II) at 375nm
(concentration – 50 mgL^{-1}, Shaking velocity – 200 rpm, Biosorbent dosage – 10gL^{-1})

Time(hr)	pH				
	2	4	6	8	10
0	0.748	0.654	0.475	0.357	0.183
1	0.567	0.831	0.853	0.841	1.371
2	0.493	0.605	0.974	0.753	0.882
3	2.187	0.759	1.845	0.507	1.017
4	1.327	0.868	1.032	0.732	0.582
5	0.705	1.485	0.489	1.382	0.856

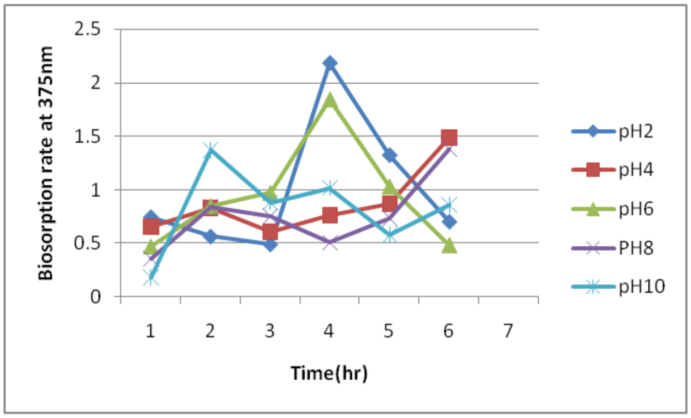

Figure 2: Effect of pH

Effect of nickel concentration

Biosorption studies were carried out by varying the nickel concentrations for 1 to 6 hours. The absorbance values were recorded by using spectrophotometer analysis and their respective concentrations are calculated (Table 4 and Figure 3). It was observed that with an increase in the concentration, removal of Ni (II) also increases and it is observed to be maximum at 150 mgL^{-1}.

Table 4: Biosorption of Nickel(II) at 375nm
(pH - 6, Shaking velocity – 200 rpm, Biosorbent dosage – $10gL^{-1}$)

Time(hr)	Concentration (mgl^{-1})		
	200	150	100
0	0.484	0.502	0.304
1	0.532	0.630	0.510
2	0.627	0.762	0.567
3	0.786	0.841	0.603
4	0.830	0.964	0.647
5	0.902	1.06	0.783

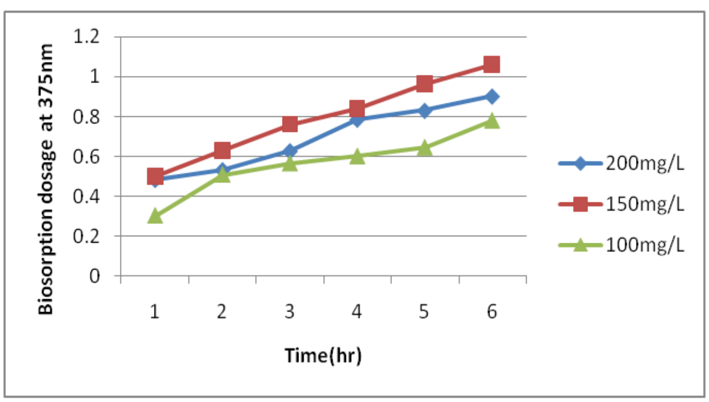

Figure 3: Effect of Nickel concentration

Effect of biosorbent dosage

Biosorption studies were carried out by varying the biosorbent dosage for 1 to 6 hours. The absorbance values were recorded by using spectrophotometer and their respective concentrations are calculated (Table 5 and Figure 4). It was observed that with an increase in the biosorbent dosage, removal of Ni (II) decreases rapidly and it is observed that the maximum absorption rate is observed at 17.5gL^{-1}.

Table 5: Biosorption of Nickel (II) at 375nm
(pH - 6, Shaking velocity – 200 rpm, concentration – 50 mgL^{-1})

Time(hr)	Biosorbent dosage (gl^{-1})				
	7.5	12.5	17.5	22.5	27.5
0	0.405	0.342	0.483	0.519	0.372
1	0.702	2.034	0.887	2.407	1.406
2	0.967	2.314	1.531	0.856	1.026
3	0.765	0.933	2.79	2.576	1.667
4	0.274	0.215	0.372	0.585	0.894
5	0.873	0.683	0.730	0.995	0.621

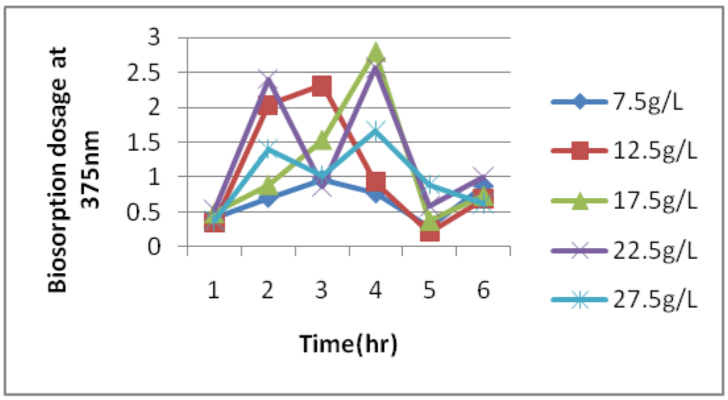

Fig 4: Effect of Biosorbent dosage

In this study, it can be concluded that,

1. With an increase in the shaking velocity, removal of Ni (II) increases.
2. With an increase in the pH of Nickel solution, removal of Ni (II) decreases.
3. With an increase in the concentration of the Nickel solution, the removal of Ni (II) increases.

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