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# BIOSORPTION EFFICACY OF ISOLATED BACTERIAL STRAIN FOR NICKEL REMOVAL FROM SYNTHETIC SOLUTION

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**ABSTRACT**

**In the present research work, nickel tolerant bacterial colonies were isolated and used for biosorption of nickel from synthetic solution at optimized parameters. The results revealed that maximum biosorption of Ni(II) is 60.3% for an optimum concentration of 30 ppm at a contact time 20 hours, pH 4, temperature 25!,dextrose concentration 0.8 g/100 mL and inoculum dosage 4 mL/100 mL of solution. These indicated that the bacterial isolate can be used efficiently in the removal of nickel from synthetic solution.**

**KEY WORDS :** Biosorption, Heavy metals, Biosorbent, Industrial effluent, Nickel removal

## INTRODUCTION

Nickel is generally present in the industrial effluents of mining, painting, galvanization, smelting, dye manufacturing, battery manufacturing, electro-plating and metal finishing industries (Al-Qodah, 2006). Due to negative effects of nickel like cancer and mutations in humans, it is essential to remove Ni (II) from industrial effluent before discharging it safely into environment. A number of techniques like coagulation, froth flotation, filtration, ion exchange, advanced oxidation processes, solvent extraction, adsorption, electrolysis, microbial reduction and activated sludge are available to remove Ni (II) from industrial effluent (Raval *et al*., 2016). These are restricted due to their limited removal efficiency, sensitive operating conditions and cost factor. In recent years, biosorption technology hasbeen used due to its convenience, easy handling, lower operating costs (Choi *et al*., 2009). The objectives were to investigate the removal of Ni(II) from synthetic solution by using bacterial biomass under optimized conditions. Identification was done by morphological and biochemical tests.

## MATERIALS AND METHODS

### Isolation and Identification of nickel tolerant bacterial strain

The bacterial strain tolerant to nickel was isolated on nutrient agar supplemented with 50 mg/L of nickel from electroplating industrial effluent. After 48 h of incubation, cells were harvested by centrifugation. 0.1 mL of the serial dilution of waste water was spread on the surface of the agar plates and incubated at 37 ºC for 48 hours, colonies based on morphological appearance was selected and sub cultured. Morphological and biochemical identification of isolated bacterial strain was done.

### Preparation of metal solution

The standard stock solution of 1000 mg/L $NiSO_4$ was prepared. Nickel estimation was done by DMG method spectrophotometrically which is based on the reaction of nickel with DMG (Dimethylglyoxime) in the acidic medium to red colored complex.

**Biosorption Studies :** The biosorption potential of isolated biomassfor removal of nickel was observed by varying initial metal concentration (10- 50ppm), contact time (5-25 hours), pH (2 -10), temperature ($15^0$C- $37^o$C), amount of dextrose (0.2-1g) and volume of inoculum (1-5 mL). The experiments were carried out at 37°C in shaker asks containing 90 mL of metal solution and 10 mL of a cell suspension to achieve the desired initial metal concentration and cell density. The % removal of metal was determined by measuring the residual metal concentration in the supernatant after centrifugation by DMG method. The effect of various operating conditions on

removal of nickel was determined using the following formulae:

% removal = $C_f$ - $C_i/C_i \times 100$ where $C_i$ - initial concentration, $C_{f-}$ final concentration

## RESULTS AND DISCUSSION

### Effect of contact time and pH

The effect of varying contact time i.e. 5- 25 hours on nickel removal was observed. As seen from Fig. 1, % removal increases as the contact time increases but upon reaching at a particular point it became saturated because bacteria stops growing upon reaching at stationary point. The optimized contact time came to be 20 hours for maximum nickel removal (54.7%).

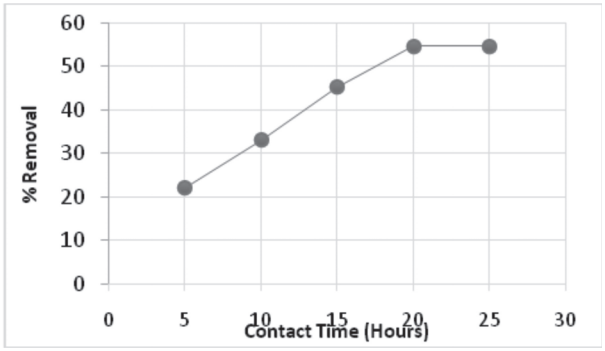


**Fig. 1.** Effect of contact time on % removal of nickel using isolated bacterial strain

**Operating conditions :** Agitation speed- 200 rpm, concentration of nickel- 30 ppm, Amount of inoculum- 2 mL, Temperature -37 ºC, pH- 7

The pH of solution was set at 2, 4,6,8 and 10 to evaluate its effect on the removal of nickel. From Fig. 2, the optimized pH came to be 4 for maximum nickel removal (55.3%). The presence of anionic polymers like peptidoglycan, teichoic acids in cell wall resulted in the metal binding efficacy of bacteria. Optimum pH values for bacteria biosorption are acidic, since the cell wall keeps negatively charged (Vieira and Volesky, 2000). According to studies of Rodriguez *et al.*, (2006) as the solution pH increased from 2.5 to 4.5, an increment of $Ni^{2+}$ adsorption was observed. This might be explained because at very low pH values functional anionic groups could be bound to hydronium ions ($H_3O^+$), leading to restriction of cation uptake as result of charge-repulsion forces, which become stronger as pH decreases.

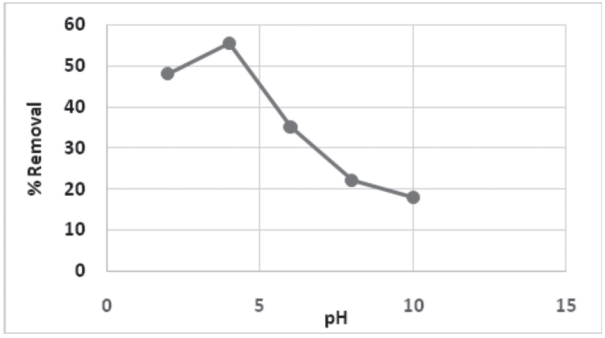


**Fig. 2.** Effect of pH on % removal of nickel using isolated bacterial strain

**Operating conditions**:- Agitation speed-200 rpm, amount of inoculum-2 mL, contact time -20 hours, conc. of nickel – 30 ppm, Temperature-37 ºC

### Effect of temperatureand carbon source

The inoculum was added in nickel containing medium and flasks were setin temperature range of 15ºC to 37 ºC for incubation. From Fig. 3, as the temperature increases, molecules move faster, enzymes speed up metabolism and cells rapidly increase in size. Thus % removal increases but above a certain value all of these activities are proceeding at such high rates that enzymes start to denature, and the total effect is detrimental. The optimized temperature came to be $25^0$C (60.7%) for maximum removal of nickel. The results are comparable to the studies of Cabral, (1992) and Ozturk *et al.*, (2004) who found maximum nickel removal at 20-25 ºC and decreasing the % removal on going to higher or lower values.

Different carbon doses in the form of dextrose i.e. 0.2-1.0 g/100 mL of solution was added to see the effect on % nickel removal. From Fig. 4, it is evident that dextrose support rapid growth of cells and high cell yields that increase the rate of uptake of

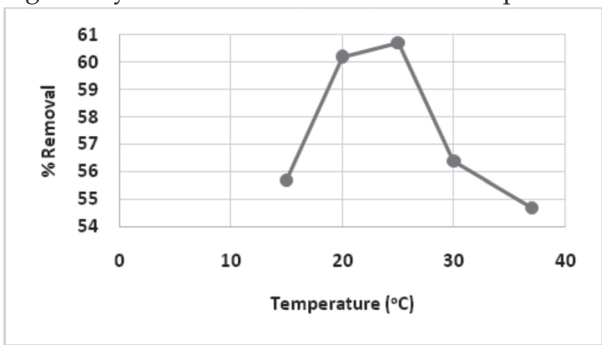


**Fig. 3.** Effect of temperature on % removal of nickel using isolated bacterial strain

**Operating conditions**:- Agitation speed-200 rpm, amount of inoculum-2 mL, contact time -20 hours, conc. of nickel – 30 ppm, pH-4

nickel. The optimized amount of dextrose is found to be 0.8 gm/100 mL of the media showing 61.2% nickel removal.

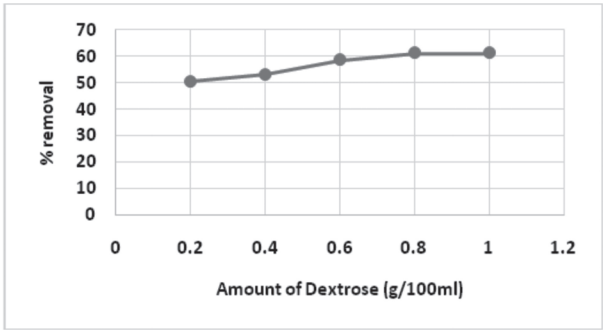


**Fig. 4.** Effect of amount of dextrose on % removal of nickel using isolated bacterial strain

**Operating conditions :** Agitation speed-200 rpm, contact time-20 hours, concentration of nickel-30 ppm, Temperature-25 ºC, pH-4

### Effect of amount of inoculumand metal concentration

As the inoculum volume increases, % removal of nickel increases but reaching on a particular concentration, the % removal (62%) became constant because the concentration of metal equals to the concentration of bacteria. From Fig. 5, optimum volume of the inoculum was 4 mL/100 mL solution. These results are comparable to Gheethi *et al*., (2017) and Selatnia *et al*., (2004) whose results revealed that the biosorption rate of metals increased with increase in concentrations of biomass doses to certain range due to the equilibrium limitations and then decrease due to the biomass granules, which are agglomerated.

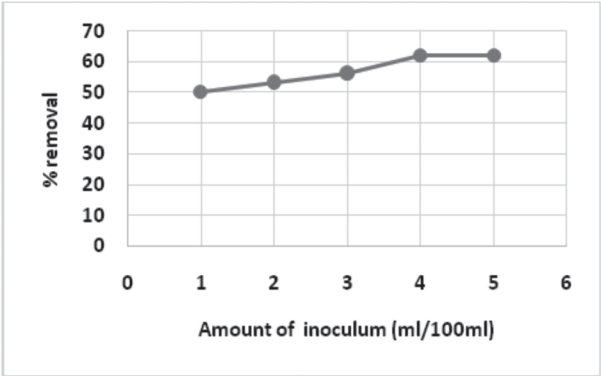


**Fig. 5.** Effect of inoculum volume on % removal of nickel using isolated bacterial strain

**Operating conditions :** Agitation speed-200rpm, contact time-20 hours, concentration of nickel-30 ppm, Temperature-25 ºC, pH-4, amount of dextrose-0.8 g/100 mL.

The effect of initial metal concentration in rage of 10-50ppm was evaluated on nickel removal by isolated bacterial biomass. From Fig. 6, maximum nickel removal occurred at 30ppm concentration under optimized conditions. The isolated non-viable strain is more efficient at higher concentrations for nickel removal. According to studies of Ilhan *et al*., (2004) and Abdel-Monem *et al*., (2010) the nonviable cells frequently exhibit a higher affinity for nickel ions compared with viable biomass probably due to the absence of competing protons produced during metabolism.

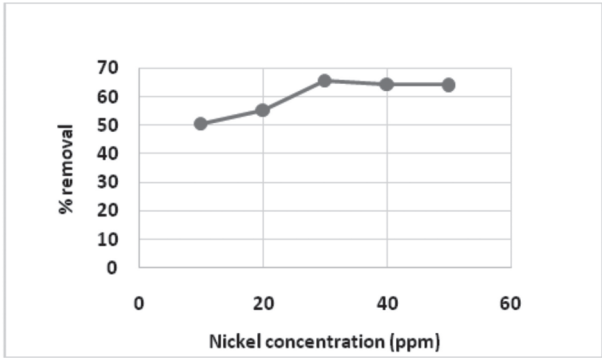


**Fig. 6.** Effect of initial metal concentration on % removal of nickel using isolated bacterial strain

**Operating conditions:** Agitation speed-200 rpm, contact time -20 hours, Temperature-25 ºC, pH-4, amount of inoculum-4 mL, amount of dextrose-0.8 gm/100 mL.

### Characteristics of isolated resistant bacterial strain

The bacteria that could grow in the presence of nickel was identied based on morphological and biochemical features following Bergey's Manual of Determinative Bacteriology (Bergey, 1994). (Table 1).

According to studies of Karakagh *et al*., (2012) the isolated strain having these characteristics might be

**Table 1.** Morphological and biochemical tests of the isolated bacterial strain

| S.No | Test | Result |
|---|---|---|
| 1 | Cell shape | Round |
| 2 | Color | milky white |
| 3 | Elevation | Raised |
| 4 | Gram test | +ve |
| 5 | Catalase test | +ve |
| 6 | Indole Production | -ve |
| 7 | Methyl red test | -ve |
| 8 | Voges-Proskauer test | -ve |
| 9 | Citrate utilization | -ve |
| 10 | Gelatin liquefaction | -ve |
| 11 | Urease | +ve |
| 12 | Glucose utilization | +ve |

*Bacillus sp.* possessing biosorption ability for cadmium and nickel isolated from sewage treated soil.

## CONCLUSION

The isolated nonviable bacterial strain proved to be an effective biosorbent under optimized conditions for nickel removal from synthetic solution at high concentrations.

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