REMOVAL OF IRON FROM WATER BY USING LOW COST ADSORBENTS: A REVIEW

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ABSTRACT

Iron is a worldwide observed public health problem. One of the major sources of iron is drinking water. Excess concentration of iron creates major issues related to the public concerned. The acceptable limit of iron is 0.3 mg/L according to the guidelines WHO guidelines. In developing countries like India removal cost of metal ions like iron is the major factor of consideration. Adsorption is one of the cost effective method adopted globally because of its ease to use and preparation. This review focused on the different used adsorbents for the removal of iron by using method of adsorption. Utility of different material of various plants, agro- wastes, other bio-masses as bio-adsorbents are over viewed with its different parameter.

Keyword: **-** *Iron, Adsorption, Bio- Adsorbent, Drinking Water*

1. INTRODUCTION:

Iron is the fourth element of the earth's crust, the second most abundant metal in the earth is mainly present in groundwater but also in the surface waters. Iron is common metallic elements that occurs together naturally especially in deeper wells with little or no oxygen present. Iron is one of the major impurities that is commonly found in many sources of water. Iron deposited in the distribution system may promote the growth of microorganisms leading to high contamination in drinking water. Natural sources of iron may include weathering of iron bearing minerals like amphibole, iron sulfide and iron rich clay minerals. The main naturally occurring iron minerals are magnetite, hematite, goethite and siderite. Weathering processes release the element into waters. Both mineral water and drinking water contain iron carbonate. In areas where groundwater flows through an organic rich

soil, iron will also dissolve in the groundwater. Iron can also have anthropogenic sources including industrial effluents, landfill leakages and acid mine drainage. Well casing, pump parts, piping and storage tank can also contribute iron to groundwater.

The World Health Organization recommended minimum iron level of 0.3 mg/l in water. Water having iron level above 0.3 mg/l require treatment. Iron give water an unpleasant taste, odor and color. Iron causes reddish-brown stains on laundry, porcelain, dishes, utensils, glassware, sinks, fixtures and concrete. The presence of this element in excess causes degradation of the water quality, the corrosion and clogging of piping and reservoirs of waters. In addition, the precipitation of iron promotes the growth of bacteria. Iron removal from groundwater is therefore, a major concern for most scientific researchers. Determination of iron is very important in explorations of new water supplies, particularly from bore well and other surface water sources. The drinking water can be rejected only on the basis of excess iron present in it. Iron can be toxic to freshwater aquatic life above 1 mg/L and may interfere with fish uptake of oxygen through their gills above 0.3 mg/L.Therefore, pre-concentration or removal of iron from aqueous solutions is a matter of great concern in analytical and environmental works. Many of the researchers work on the removal of iron from water.

2. REVIEW OF LITERATURE

2.1 WOODEN CHARCOAL AND SAND

Ahmad Hasan Nury et. al (2013) used processed wooden charcoal (PWC) and processed sand (PS) as filter media and evaluates adsorptive capacity of them for dissolved iron removal through continuous mode column studies. The experiments were carried out using synthetic water containing Fe (II) at a fixed pH of 5.5 and zero dissolved oxygen levels. Different bed depth used to obtain the adsorption breakthrough curves. An increase of breakthrough time and adsorption bed capacity were found with the increase in bed depths, while breakthrough time and uptake of Fe (II) ions onto the adsorbent decreases when the linear flow rate through the bed increases. At different bed depths, PWC shows higher adsorption capacity for Fe (II) as compared to PS. Breakthrough profiles of up-scaled columns and indigenous unit models indicate that for same bed heights and flow rate, the up-scaled columns perform better than indigenous unit models and yield higher breakthrough throughputs. In the meanwhile, the up-scaled columns also performed reasonably well to remove fluoride, turbidity, sulfate and alkalinity at breakthrough point of Fe (II).

2.2 UP-FLOW ROUGHING BIOFILTER

G.K. Khadse et. al (2013) used Hand pump attachable iron (Fe) removal plants (IRPs) based on up-flow roughing biofilter principle were installed for potable water supply from the tube well water in rural areas containing excess iron. The performances of the IRPs were evaluated for the removal of Fe and Mn (manganese). Desirable modifications were made in IRPs in order to improve the Fe removal capacity and dissolved oxygen content in the treated water in order to make the water suitable for drinking. After desirable modifications in IRPs, it was observed that the iron content reduced up to permissible limit (1 mg/L or less as per BIS: 10500, 1991 standard) in treated water from 3-6.8 mg/L of Fe in raw water. Hand pump attachable IRPs based on up-flow roughing biofilter along with controlled aeration and proper O&M can be used for Fe removal. This may be helpful in appropriate and sustainable water quality improvement in iron-affected areas.

2.3 CHELATING RESIN PUROLITE S930

Petru Bulai et. al worked on the sorption characteristics of Iron (II) on iminodiacetic resin Purolite S930 in various operating conditions such as initial pH, copper concentration, contact time, temperature, ionic form of the resin and resin dose. The percent of Iron (II) removal has a maximum at pH 5.0, and increases with the increasing of resin dose, of the contact time and decreases with increasing initial concentration of solution. In the experiments was used the S930 chelating resin obtained from Purolite International Limited (Hounslow, UK) Sorption of iron (II) ions on Purolite S930 in hydrogen (S930-H) form was carried out in batch experiments using 50.0 mL of iron (II) solutions with different initial concentrations (10–300 mg/L) that where added to Erlenmeyer flask already containing 0.05 g of dry resin.

2.4 NATURAL MATERIAL

Danka barlokova et. al (2009) found more efficient and cost-effective materials and technologies used in water treatment. The goal of this study is to compare activated natural zeolite-clinoptilolite with activated filtration sand and the imported material Birm (from the Clack Corporation, USA) in removal of iron and manganese from water.

Obtained results carried out in the water treatment plant in Holíč prove that Klinopur-Mn is suitable for removal of iron and manganese from water and is comparable with other imported materials. Natural or synthetic zeolite can be used as a filtration material for removal of iron and manganese from water. Birm, Greensand, Pyrolox, and MTM are the most frequently used materials in filtration. quently used materials in filtration. Birm is a granulated filter medium (imported from the USA) used for iron and manganese removal from water. It is a specially developed material containing MnO2 film on the surface (catalyst). It is recommended to use Birm for lower iron concentrations (to Fe2+ concentration of 6.0 mg·l-1 and Mn2+ about 3.0 mg·l-1) and for household water treatment. It can also be used in gravity or pressure filters.

2.5 DISSOLVED AIR FLOTATION (DAF)

R. B. Moruzzi1 et. al (2004) have studied comparing iron organic complexes, color, turbidity and manganese removal efficiencies of two techniques: oxidation/coagulation/sedimentation and oxidation/coagulation/dissolved air flotation (DAF). The focus was the suitable adjustment of the coagulation processes rather than the oxidation process. In this way, lower dosages of oxidant and coagulant could be added increasing the removal efficiency and saving chemicals. The results showed that DAF is an attractive alternative to promote the removal of organic iron compounds (97% of removal efficiency, residual of 0.17mg/L), color (98% of removal efficiency, residual <2CU) and turbidity (95% of removal efficiency, residual of 0.70NTU) by using low dosages of chemicals (15mg/L of ferric chloride) in a lower pH value (6.3) than the commonly recommended one (>7.5).

2.6 MSC ADSORBENT

Dipankar Thakuria1 et. al (2016) worked on Removal of iron and fluoride from groundwater using the process of adsorption. The experiments were performed on various parameters like dosage of adsorbent, pH, temperature and contact time to check their influence on adsorption. Adsorbent dosage of 4.7 g/50 ml at pH 5, temperature of 20ºC and contact time of 420 minutes were considered as optimum. The adsorbents were prepared and cleaned before using as adsorbent. They were kept in contact with 0.1 N HCl at 20ºC at 120 rpm for 24 hours in an orbital shaking machine. After 24 hours they were filtered and dried in an oven at 105ºC again for 24 hours.

2.7 CONSTRUCTED SOIL FILTER (CSF) SYSTEM

Pravin D. Nemade et .al (2016) conducted a study on removal of iron from water by using a constructed soil filter. The experiment was conducted in a bioreactor which is fabricated by aluminium mounted on metal grid filled with formulated media and under drain. The total height of bioreactor is 30cm with a diameter of 28.5 cm. The weight of the media is 26.5 kg. A sand filter containing gravel (size: 8-12mm), thin gravel (size:5–8 mm), sand (size: 1–2mm) without media was used as control for the experiments. Six run on control (SF) and experimental (CSF) unit were conducted with continuous flow rate60 ml min−1. Effluents in continuous tank were analyzed for iron,. Results indicated that iron level from 5 to less than 0.3mgl. The results revealed very high removal efficiency, i.e., over 99% and water quality as per WHO standard.

2.8 MODELING IN SITU IRON REMOVAL

Appelo et.al (2000) investigated that In situ iron removal is a useful technique for reducing the ironconcentration in groundwater pumped for consumption or industrialpurposes.The technique entails the periodicinjection of a volume of aerated or oxygenated water in an aquifer, followed by pumping of the injected water and subsequently of groundwater in whichthe iron concentration is lower than in native groundwater. Iron in theaquifer is oxidized during injection of the oxygenated water and precipitates as iron-oxyhydroxide. The loss of iron also liberates cation exchangerswhich are filled again when pumping is resumed and groundwater withdissolved iron contacts the cation exchange sites in the aquifer .During pumping, ferrous iron is sorbed from groundwater on the exchange and sorption sites, and the breakthrough of dissolved iron is retarded. Other trace elements such as arsenic may beeliminated jointly with iron by sorption or co-precipitation.

2.9 BIOLOGICAL FILTERATION

Pierre Mouch et.al (1992) suggested that the principle of biological iron and manganese can be easily explain with reference to the stability diagram(Eh-pH) to oxidise iron and manganese prior to filteration when they are present in the reduces soluble stage (Fe2+ & Mn2+) in ground water deprived of dissolved oxygen,the conventional treatment

by physical-chemical process,for reason related to the reaction kinetics ,demands condition of intensive oxidation .These gives the water an Eh value much higher than that which diffentiates the respective stability field of the reduced and oxidized form.In practise these physical-chemical treatment required intensive aeration at pH >7.2 to remove iron along with the use of potential oxidant (O3,KMNO4,Clo2) to remove mangenese.Biological iron and mangenese treatments offer the advantages of simplicity and economy.

2.10 DUCK EGGSHELL

Iriany et.al (2013) focused on the study of the ability of adsorption, Equilibrium time, adsorption kinetics, adsorption isotherm and capacity adsorption of heavy metal such as Fe (III) using duck eggshell adsorbent. Materials that used in this research are duck eggshell adsorbent, heavy metal Fe(III), chloric acid and aquabidest. Observed variables are the equilibrium time and residual concentration of Fe (III).Adsorbent was mixed with heavy metal Fe(III) solution. The sample was being taken every 10 minutes. The concentration was analyzed with AAS (Atomic Absorption Spectrophotometer) in order to get the equilibrium concentration of heavy metal Fe (III) solution. The increasing amount of adsorbent will increase percentage adsorption and equilibrium time will be longer. Bangham model can be used to describe the kinetics of Fe (III) sorption. The Langmuir adsorption models were applied to experimental equilibrium data and the isotherm constants were calculated using linear regression analysis.

2.11 DIFERRIC RABBIT SERUM TRANSFERRIN BY RABBIT RETICULOCYTES

John Williams et.al (1982) suggested that When radio iron-labelled transferrin with "5Fe located predominantly in the N-terminaliron-binding site and 59Fe predominantly in the C-terminal iron-binding site was incubated with rabbit reticulocytes, both radioisotopes of iron were removed at similar rates. Electrophoresis of transferrin samples taken during the course of an incubation, in polyacrylamide gels containing 6M-urea, showed that iron was removed in a pair wise fashion, giving rise to iron-free transferrin.

2.12 RAPID SAND FILTER

Albrechtsen et.al (2012) studied that manganese and iron can either be removed physico-chemically or biologically or combined. The physico-chemical oxidation and precipitation of manganese can theoretically be achieved by aeration, but this process is slow unless pH is raised far above neutral, making the removal of manganese by simple aeration and precipitation under normal drinking water treatment conditions insignificant. Manganese may also adsorb to the existing filter material, which may result in an autocatalytic oxidation of manganese. Iron is usually easier to remove. First, iron is rapidly chemically oxidized by oxygen at neutral pH followed by precipitation and filtration. For many years, research has focused on the biological removal of manganese and iron, due to the associated energy and chemical savings .Furthermore, biological oxidation of manganese and iron results in denser precipitates than those obtained by chemical oxidation, reducing the number of required backwashes due to clogging of the filters. A batch assay was developed to quantify the microbial manganese and iron removal. The assay allows testing the effect of various parameters as well as distinguishing between biological and non-biological removal processes.The interaction between nitrification, manganese and iron removal was investigated and showed that ammonium had a positive effect on manganese removal whereas iron had a negative effect on manganese removal and even caused an increase of manganese.

2.13 NAOCL OXIDATION AND MF FILTRATION

Chi-ChuanKan et.al (2012) investigated that the removal conditions of iron and manganese ions from groundwater by aeration, chlorine oxidation and microfiltration (MF). The removal effects of iron and manganese under the conditions of oxidant doses, pH and reaction times were investigated in the Jar-test. Moreover, pilot-scale experiments were executed in Chang-Hua water treatment plant. The raw water containing iron and manganese ions were firstly oxidized by NaOCl and followed by MF filtration. The oxidized metal ions particles in membrane permeate were investigated by particle counter. For the Jar-test, the result indicates that pH higher than 7 and NaOCl dosage more than 3 mg -1 2+ L are necessary to reach more than 90% Mn removal efficiency. For the pilot test, the Mnconcen- -1 tration of permeate was gradually decreased from 0.1 to 0.01 mg L after 2 wk operation. The accu- mulated sludge that is Fe-Mn oxide on membrane contributes an important role for Mn removal. Thus, this study confirmed that MF process can be applied properly for improving water quality to comply more stringent water quality standards. The Fe concentration in raw water generally ranged from 0.3 to 1.5 mg L. In this study, the

groundwater with Fe and Mn concentration at 0.65 and 0.5 mg L was tested. The Fe and Mn removal by aeration and NaOCl oxidation from pH 6 to 9.

2.14 NATURAL SILICA SAND

Marina Valentukevičienė et.al (2008) focused on of the removal of iron and ammonium ions from groundwater by natural silica sand was carried out. Coarse sand particles were used (0.7–2.0 mm): the silica sand filter medium being 750 mm height. Silica sand material was washed and dried at 105 °c in an oven before using it in the filter bed; 500 l of groundwater artificially polluted with ironsulphate and ammonium chloride solutions passed through the filter charged with silica sand. The best removal of iron compounds from the water solution was obtained by using a filter medium 1 m high with the finest silica sand. Iron removal efficiency was 95% using coarse silica sand. The highest ammonium removal efficiency (94%) was achieved using 0.7–2.0 mm silica sand.

2.15 OXIDIZING BACTERIA

Ioannis A. Katsoyiannis et.al (2006) suggested that the method relies on the use of indigenous non-pathogenic iron- and manganese-oxidizing bacteria. Dissolved iron and manganese species often coexist with arsenic in groundwater. Therefore, the application of this method could provide consumers with water of high quality, which is practically free of iron, manganese and arsenic, complying with the respective legislative limits. In this paper the biological oxidation of iron and manganese has been reviewed and recent findings regarding the removal of arsenic have been summarized. Arsenic (III or V) can be removed efficiently from a wide range of initial concentrations with practically limited operational cost, apart from the capital costs for the installation of treatment units. As a result, the use of chemical reagents for the oxidation of trivalent arsenic can be avoided, because As (III) was efficiently oxidized to As (V) by these bacteria (acting as catalysts) under similar conditions, which are usually applied for the removal of iron and manganese by biological means.

2.16 ADSORPTION AND FILTRATION

Dipankar Thakuria et.al (2016) focused on the problems related to groundwater contamination by Iron and Fluoride which are common and serious all over the world, especially in developing countries. Excess amounts of these contaminants have created health problems. For this reason, the maximum permissible limit for iron given by WHO and BIS is 1 mg/l, however 0.3 mg/l is the desirable limit. For fluoride, the maximum permissible limit is 1.5 mg/l but as per WHO the desirable limit is 0.8-1.2 mg/l.. Adsorption is a technique which can be effectively used for removal of these ions from groundwater. In the present paper an attempt has been made to study the iron and fluoride contamination, their effects to health and environment and removal their removal from groundwater using the process of adsorption and adsorptive filtration.
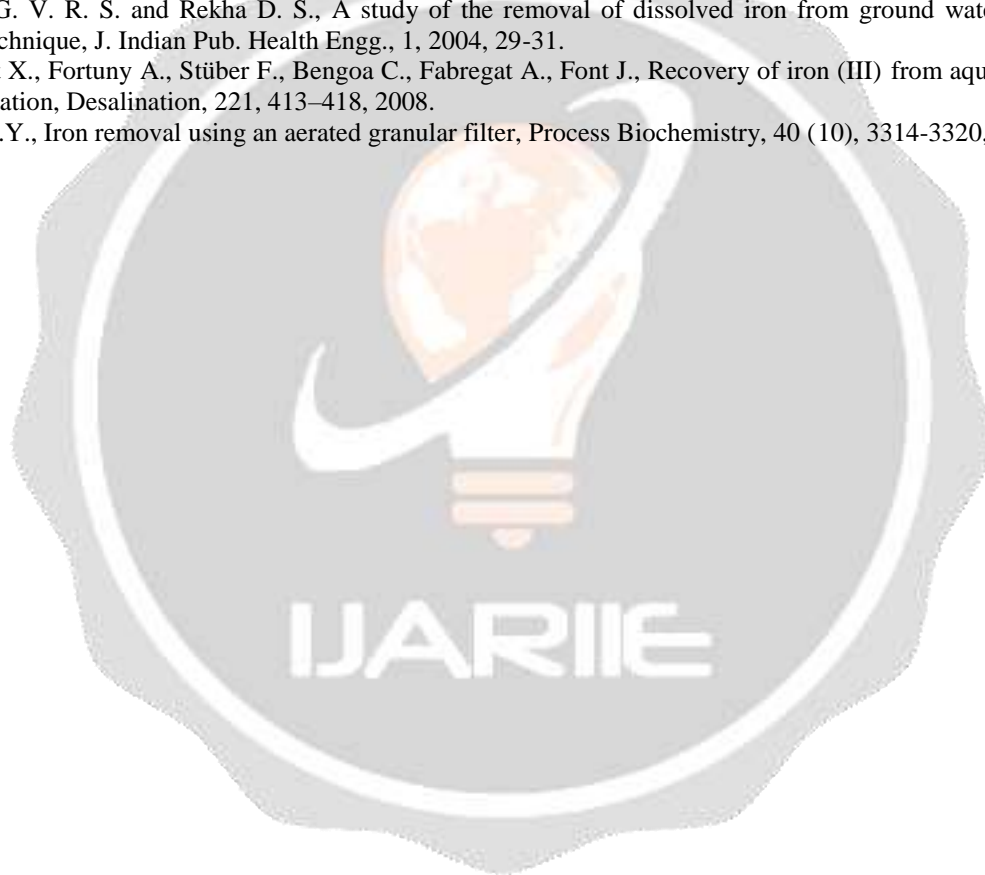
3. CONCLUSIONS

This review provides information about the various adsorbents used in the process of removal of iron from water. The removal efficiency of adsorbents is depends on different parameters in batch and column analysis study. The uptake capacity increases with increasing the dose of the adsorbent and decreasing with the size of the adsorbent.
A review of studied adsorbents in various forms presented here shows a great potential for the iron removal. This review also concludes that the use of commercially available adsorbents can be replaced by the inexpensive and effective bio-adsorbents.

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