

# Removal of Nickel from Simulated Wastewater Using Tea waste as a Natural Adsorbent

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**ABSTRACT:** The study on removal of poisonous Nickel from simulated wastewater has to be investigated with aim of detoxifying industrial waste effluent before their safe disposal onto land or into river water. Among various methods available for removal of toxic metals, adsorption process is widely used by various researchers for the removal of toxic metals. The objective of the present study is to contribute in search for less expensive adsorbents, in this regard tea waste powder is proven to be effective and promising adsorbent. Vital objective of this investigation was to assess the performance of tea waste as a low cost adsorbent in removing Nickel ions from aqueous solutions.

Experiments were conducted in the laboratory for batch mode adsorption studies and influence of factors like pH, initial metal ion concentration, dosage of adsorbent, and contact time under room temperature conditions were studied. Detailed investigation of the experiments revealed that, removal of Nickel ions in aqueous phase was found to be highly dependent on pH, 93.14% efficiency was obtained at pH 10, 80.64% efficiency was obtained at initial metal ion concentration of 20ppm, 60.75% efficiency was obtained at 3gm of adsorbent dose, 63.5% efficiency was obtained at 120min contact time. Further applicability of Langmuir, Freundlich and Tempkin isotherms for the adsorption of metal ions has been evaluated. All the three isotherms showed a good fitting to the experimental data. Hence by this study it can be concluded that the tea waste can be used effectively and economically to remove Nickel ions from wastewater.

**KEYWORDS :** Nickel, Adsorption, Adsorbent, Isotherms

## I. INTRODUCTION

The energy issue is a global concern, given the recurrent crises in the electricity sector. Over the past decade, the energy sectors of many countries endured intense changes with stimulus to the de-centralization of power generation, giving the distribution networks central role in this new model. Energy generation plays a key role in human life, along with means of transportation, telecommunications, water and sanitation.

Environmental Pollution is currently one of the most important issues facing humanity. It is undesirable side effects of industrialization, urbanization, population growth and unconscious attitude towards the environment. In general, sewage effluents from industries and municipal origin contain appreciable amounts of plants nutrients and variable amount of metallic cat ions like Zn, Cu, Fe, Mn, Pb, Ni, Cd, etc. Long-term irrigation with such effluents increases organic carbon content and toxic metals accumulation in soils and the chances of their entrance in food chain, and this ultimately causes Significantly health concern. Toxic metals have a great tendency to bio-accumulate and end up as permanent additions to the environment. The removal of toxic metals from wastewater has recently become the subject of considerable interest owing to strict legislations introduced to control water pollution. Among various water purification and recycling technologies, adsorption is a fast, inexpensive and universal method.

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The development of low-cost adsorbents has led to the rapid growth of research interests in this field. One of the important toxic metals, Nickel (II) finds its way into the water bodies through effluents from industries. It is present in the effluents of silver refineries, zincbase casting and storage battery industries. The higher concentration of Ni causes poisoning effects like headache, dizziness, nausea, tightness of the chest, dry cough, vomiting, and chest pain, shortness of breath, rapid respiration, cyanosis and extreme weakness. Cost is an important parameter for comparing the adsorbent materials.

Activated carbon has been recognized as a highly effective adsorbent for the treatment of toxic metals in wastewater, however, high cost of activated carbon and 10-15% loss during the regeneration has affected the utilization of activated carbon in the developing countries. For the removal of the toxic metals many attempts were made by using eco-friendly adsorbents easily available at low cost, as it has been necessary to take steps for the treatment of the industrial wastewater before it is discharged into the streams.

The present study was carried out to assess the potential of adsorbing nickel from aqueous solution onto adsorbent, prepared by using tea wastes and adsorption isotherms have been studied. In the present study, it is proposed to use tea waste as natural adsorbent for the adsorption of Nickel.

## II. MATERIALS AND METHODS

### MATERIALS

#### Preparation

In this study, tea waste powder was used as an adsorbent. This adsorbent was selected on their cost effectiveness and ready availability. The raw material required for the project that is tea waste collected from tea stalls and restaurants. The powder was washed with distilled water with 0.1N HCl solution for few hours by thorough mixing to remove all the dust particles and other impurities from seed shells. Then it was boiled with water up to color removal. The cleaned powder was sundried for 3 days after color removal it is dried in hot air oven at 80°C for 12 hours. The powder is subjected to sieve analysis in sieve shaker, the powder of size 1.18mm sieve retained is selected. The powder was stored in pre cleaned plastic bottles and kept air tight to avoid absorption of moisture from the atmosphere. These prepared tea waste powder was used for the experiments.

#### Reagents used

All reagents were of Laboratory grade and deionized water was used throughout the experiments. Diluted standard solutions of metal ions were prepared using appropriate volumes of stock solution and deionized water. 0.1N HCl and 0.1 N NaOH solutions were prepared and used for adjusting the pH of the solution.

#### Preparation of Stock Solutions

Laboratory grade Nickel sulphate of required quantity was dissolved in distilled water to prepare stock solution. 4.477gms of NiSO<sub>4</sub>·6H<sub>2</sub>O was added in the 100ml of distilled water in 1000ml volumetric flask. Nickel concentration of this was 1000mg/l. Stock solution was diluted with distilled water to obtain solutions of various concentrations.

#### Analysis of Metal Ions

A Flame Atomic Absorption Spectrophotometer GBC Avanta model was used to determine the concentrations of Nickel ions in the aqueous solution at wavelengths of 400nm. The metal was analyzed using the air-acetylene flame and the hollow cathode tube was used. Measurements were recorded when three repeatable readings were obtained. Metal ion concentrations were determined reference to the appropriate standard metal ion solutions.

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## Methods

The methods used for adsorption studies are as follows:

- Batch adsorption studies
- Column studies

### Batch adsorption studies

A series of batch experiments were carried out for the removal of nickel ions and to determine the adsorption isotherms of selected toxic metals on the adsorbents. Effect of several parameters such as pH, concentration of metal ion, concentration of adsorbent and contact time on adsorption of nickel on powdered tea waste was studied by batch technique.

For each experimental run, a fixed amount of the adsorbent weighed in digital weighing balance and transferred into five 1000 ml beakers containing 300 ml stock solution which were numbered and kept. Batch experiments were carried out at an agitation of 100 rpm, samples at predetermined time intervals were collected, filtered by whatman filter paper and remaining nickel was analyzed by Atomic Absorption Spectrophotometer as per standard methods.

The percentage removal of toxic metal from the solution was calculated using the equation,

$$\% \text{ Removal} = \frac{C_i - C_f}{C_i} \times 100$$

Where

$C_i$  and  $C_f$  represent initial and final concentration Ni ions.



Fig.1: Series of Beakers Containing 300ml Stock Solution and Adsorbent.



Fig.2: Collected Samples after Filtration.

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Batch experiments were carried out by using four variables:

- Varying concentration of metal ion
- Varying the pH
- Varying contact time.
- Varying the adsorbent dosage.

### Column Adsorption Studies

In this method the adsorption experiments carried out in glass column that is equipped with stopper for controlling the column flow rate. The sample solution is passed through the adsorption column by gravitation. The flow rate is kept constant by controlling the stopper value. Inlet of the column is connected to the feed bucket with the plastic tubing afterwards, the pH is adjusted. The column is filled with adsorbent with required depth.

### Adsorption Isotherms

A systematic approach whereby the data are taken over a range of fluid concentrations at a constant temperature, a plot of solute loading on the adsorbent versus concentration or partial pressure in the fluid, called an adsorption isotherm. The arithmetical models that illustrate the distribution of the adsorbate species among adsorbent and liquid is known as the adsorption isotherm. Among the widely used, isotherms are Langmuir, Freundlich and Tempkin isotherm.

## III.RESULTS AND DISCUSSIONS

Batch adsorption studies

### Effect of pH :

The studies were conducted on initial metal ion concentrations of 50ppm and constant adsorbent dose of 3gm/300ml solution at, an agitation period of 120min. Effect of pH on adsorption was conducted at ranges of 2,4,6,8 and 10 in each solution. The percentage adsorption increases with increase in pH.

Table 1: Effect of pH on Removal of Nickel ions

pH	Adsorbent Dose(grams)	Contact Time (min)	Initial Metal Ion Concentration (ppm)	Final Concentration (ppm)	Removal Efficiency (%)
2	3	120	50	44.226	11.548
4	3	120	50	29.539	40.922
6	3	120	50	18.282	62.344
8	3	120	50	13.728	72.544
10	3	120	50	3.434	93.132

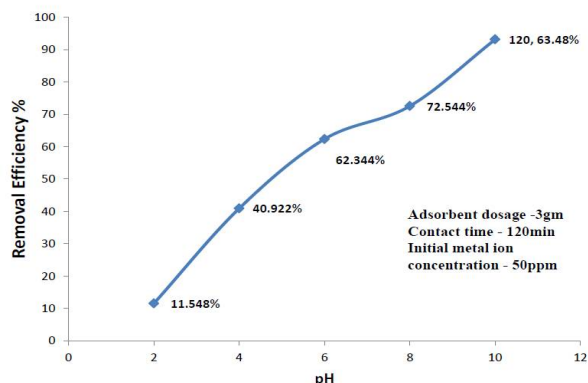


Fig. 3: Effect of pH on % removal of Nickel ions by tea waste adsorbent.

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### Effect of initial concentration of nickel ions:

The studies were conducted at room temperature at constant adsorbent dose of 3gm/300ml solution with pH of 5.5 at an agitation period of 120min.

Effect of initial concentration of nickel ions was conducted at ranges of 10ppm, 20ppm, 30ppm, 40ppm, 50ppm. The percentage removal is highly effective on 10ppm initial ion concentration, after which percentage removal decreases gradually.

Table 2: Effect of Initial Metal Ion Concentration on Removal of Nickel Ions.

pH	Adsorbent Dose(grams)	Contact Time (min)	Initial Metal Ion Concentration (ppm)	Final Concentration (ppm)	Removal Efficiency (%)
5.5	3	120	10	4.450	55.500
5.5	3	120	20	3.872	80.640
5.5	3	120	30	7.052	76.493
5.5	3	120	40	11.151	72.123
5.5	3	120	50	18.154	63.692

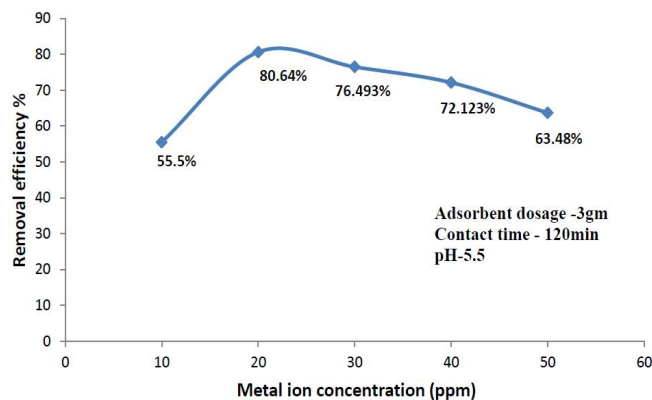


Fig. 4: Effect of initial metal ion concentration on % removal of nickel ions by tea wastes adsorbent.

### Effect of amount of adsorbent:

The studies were conducted at room temperature with an initial metal ion concentration of 50ppm, with pH of 5.5 at an agitation period of 120min.

Effect of amount of adsorbent was conducted at adsorbent doses of 0.6g, 1.2g, 1.8g, 2.4g , and 3g, and the removal efficiency decreases gradually with decrease in adsorbent dosage.

Table 3: Effect of Amount of Adsorbent on Removal of Nickel Ions.

pH	Adsorbent Dose(grams)	Contact Time (min)	Initial Metal Ion Concentration (ppm)	Final Concentration (ppm)	Removal Efficiency (%)
5.5	0.6	120	50	34.826	30.348
5.5	1.2	120	50	30.909	38.182
5.5	1.8	120	50	28.348	43.304
5.5	2.4	120	50	26.582	46.836
5.5	3.0	120	50	19.627	60.746

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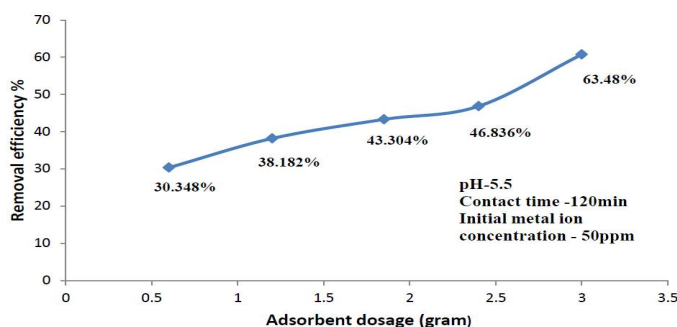


Fig.5: Effect of amount of adsorbent on % removal of nickel ions by tea waste adsorbent

Effect of contact time:

Effect of contact time was conducted at time ranges of 30min, 60min, 90min, 120min, 180min. Removal is highly effective in the range of 30 to 60min beyond which efficiency decreases with increase in contact time.

Table 4: Effect of Contact Time on Removal of Nickel Ions.

pH	Adsorbent Dose(grams)	Contact Time (min)	Initial Metal Ion Concentration (ppm)	Final Concentration (ppm)	Removal Efficiency (%)
5.5	3	15	50	22.853	54.29
5.5	3	30	50	19.444	61.11
5.5	3	60	50	18.478	63.04
5.5	3	90	50	18.525	62.95
5.5	3	120	50	18.259	63.48

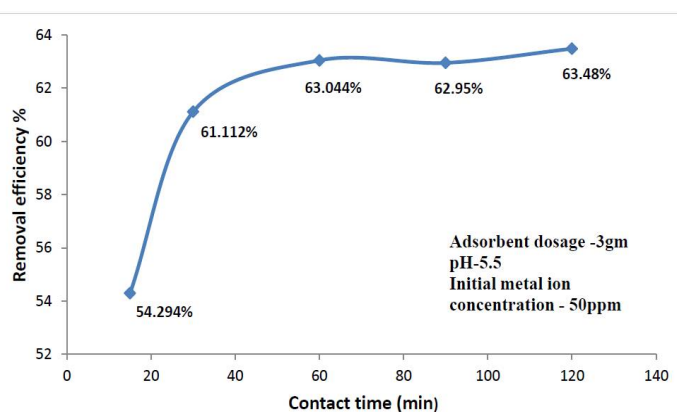


Fig.6: Effect of Contact Time on % Removal of Nickel Ions by Tea Waste Adsorbent

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### Adsorption Isotherms

#### A. Langmuir Adsorption Isotherm:

Langmuir Adsorption Isotherm Results are as follows:

Table 5: Langmuir Adsorption Isotherm for Removal of Nickel ions.

Final Concentration (Ce)	Adsorption Capacity (qe)	Ce/qe
22.853	2.710	8.433
19.444	3.055	6.364
18.478	3.152	5.862
18.525	3.147	5.886
18.259	3.174	5.752

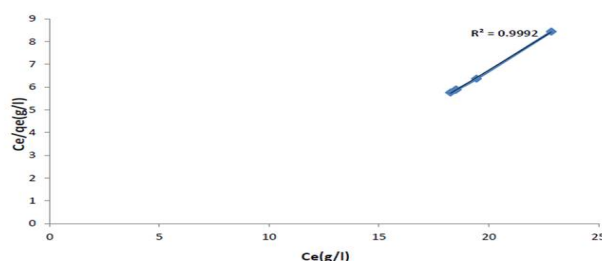


Fig.7: Langmuir Adsorption Isotherm for Adsorption of Nickel Ion.

Correlation coefficient (R2) for Langmuir adsorption isotherm is 0.9992.

#### B. Freundlich Adsorption Isotherms

Freundlich Adsorption Isotherm Results are as follows:

Table 6: Freundlich Adsorption Isotherm for Removal of Nickel ions.

Final Concentration (Ce)	ln(Ce)	Adsorption Capacity (qe)	ln(qe)
22.853	3.129	2.710	0.997
19.444	2.967	3.055	1.116
18.478	2.916	3.152	1.148
18.525	2.919	3.147	1.146
18.259	2.904	3.174	1.155

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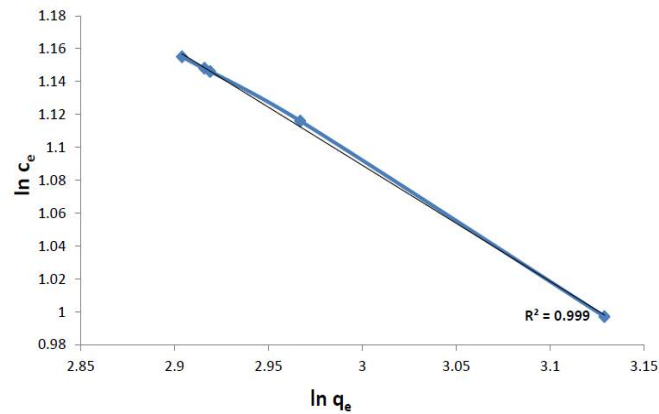


Fig.8 : Freundlich Adsorption Isotherm for Adsorption of Nickel Ion.

Correlation coefficient (R2) for Freundlich adsorption isotherm is 0.999.

### C. Tempkin Adsorption Isotherm:

Tempkin Adsorption Isotherm Results are as follows

Table 7: Tempkin Adsorption Isotherm for Removal of Nickel ions.

Final Concentration (Ce)	ln (Ce)	Adsorption Capacity (qe)
22.853	3.129	2.710
19.444	2.967	3.055
18.478	2.916	3.152
18.525	2.919	3.147
18.259	2.904	3.174

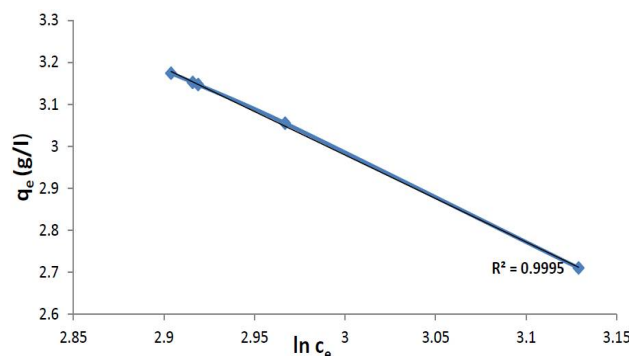


Fig.9: Tempkin Adsorption Isotherm for Adsorption of Nickel Ion.



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Table 8: Correlation Coefficient ( $R^2$ ) for Adsorption Isotherms.

Model	$R^2$
Langmuir	0.9992
Freundlich	0.999
Tempkin	0.9995

All the three isotherms showed a good fitting to the experimental data.

## IV. CONCLUSIONS

- The tea waste is a cheap and effective adsorbent for removal of nickel ions from wastewater without requiring any pretreatment.
- Tea waste which was used as adsorbent showed good adsorption capacity in batch adsorption study.
- Activation of the adsorbent is not required hence, only drying and size reduction costs are considered.
- Detailed investigations of the batch experiments showed that for maximum removal of nickel ion by Tea waste as adsorbent optimum parameters obtained are pH 10 with adsorbent dose of 3g/300ml, contact time of 120 minutes 93.14% removal efficiency and 20 ppm initial metal ion concentration 83.64% removal efficiency was obtained.
- The Applicability of Langmuir, Freundlich and Tempkin isotherms for the adsorption of metal ions has been evaluated. These three isotherms model shown a good fitting to the experimental data.

## IV.SCOPE FOR FUTURE WORK

The method may be tested for removal of other metal ions for industrial wastewaters.

- Pilot plant applications are beneficial for field application.
- Recovery of valuable metals and Reuse of adsorbent may be studied in detail.
- As the pH of industrial wastewater varies, the applicability of this adsorbent to remove the toxic metals at different pH needs further research. Furthermore, there is a need to explore the effect of different operating parameter such as pH, adsorbent dose, loading volume and mechanism of action.
- Further research is required to utilize this adsorbent for maximum removal of toxic metals. Different modes of operation can be tried for maximum adsorption of toxic metals. Also behaviour of the adsorbent need to be tested with real industrial effluents where different types of toxic metals are present and analyzing the adsorption capacity.

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