# ADSORBTION OF HEAVYMETALS BY CHITOSAN COATED ZEROVALENT IRON NANO PARTICLES

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**Abstract -** *Nano particles are widely used in water treatment process due to its larger surface area and it can be effectively used for removing metal ions from ground water. Water contamination is one of the major problems which the world is facing today. Water contamination not only effect environment and human health, but it has also impacts on economic and social costs. In the present study, Chitosan coated zerovalent iron nanoparticles is used for the removal of lead and copper from its solution.*

**Key Words:** Chitosan, Adsorbtion, Zerovalent iron nano particles

## 1.INTRODUCTION

Nanotechnology has been considered as one of the most important advancements in science and technology. Nano particles are one of the most important building blocks in fabrication of nonmaterial's. Their basic properties, extremely small size and high surface-area-to volume ratio, provide better kinetics for the adsorption of metal ions from aqueous solutions.

The nanoparticles (NPs) are ultrafine particles in the size of nanometre order. In many cases, the particles from 1 to 100 nm are generally called nanoparticles. The nanosized magnetic materials show many novel properties, especially, magnetization behavior is different than bulk magnetic material

- Recently, the use of nanosized magnetic material as adsorbents has attracted increasing interest due to their high surface area and unique super paramagnetism1

- Heavy metal contamination to various surface water or groundwater is of great concern because of the toxic effect of heavy metal ions to plants, animals and human beings. Therefore, effective removal of heavy metal ions from water or various industrial effluents is very important and has attracted considerable research and practical interest. Several technologies including chemical precipitation, ion exchange, reverse osmosis and adsorption etc., have been used to remove heavy metal ions from various aqueous solutions. Among these methods, adsorption has increasingly received much attention in recent years because the method is simple, relatively low-cost and effective in removing heavy metal ions from wastewater, especially at medium to low metal ion concentration solution. Adsorption becomes most effective when the surface area of the adsorbents is increased. The application of nanoparticles in this context is therefore highly suitable for the environmental remediation and pollutant removal. In the last decade, zero valent iron (ZVI) has been increasingly used in ground water remediation and hazardous waste treatment. Nano zero valent iron is being used successfully to treat various metallic ions due to its larger specific surface area and more active sites2
- Gupta have demonstrated the applicability of zerovalent iron encapsulated chitosan nano spheres for the removal of total inorganic arsenic3
- These nanoparticles provide a promising single-step treatment option to treat heavy metal contaminated natural water, which requires no pretreatment. Zero Valent Iron (ZVI) nanoparticles have emerged as very successful agent for the removal of heavy metals due to their high reducing capability surface area and magnetism4.
- Chitosan is a cationic natural polysaccharide obtained by deacetylation of chitin, the second most abundant polysaccharide in nature.Chitosan and their nanoparticles have gained more attention as drug delivery carriers because of their better stability, low toxicity, and simple - mild preparation method.5
- Chitosan is commercially available in several types and grades that vary in molecular weight between 10000 and 1000000 and vary in degree of deacetylation and viscosity. Chitosan is used for this purpose in water purification plants throughout the nation.6
- Chitosan is a cationic polyelectrolyte present in nature. Chitosan has shown favorable biocompatible characteristics as well as the ability to increase membrane permeability7

Chitosan (Poly[(1,4)-2-amino-2-deoxy-D-glucopiranose] has a structure as shown in Figure 1

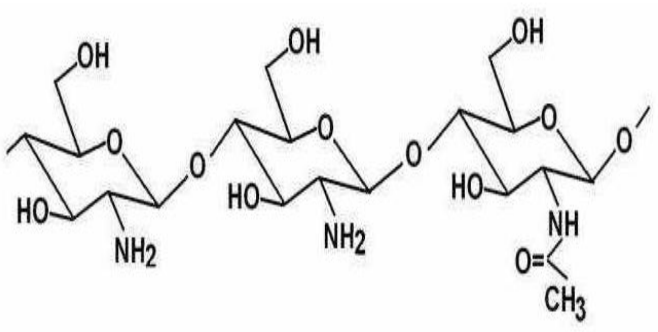

**Figure 1:** Structure of Chitosan

## 2.REVIEW OF RELATED STUDY

In recent years, discharge of wastewaters containing heavy metals ions to the environment has been one of main challenges of industrial and semi-industrial countries. Heavy metals are persistent and unbiodegradable in environment and can be accumulated in aquatic organisms (Turan et al., 2011). Cadmium is used as a raw material in processes such as metallurgy, cadmium - nickel batteries production, oil dyes, mining, stabilizers and alloys. Cadmium, even at low contents, is harmful to human, which can create various problems as follows: cancer, hyperglycemia, immune deficiency and anemia. Thus, this metal is considered as priority pollutants in many countries (Regmi et al., 2012; Pérez-Marín et al., 2007).

Several physical and chemical methods: precipitation, membrane filtration, ion exchange, activated carbon adsorption and precipitation/adsorption has been extensively applied to remove cadmium from industrial effluents (Turan et al., 2011; Regmi et al., 2012; Pérez-Marín et al., 2007), which of these processes have their both advantages and disadvantages. Adsorption is considered as an effective and economical method for wastewater treatment because of its easy operation and high efficiency. Various 2 SHOKOHI et al. adsorbents such as activated carbon, zeolites, mineral clays, lignocelluloses, natural minerals, modified polymers, etc. have been taken into account for removing pollutants from aqueous environments. Nonetheless, these adsorbents have some drawbacks like diffusion limitation, lack of active surface sites, high price and difficult separation from wastewater and by-products generation. Nanoadsorbents such as nano-alumina, modified carbon nanotubes, zero-valent iron nanoparticles (INPs) which have higher efficiency have been recently employed (Turan et al., 2011; Gupta and Nayak, 2012; Boparai et al., 2011).

## 3.MATERIALS AND METHODS

### 3.1.Synthesis of Zero-Valent iron nanoparticles

The synthesis of iron nanoparticles is done by reducing iron sulphate (II) in aqueous medium. The method consists in reducing iron Fe (II) to zero-valent iron using sodium borohydride.

The solution of NaBH4 (0.2M) and FeSO4.7H2O (0.05M) were made in 1:1 volume ratio, then the solution of FeSO4.7H2O (in a 500 ml beaker) was kept on magnetic stirrer at 400 rpm in room temperature. Now NaBH4 solution was added drop wise from burette at the rate of 1 ml/min in stirring beaker containing FeSO4.7H2O solution. The generated iron nanoparticles were filtered by whatman filter paper and stabilized with a large volume of deionized water. At the end it was diluted with ethanol (~5%)

synthesized nanoparticles which were dried in hot oven at 5000C for 24 hrs.

SEM image showed that the Fe nanoparticles do not appear as discrete particles but form larger dendritic flocs. The aggregation is due to the Van der waals forces and magnetic interaction among the particles. Similar findings have also been reported by Rahmani et al.,**[8]**.

### 3.2.Fabrication of Chitosan – Zero valent Iron nano composite strips

Two percentage of Glacial acetic acid solution was added with distilled water. 1 g of Chitosan was accurately weighed and it was added to the acetic acid solution. It was then stirred for four hours. After 4hrs, a transparent solution was appeared.0.05 gram of Iron (o) nano particle was added to the above solution. It was then stirred in a magnetic stirrer for an hour. After an hour, a Chitosan – Fe solution was then formed.

The solution was allowed to cool and then fabricated. A strip was formed. The strip was cut into an equal size of 1 square centimeter. 1000 ppm solutions of Copper and Lead were prepared. From the stock solution 40, 60, 80and100ppm solutions were prepared for Lead and Copper metals.15 ml of the 40ppm, 60ppm, 80ppm and 100ppm of copper solution were taken separately in a beaker. 1sq.cm of Fe- chitosan nano composite strip was immersed in each concentration of lead and copper solution for an hour. The strip was taken after one hour and the solution was sent for Atomic Absorption Spectroscopy for the measurement of absorption of heavy metals by nano particles.

## 4.RESULTS AND DISCUSSION

The adsorption of heavy metals by zero valent Iron chitosan strip for 40ppm concentration was from 45.7% and 61.5% for copper and lead respectively. The adsorption of heavy metals by zero valent Iron chitosan strip for 60ppm concentration was from 48.49% and 63.58% for copper and lead respectively. The adsorption of heavy metals by zero valent Iron chitosan strip for 80ppm concentration was from 59.13% and 69.88% for copper and lead respectively. The adsorption of heavy metals by zero valent Iron chitosan strip for 100ppm concentration was from 61.7% and 70.2% for copper and lead respectively.

From the above result, it is evident that the percentage of adsorption of lead is higher than the percentage removal of Pb(II) is higher than Cu(II). The highest value for Pb(II) than that of Cu(II) may be attributed to the strength of bond formation (stability) along with Jahn-Teller effect that is predominant for Pb(II) complexes.

Wojnárovits also defined the smaller the hydrated ionic radius, the greater will be the ability to penetrate into smaller pores and therefore greater access to active groups of the adsorbent. **[9]**

On the other hand, the greater the ion's hydration, the farther it is from the adsorbing surface and the weaker its adsorption. When the electrostatic forces between the surface of the adsorbent and the ions of adsorbents are attractive, an increase in the ionic force decreases the adsorption capacity. On the other hand, when the electrostatic attraction is repulsive, the increase in the ionic force or strength increases the adsorption capacity.

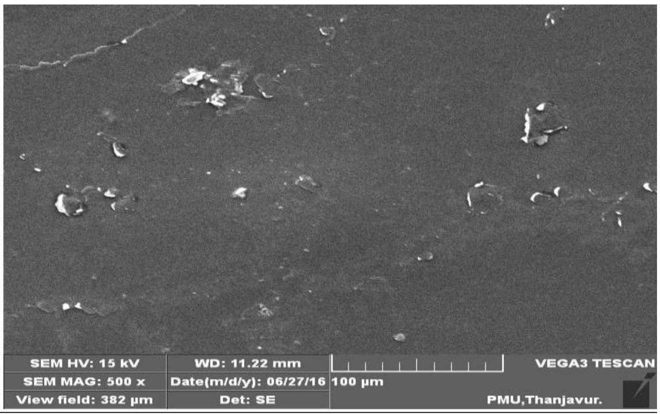


**Figure 2: SEM image of copper adsorbed chitosan coated zerovalent iron Nano particle**

**Table – 1: Initial Concentration: 40 ppm**

| S.No | Name of the Metal | Percentage of Adsorption |
|---|---|---|
| 1 | Cu | 45.7 |
| 2 | Pb | 61.5 |

**Table – 2: Initial Concentration: 60ppm**

| S.No | Name of the Metal | Percentage of Adsorption |
|---|---|---|
| 1 | Cu | 48.49 |
| 2 | Pb | 63.58 |

**Table – 3: Initial Concentration: 80 ppm**

| S.No | Name of the Metal | Percentage of Adsorption |
|---|---|---|
| 1 | Cu | 59.13 |
| 2 | Pb | 69.88 |

**Table – 4: Initial Concentration: 100 ppm**

| S.No | Name of the Metal | Percentage of Adsorption |
|---|---|---|
| 1 | Cu | 61.7 |
| 2 | Pb | 70.2 |

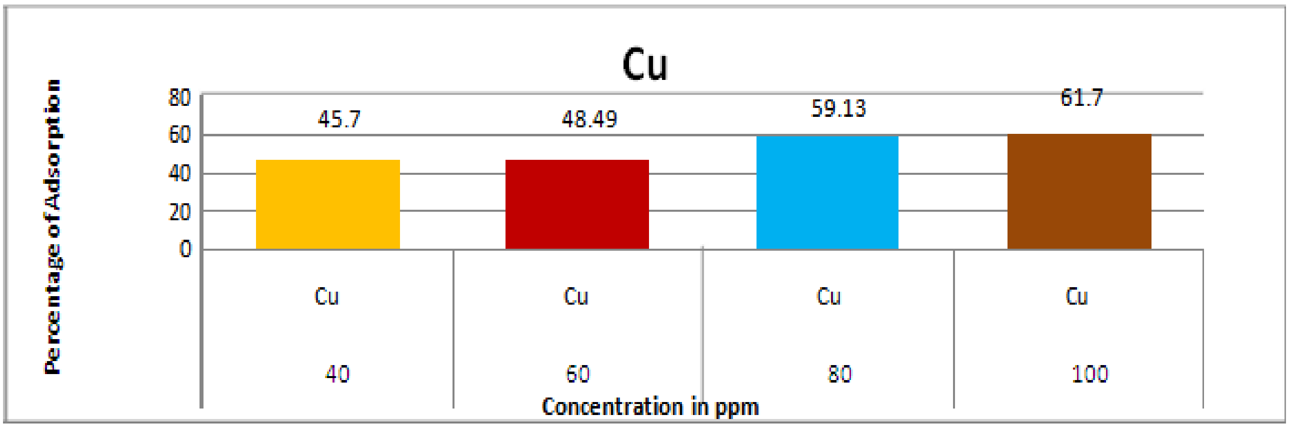


**Figure 3 : Adsorption of Copper by Zerovalent iron –chitosan Nano particles at different concentration**

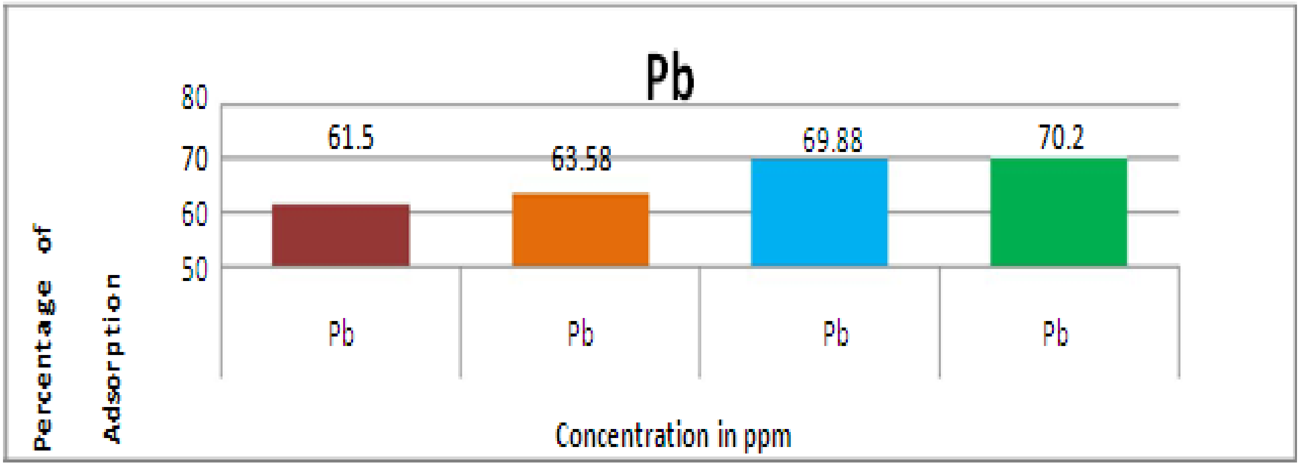


**Figure 4 : Adsorption of Lead by Zerovalent iron –chitosan Nano particles at different concentration**

## 4.CONCLUSION

Nanotechnology based treatment has offered very effective, efficient, durable and eco friendly approaches. These methods are more cost-effective, less time and energy consuming with very less waste generations. In the present study showed that chitosan coated-ZVI nano particles could be used as an effective adsorbent for the removal of heavy metals from ground water.

## REFERENCES

[1] Ambashta and Sillanpaa (2010) Water purification using magnetic assistance, A Review Journal of Hazardous Materials, vol 180(1-3), pp 38-49.
[2] Pang et al., (2011) Preparation and application of stability enhanced magnetic nanoparticles for rapid removal of Cr(VI), Chemical Engineering Journal, vol 175(0), pp 222-227.
[3] Madala Suguna et al., (2014)Separation Science and Technology, vol 49, pp 1613-1622.
[4] Gupta et al., (2013)Environment Science Pollution, Res vol 20, pp 1261-1268.
[5] Agarwal (2015)International Journal of Environment Res, vol 9(3), pp 1055-1068.
[6] Sanaa et al., (2001) Anti-Corrosion Methods and Materials, vol48(1), pp 227-235.
[7] Aspden et al., (1997) J.Pharm.Sci, vol 86, pp 509-513
[8] Rahmani et al., (2011)World Academy of Science Engineering and Technology, vol 74, pp 8083.
[9] Wojnárovits et al., (2010) Radiation-induced grafting of cellulose for adsorption of hazardous water pollutants: A review. Radiat Phys Chem. vol79, pp 848–862.
[10] Turan N.G., Mesci B. and Ozgonenel O. (2011), The use of artificial neural networks (ANN) for modeling of adsorption of Cu (II) from industrial leachate by pumice, Chem. Eng. J., 171(3), 1091-1097
[11] Boparai H.K., Joseph M. and O'Carroll D.M. (2011), Kinetics and thermodynamics of cadmium ion removal by adsorption onto nano zerovalent iron particles, J. Hazard. Mater., 186(1), 458-465.