Study of adsorption competence of carbon black obtained from scrap tyres pyrolysis plant for removal of Ni (II) from waste waters

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***Abstract*—-Present study is based on the scope of utilization of industrial wastes in minimization of effluent pollution caused in our ecosystem. Heavy metal pollution is on a rise with the ever increasing disposal of hazardous chemical waste in our water bodies. For this carbon black is chosen as an adsorbent material which was obtained from furnace oil producing plant, which uses wastage tyres as a raw material. It was investigated for its adsorption competency for Nickel adsorption from aqueous solutions. The sorption capacity of carbon black was examined as a function of pH, agitating speed, and adsorbent concentration. The biosorption process was very fast; 88.65% of Ni (II) removal occurred and maximum removal obtained at pH of 3. The surface characteristics of carbon black have been discussed using SEM, FTIR and XRD. The results indicate that carbon black can be employed as a eco-friendly low cost alternative to commercial adsorbents in the removal of Nickel (II) from water and wastewater.**

Index Terms—**Adsorption, Carbon black, Wastage tyres.**

I. INTRODUCTION

With advent of urbanization and industrialization Mother Nature has been greatly affected. All the natural phenomenons are at the receiving end for the casual disposal of unlimited hazardous industrial effluents in various concentrations into our ecosystem. Although in small run the ill effects are not much noticeable, but with time the catastrophe of the toxins beyond limits is inevitable. Human kind has been evolving in all the various fronts through the development of science, sophisticated lifestyle, although has brought up many major concerns dealing with the future aspects of quality of environment that will be available to coming generations.

The increased use of heavy metals in process industries such as the electroplating, tanning and textile industries, also use of insecticides, pesticides and fertilizers often results in the generation of large quantities of dilute effluents containing mixtures of heavy metals, posing environmental disposal problems. In addition, mining, mineral processing and extractive metallurgical operations produce large amounts of metal bearing liquid wastes requiring treatment. Unlike most other toxic pollutants, metals can accumulate throughout the food chain due to their non biodegradability and thus have potentially detrimental effects on all living species. Once they enter the food chain, large concentrations of heavy metal ions may accumulate in the human body. If the metal ions are ingested beyond the permitted concentration, they can cause serious health disorders [1].

It is pretty evident that with evolving technologies we are in dreaded need to upgrade the patterns in which we currently deal with our industrial effluents. It is out of question to stop industries in view to pollution minimization, although lot of scope is at hand in management of industrial effluents in a manner that assist in lowering the impact of the harm caused.

To answer the need the present study is aligned in utilization of an industrial byproduct as an adsorbent material to curb the heavy metal pollution in waste waters. The byproduct chosen for the study comes from furnace oil producing plant which exploits scrap tyres. The wastage tyres are fed into a reactor vessel and heated under controlled conditions of temperature and pressure. The process brings about molecular restructuring of the rubber under the pyrolysis process as a result; furnace oil in gaseous form is produced along with other gases. These vaporized gases are passed through heat exchanges, where in the furnace oil is condensed into liquid form. During the process, carbon black and steel are also generated.

Present study is delineated in tapping carbon black so generated as a potential adsorbent material for removal of Ni (II) from synthetic waste water. Nickel occurs in natural water as a divalent cation with pH range between 5-9. Nickel is the metal component of the enzyme urease and considered to be essential to plants and some domestic animals. When compared to other transition metals, nickel is a moderately toxic element. However, it is generally well known that inhalation of nickel and its compounds can lead to serious problems including cancer of respiratory systems. Moreover nickel can cause a skin disorder known as nickel-eczema [3]. The safe limit for nickel in drinking water by USEPA is 100 μg/L and WHO is 70 μg/L. The permissible limit for nickel in drinking water in Indian standards by BIS 1998is 0.02 mg/L. The concentration limit of nickel in industrial wastewater is 3.0 mg/L by USEPA (1998).

Conventional methods for removing dissolved heavy metal ions include chemical precipitation, chemical oxidation or reduction, filtration, ion exchange, electrochemical treatment, application of membrane technology and evaporation recovery. However, these technology processes have considerable disadvantages including incomplete metal removal, requirements for expensive equipment and monitoring system, high reagent or energy requirements or generation of toxic sludge or other waste products that require disposal [4, 5]. Adsorption, an alternative technology for conventional wastewater treatment, has received considerable attention for the development of an efficient, clean and cheap technology.

II. MATERIALS AND METHODS

Preparation of activated carbons

Carbon black, a residue from furnace oil producing plant using wastage tyres was used as the adsorbent material. Plant from which carbon black was obtained is located in the Vidarbha region of Maharashtra. Carbon so acquired was washed with double distilled water and dried in an oven at 110oC, followed by cooling at room temperature.

Preparation of Ni (II) solution Adsorbate

A standard stock solution of Nickel Chloride hexahydrate, each milliliter of which contained 10 mg of Nickel, was made by dissolving 40.494 grams of the salt in distilled water, and accurately diluting to 1 liter.
To produce color system varying volumes of the standard Nickel solution in a 100 ml volumetric flask were just neutralized with 15 M ammonium hydroxide, diluted to the mark with 1.5M ammonium hydroxide, and thoroughly shaken [6].

Chemicals and equipment

All reagents used were of AR grade. De-ionized double distilled water was used throughout the experimental studies. ACS reagent grade HCl, NaOH and buffer solutions (E. Merck) were used to adjust the solution pH. An Elico (LI-129) pH meter was used for pH measurements. The pH meter was calibrated using buffer standard solutions of pH 4.0, 7.0 and 9.2. Fourier transform infrared spectrophotometer (multinuclear FT NMR Spectrometer model Avance-II (Bruker)) was used to analyze the organic functional groups of the biosorbent. The metal concentrations in the samples were determined using spectrophotometer. Wide angle X-ray diffraction (WAXD) patterns of powder DRFP sample was recorded on an X-ray diffractometer (Panalytical's X'Pert Pro), by using Cu Kα radiation (λ=1.54060 Å) at 45 kV and 4 mA. Scanning Electron Microscopy (JEOL/EO) was used to study the surface morphology of the biosorbent.

Batch adsorption experiments

Batch adsorption experiments were carried out by agitating 2 g of the carbon black samples with 100 ml of Nickel (II) solutions of desired concentrations at room temperature using an orbital shaker operating at 200 rpm. The effect of initial metal ion concentrations was carried out by shaking 100 ml Nickel (II) solutions of desired concentrations (2.00, 4.00, 8.00, 16.00, 24.00, 32.00, 40.00 mg/l) with 2 g of the adsorbent. The sample was then filtered using Whatman No. 42 filter paper and analyzed for the concentration of metal ions remaining in the solution using spectrophotometer.
All the investigations were carried out in duplicate to avoid any discrepancy in experimental results. The percentage of metal and the amount of metal adsorbed by the biomaterial was computed using the equation:

$$\% \text{ Removal} = \frac{(C_0 - C_e)}{C_e} \times 100 \qquad (1)$$

$$\text{Amount adsorbed } (q_e) = \frac{(C_0 - C_e)}{m} \times V \qquad (2)$$

Where, C_0 = initial concentration of metal solution in mg/l
C_e = equilibrium concentration of metal in mg/l
m = mass of the adsorbent in grams
V = volume of test solution in liters

RESULT AND DISCUSSION

Characterization of the biosorbent

Scanning electron microscope: Scanning electron microscope has been widely used to study the morphological features of the biosorbent. Study of the SEM micrographs of carbon black is shown in Fig. 1 indicating the presence of asymmetric pores and open pore structure, which may provide high internal surface area and a rough structure on the surface of carbon black, which is favorable for biosorption of Ni (II) from aqua solutions.

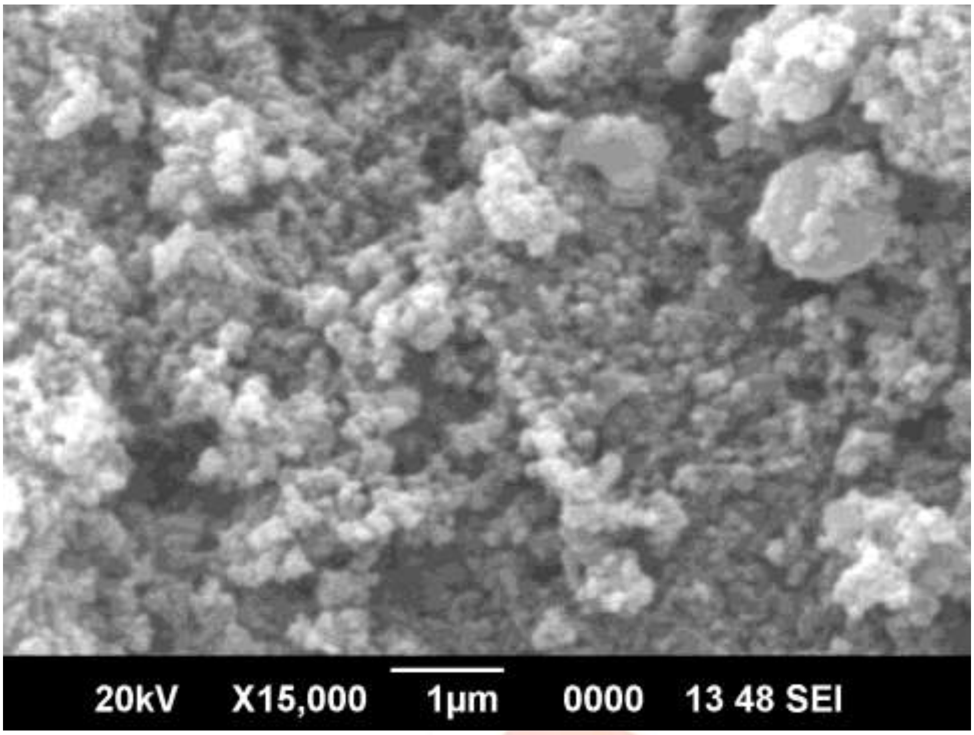

Fig. 1: SEM micrographs of carbon black

X-ray diffraction: XRD pattern of the carbon black shown in Fig. 2 illustrates the presence of a significant amount of amorphous material in the sample.

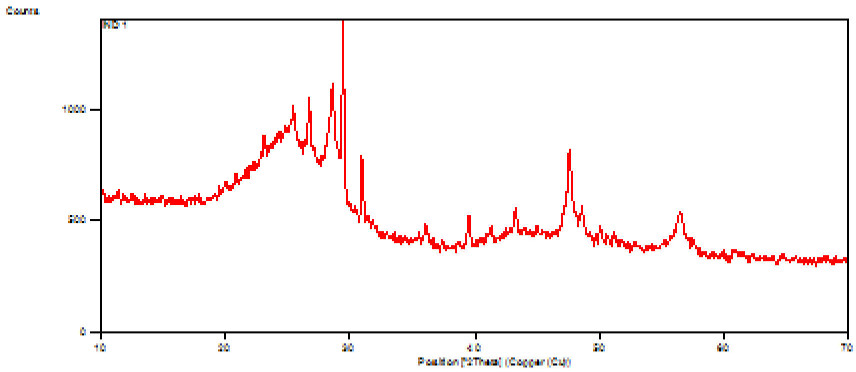

Fig. 2: XRD of the carbon black

Infrared spectroscopy: The FTIR spectra of carbon black Fig.3, showed the presence of many functional groups, indicating the complex nature of carbon black biosorbent as shown in Table 1.

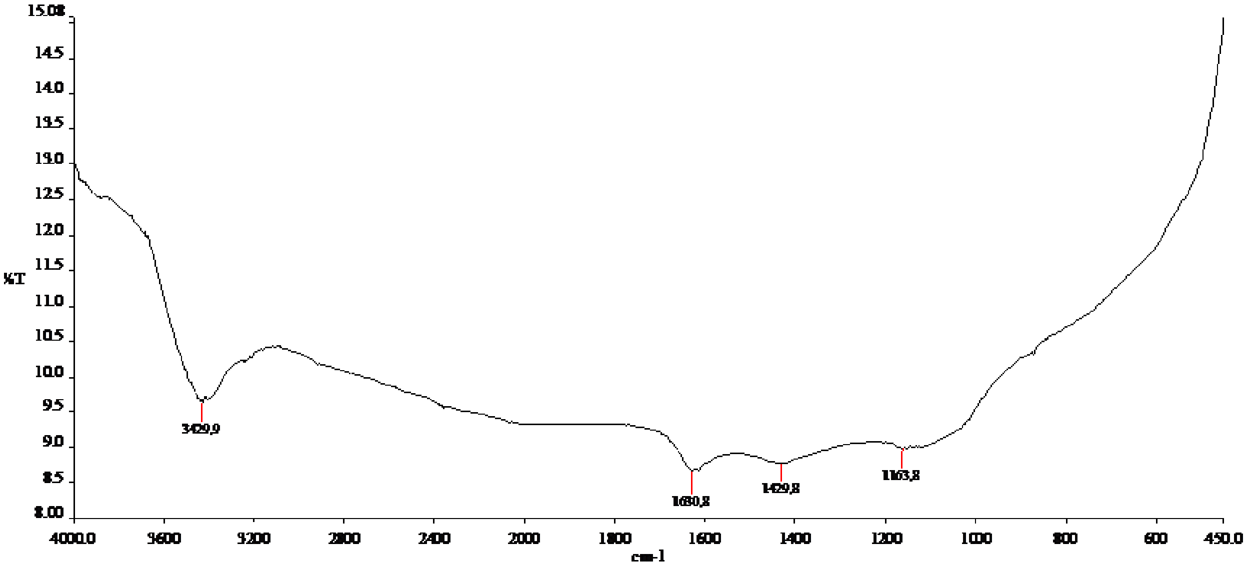

Fig. 3: FTIR spectra of carbon black

Table 1: FTIR spectra of carbon black

Wavelength (cm^{-1})	Possible Assignment	Functional Group
3429	O-H stretch, H-bonded	Alcohol, phenols
1630	N-H bend	I amines
1429	C-H stretch	Alkanes
1163	C-N stretch	Aliphatic amines

Influence of Ph: It is well known that pH of the medium is most important factors that influence the biosorption process [7] The pH level affects the network of negative charge on the surface of the adsorbing material, as well as physicochemsitry and hydrolysis of the metal. Percentage removal of the metal ion as a function of pH is shown in the Fig. 4. It has been observed that under highly acidic conditions (pH≈2.0) the amount of metal removal was small, while the sorption had been increased with the increase in pH from 3, and then decreased in the range 4.0 to 5.0. The lower removal efficiency at low pH is apparently due to the presence of higher concentration of H+ in the solution which competes with metal ions for the adsorption sites of the adsorbent. With increase in pH, the H+ concentration decreases leading to increased metal uptake.

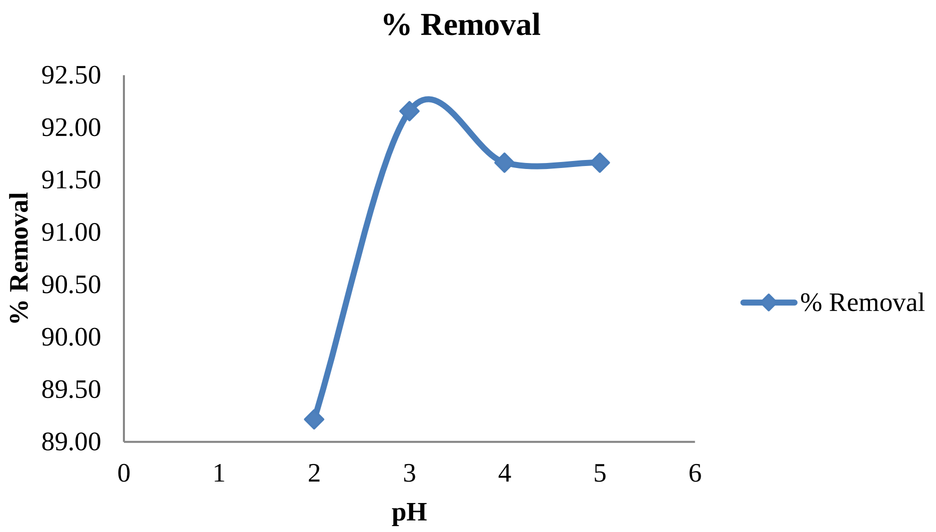

Fig. 4: % Removal of Ni (II) as a function of pH

Effect of biosorbent dose: Biosorption of Ni (II) onto carbon black was studied by changing the quantity of sorbent from 0.1 to 5g in the test solution while maintaining the initial concentration 40 mg/ml and contact time 2 h constant. Biosorption of Ni (II) as a function of adsorbent dose is shown in Fig. 5 indicates the effect of sorbent dose on the Ni (II) adsorption by carbon black. Obviously, the adsorption efficiency increased as the sorbent dose increased, but it remained almost constant when the sorbent dose reached 2g. This may be explained by the following analysis. When sorbent ratio is small, the active sites for binding metal ions on the adsorbent surface is less, so the adsorption efficiency is low; when adsorbent dose increased more metal ions were adsorbed. Thus it results in the increment of adsorption efficiency until saturation.

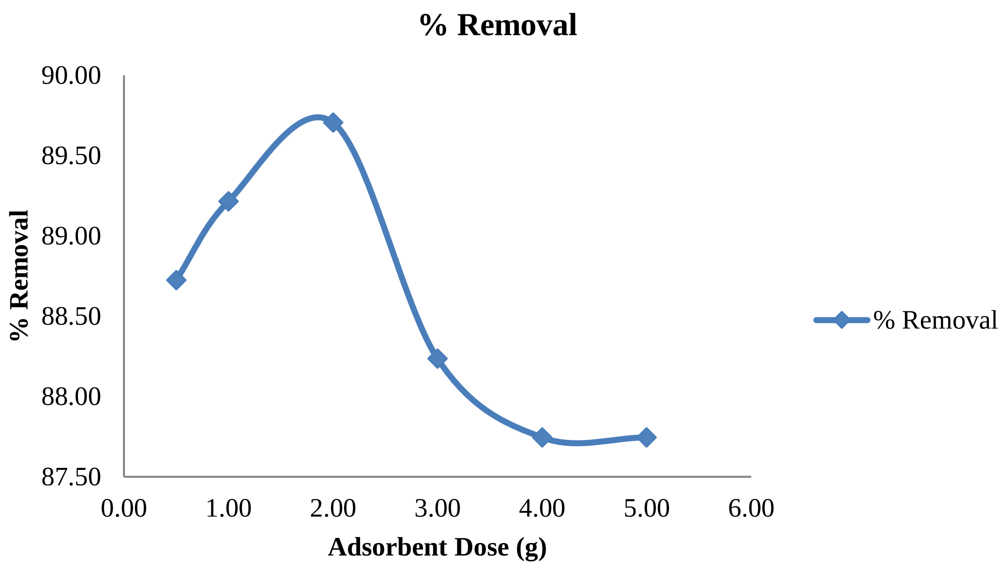

Fig. 5: Biosorption of Ni (II) as a function of adsorbent dose

Effect of contact time: The Effect of contact time on adsorption of Ni (II) on carbon black at different agitation speed is given in Fig. 6. It is clear that the rate of adsorption increases with agitation speed. This is due to the fact that with the increased turbulence, there is a decrease in boundary layer thickness around the adsorbent particles. It can be seen from the figure that at 200 rpm the adsorption capacity of the adsorbent is maximum. Beyond this there is no further increase in the adsorption capacity of the adsorbent. This means that for adsorption process there is optimum speed, which is to be investigated for every adsorbent.

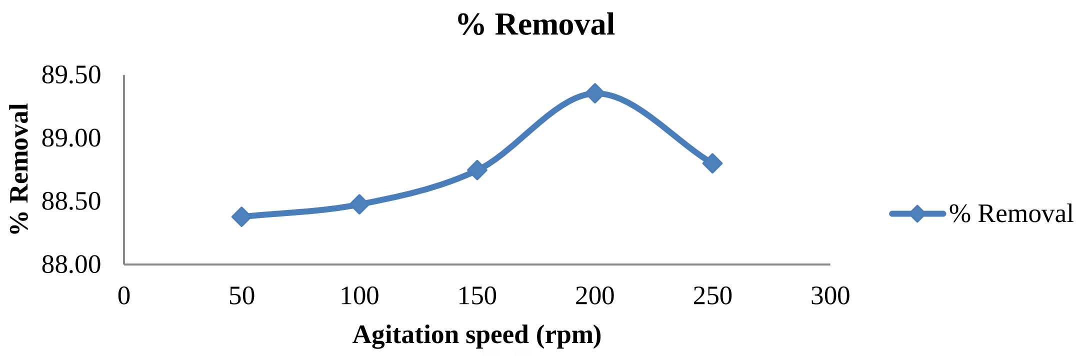

Fig. 6: Effect of contact time on adsorption of Ni (II)

CONCLUSION

The experimental investigation concluded that carbon black obtained from waste tyres pyrolysis plant could be used as potential sorbent, for the removal of Ni (II) from aqueous solution.. The maximum adsorption capacity of Ni (II) was 7.216 mg/g by carbon black. The carbon black can be used as alternative biosorbent for treatment of waste waters containing Ni (II) ions. Present study consolidates that it is possible to curb pollution effects by harnessing the potential of the byproducts produced during industrial processes as useful materials.

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