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REDUCTION OF ZINC FROM CEREMIC WASTEWATER BY USING ZERO VALENT IRON

Anant Prakash[1], A K Gautam[2]

[1]M.Tech, Department of civil engineering, Maharishi University of Information Technology, Lucknow, U.P.
[2]Assistant Professor, Department of civil engineering, Maharishi University of Information Technology, Lucknow, U.P.

Abstract-The increase in the pollutants of water due to lots of toxic substance and are becoming the reason for various problems to flora and fauna as well as on human being. This cause the urgent requirement of the Morden technique for the removal as well as treatment method of toxic from water to waste water. From all the treatment process or treatment methods water treatment by adsorption is most suitable and most effective process of treatment for pollutants such as heavy metal. The rise in the count of research article on adsorption made by using zero valent iron and this present the fact that there is an urgent requirement of an economical adsorbent for the treatment of wastewater. The result from the latest research on adsorbent shows that the ZVI bears an adaptive nature in the waste water which cause the treatment very efficient and quick. The present research work shows that the adsorptive removal of zinc from ceramic waste water. The reason behind conducting the study is to find out the compatibility and effectiveness of the adsorbent for the treatment of pollutant which is present in water.

Key Words: Zero Valent Iron, Water Treatment, Heavy Metals, pH, Alkalinity etc.

1.INTRODUCTION

Various heavy metals like manganese, iron, cobalt, vanadium, copper, zinc, molybdenum and strontium are required in essential requirements for both living organisms and growth of plants. Excess levels of such metals may lead to toxicity. Heavy metals like Cadmium, mercury, lead, and arsenic are highly dangerous as they are highly soluble and carcinogenic. Like other components in wastewater, heavy metals are not biodegradable. Making use of physical or chemical removal techniques by converting these toxic metals into non-toxic is the only solution possible. By this way, heavy metals can be avoided from entering the food chain. Industries that manufacture ink and pigments, electroplate metals, tan leather, producing fertilizer and pesticides generate huge amount of heavy metals that are thrown out into the environment without treatment. Water may also be polluted with heavy metals if a river crosses the land contaminated with heavy metals or acid rain occurs in such contaminated areas.

For removing heavy metals from inorganic effluents methods such as chemical precipitation is performed (Benefield et al., 1999). Such methods require a huge amount of chemicals that reduce the metal content in wastewater to an acceptable limit so that it can be discharged back into water bodies (Juttner et, al., 2000). But the major drawback of using chemical precipitation is that, they generate a large amount of sludge. Excess sludge increases the cost for its treatment as well as disposal (Kurniawan et al., 2006).

The use of zero valent iron (ZVI) for treating of vast range of contaminations including nitrate, dyes, heavy metals, phenol, arsenic has been increasingly employed over the last decade due to its properties like high area of surface, potent catalytic property, and high reactivity (Jagadevan et al., 2012, Tosco et al., 2014, Crane and Scott, 2012). This project aims to characterize wastewater generated from the ceramic industry, synthesize ZVI for heavy metals adsorption and also to conduct adsorption and kinetic studies for removal of heavy metals from ceramic industry wastewater.

2. MATERIALS AND METHODS

2.1 Materials

All chemicals used in this study were of analytical grade and are acquired from Merck India and Sisco Research Laboratories Pvt. Ltd. (SRL), India. Following chemicals were used for this study:

- Zero Valent Iron
- Sodium Borohydride

2.2 Method

Grab method of sampling for collection of samples is to be used following safety measures while collection. Then Physico-chemical characterization was done for collected samples Measurement of different parameters like pH, turbidity, conductivity, temperature, TDS, hardness, alkalinity, COD, nitrate and chloride is done for wastewater. Measurements of different parameters in the laboratory were conducted with the help of APHA guidelines. Then experimental setup was done. Experiments were conducted to investigate the effects of initial pH, the concentration of Zn, a dose of ZVI and time for the removal of Zn. Batch experiments were carried out using 100mL of synthetic wastewater in conical flasks and the pH adjustments were done using 1M NaOH and 1M HCl. It was the followed by analytical method in which investigation of pH, COD, Electrical Conductivity, Turbidity, Hardness, Temperature, Total Dissolve Solids, Alkalinity, Chloride, Nitrate and Zinc Concentration. Furthermore Synthesis of Nanoparticle was done. Synthesis of Zero valent iron (ZVI) was done with conventional reduction method of sodium borohydride. Further on batch study of the prepared adsorbent was conducted where Freundlich isotherm and Langmuir isotherm equation was used.

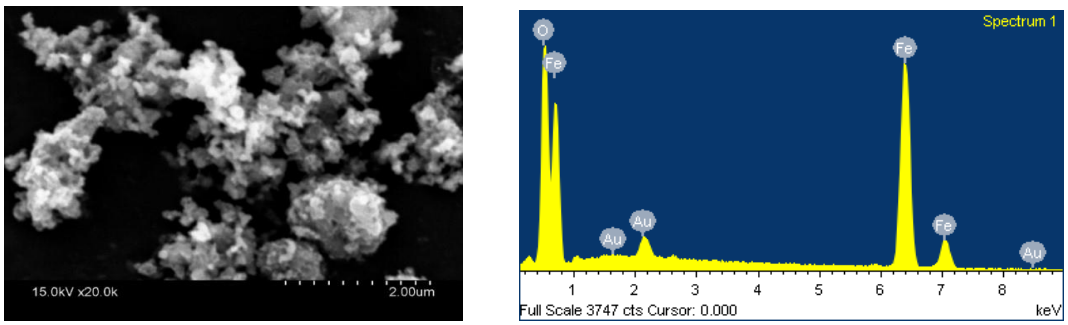
3. RESULTS

3.1 Result of Physico-chemical Parameter

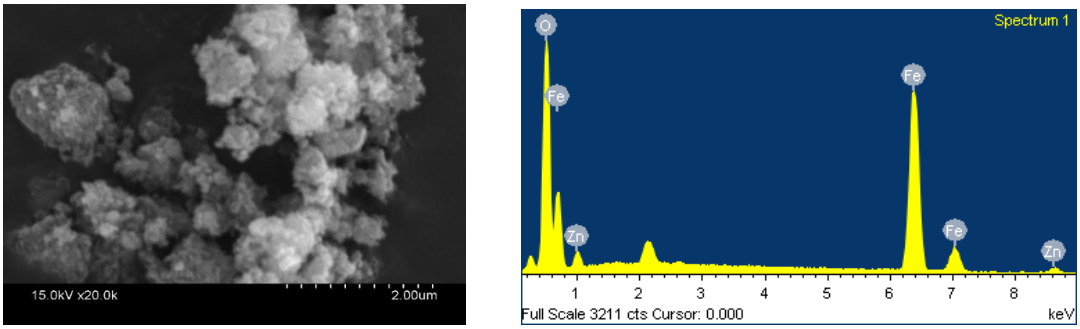
The physio-chemical characterization of different water samples were done following APHA guidelines. For ceramic industry wastewater the pH is 6.63-6.65 which is in permissible range for industrial water discharge into surface water. The total solids concentration is high as 8180 mg/L. the chemical oxygen demand COD is also high 1920 mg/L. p-alkalinity in range 48-56 mg/L as $CaCO_3$ and T- alkalinity in range as 364-416 mg/L as CaCO3. The nitrate content of wastewater in the range of 11.5289- 12.1032 mg/L and chloride content as 439.86-479.85 mg/L was found.

3.2 Characterization of zero valent iron (ZVI)

In order to analyse the change in the shape of ZVI particle earlier to the removal of zinc and after zinc adsorption Scanning electron microscope was employed. The ZVI particle morphology before and after adsorption is shown in Figure below.
It can be seen that morphology of surface changed from smooth and spherical to rough, bulgy and branched one after adsorption of zinc on ZVI. The X-ray Energy Dispersive Spectrometer (EDS) spectra of ZVI and ZVI used for removal of zinc shows changes in the peaks as shown in Figure 3 (right) and Figure 4 (right) respectively.



SEM image (above) and XRD spectra (Below) of ZVI

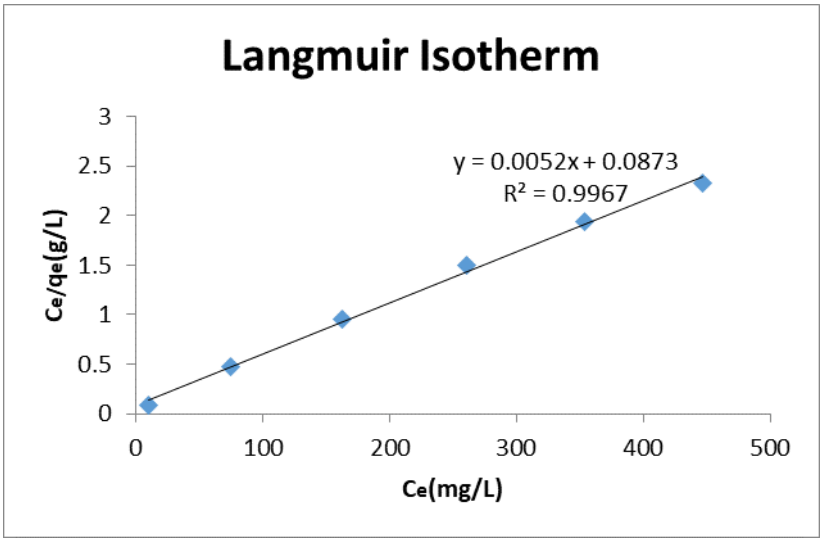


SEM image (above) and XRD spectra (below) of ZVI used for zinc removal

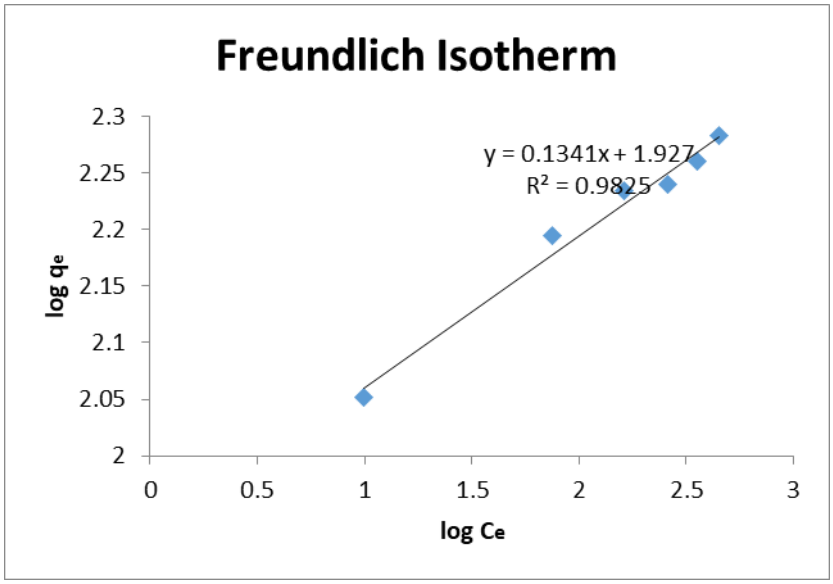
3.3 Optimization of ZVI

- For optimization, percentage zinc removal was fixed at "maximize" with the highest importance. ZVI Dose for optimization was fixed to "minimize", the target value for pH was fixed to"6.65" as the pH of ceramic wastewater was found to be 6.65.
- The optimized value for initial concentration of zinc, ZVI dose, Time, pH was found to be 109.9mg/L, 0.08 g/L, 218.15 min and 6.65 respectively.
- At these conditions, the % Zn removal was 92.9559 % with the desirability of 0.908. At optimized condition, the experiment conducted has 89.97% removal of zinc, which is near to the values predicted.

3.4 Isothermal Studies



Study of Langmuir Isotherm for Zinc at pH=6.65, ZVI Dose 0.08 mg/L and Time 220 minutes



Study of Freundlich Isotherm for Zn at pH=6.65, ZVI Dose 0.08 and Time 220 minutes

4. CONCLUSIONS

- With the use of central composite design, a four variable 5 level RSM software the effects of the initial concentration of zinc, pH, a dose of ZVI and time of contact was studied. The optimum results obtained were pH = 6.5, a dose of ZVI = 0.08 g/L, with the initial concentration of 108 mg/L and time of contact 218 min were obtained.

- At optimized condition equilibrium isotherm studies were done in which Langmuir isotherm was most suited for adsorption of zinc on ZVI, from this it could be indicated that adsorption of zinc as a monolayer has occurred on the surface of ZVI. The maximum adsorption capacity was estimated to be 192.31 mg/g at the optimized condition.

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