

Waste Water Treatment Using Eco Friendly Oxidising Agent Fe (VI)

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Abstract

Ferrate (Fe (VI)) is a potential water treatment chemical due to its dual functions as an oxidant and a subsequent coagulant/precipitant as ferric hydroxide. Hence, an application of Fe (VI) to wastewater could achieve both oxidative elimination of various micro pollutants and reduction in the COD, BOD, Total hardness, Chloride, Fluoride can be achieved.

The aim of this study was to assess the potential of Fe (VI) to oxidize selected micro pollutants and remove phosphate during enhanced treatment of municipal waste water in a single treatment step. The waste water from pond in K.R Puram, Bangalore is treated with powerful eco-friendly oxidizing agent Fe(VI) (0.005mg/L), the parameters such as, COD, BOD, TSS, Total hardness, chloride, phosphate, ammonia, cyanide etc. are measured before and after treatment. The reduction in the COD, BOD, Total hardness, Phosphate, Ammonia, Cyanides are observed.

Keywords: Waste water; Fe (VI); Pollutants

Introduction

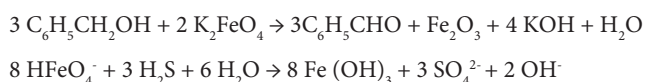
Water pollution is a serious issue which affects the physical and economic health of world community. According to W.H.O million of people suffer illness and death each year due to drinking water contamination. Filtration and disinfection methods are followed in water treatment. But filtration is poor barrier for few pollutants. Disinfection by chemicals gives by-products some of which may be toxic to human and aquatic health.

In recent years Ferrate (VI) has attained importance as environmentally friendly oxidizing agent and coagulating agent [1] in wastewater treatment. The product Fe (III) is non toxic compound. Fe (VI) oxidizes toxic chemicals [2], nitrites, glycerol, oxalates, alcohol, sulphides [3] ether, ammonia [4], urea, many other water soluble and water insoluble organic compounds, drugs [5] microbes etc., in the pH range of 6-9. It simultaneously acts as oxidant disinfectant & coagulant in water treatment.

Fe (VI) is powerful reducing agent it reduces in acids and alkalis.



When waste water is treated with Fe (VI) concentrations higher than 5 mg/L, it eliminates the organic compounds by more than 60%. It removes phosphates [6] from 2.5 to 0.80mg when the dose of Fe (VI) is more than 7 mg/L. It oxidises H₂S to thiosulphate and sulphate at pH 9-11. H₂S is formed by the incomplete oxidation of organic compounds which gives bad odour to water and has toxic nature. The oxidation of organic pollutants by Fe (VI) incorporated by nature and manmade activities reduces the COD and BOD of water samples.



The level of BOD and COD is an important factor in evaluating the organic pollutants in waste water. The discharge of impurities generate BOD & COD level to 5000-3000 mg/L and COD level to 1000-5000mg/L but discharge permits only 250mg/L & 500mg/L respectively.

The aim of our study is to check the water quality in pond and to treat it with Fe (VI) to remove the pollutants.

Experimental

Preparation of Fe (VI)

All chemicals used were of analytical grade (EMerck) and were used without further purifications. To the 250 ml sodium hypochlorite solution slowly added 25g of ferric nitrate at 25-30 degrees. The temperature is maintained at 30 degrees while saturating with NaOH. The mixture is then filtered with suction through a coarse fritted glass filter. The sodium ferrate filtrate is placed in a 250ml beaker and immersed in a 20 degree water bath 100ml of saturated KOH solution is added with stirring. Stirring is continued for 5 minutes, finally filtering through a fritted glass filter of medium porosity, the filtrate being discarded [7].

The precipitate is leached on the filter with 4-5 10ml portions of 3 molar KOH solutions. The residue remaining on the filter has a light grey cast and is discarded. The filtrate is transferred to a 250ml beaker and 50ml of chilled, saturated KOH solution is added. Any solid potassium ferrate still on the filter disk is washed out with a few ml of saturated KOH solution. The final solution is approximately 11 molar in KOH. The solution is stirred for 5 minutes and then filtered through medium porosity fritted glass.

Waste water treatment with Fe (VI)

Water sample is collected in polythene bottles from the pond in K.R Puram, Bangalore, INDIA. Water is passed through a series of process of primary treatment to remove suspended & colloidal impurities. Then it is treated with Fe (VI) over a period of 25-30 days. The water parameters are recorded regularly.

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Primary treatment: The treatment process consists of many steps (i) Physical process which include sedimentation and filtration (ii) Chemical process includes precipitation chemical coagulation followed by settling and mixed media filtration.

Microstraining: It is a special type of filtration procedure which makes use of filters oven from stainless steel wires with opening only 60-70 μm across to remove very small particles. High flow rates and low back pressures are normally achieved.

Coagulation and flocculation: The object of coagulation is to alter these particles in such a way as to allow them to adhere to each other. Most colloids of interest in water treatment remain suspended in solution because they have a net negative surface charge that causes the particles to repel each other. The intended action of the coagulant is to neutralise that charge, allowing the particles to come together to form larger particles that can be more easily removed from the raw water. The usual coagulant is alum $[\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}]$ Alum when added to water, the aluminium in this salt hydrolyses by reactions that consume. The gelatinous hydroxide thus formed carries suspended material with it as it settles down.

Then the water is analysed to determine the parameters such as COD, BOD, Sulphide, phosphate, Chloride, Cyanide, Ammonia, Hardness, Pesticides etc and Listed in Table 1.

Then the Waste water is collected in different containers and treated with Fe (VI) with Concentration from 0.001 to 0.1 at pH-9.

Determination of BOD

BOD of water sample is measure of quantity of oxygen required by micro organisms to oxidize organic wastes present in waste water over a period of five days at 20°C.

The BOD of waste water is treated with Fe (VI) before the treatment. Then waste water is treated with Fe (VI) {0.005 mg/L} at pH 9. The BOD of treated water is determined [8] at intervals of 5 days. The results are listed in Table 3.

The dissolved oxygen forms the basis for the biological oxygen demand (BOD) which is a parameter to evaluate organic wastes in a water samples.

300ml of water sample is pipette into a clean conical flask into a clean glass stoppered bottle, 3ml of manganous sulphate solution is

SL.NO	Parameters	Before Treatment mg/L
1	Colour	Blackish
2	Odour	Pungent
3	COD	151.3
4	BOD	20.0
5	Suspended Solids	158.1
6	Phosphate	3.5
7	Sulphide	100.2
8	Chloride	350.8
9	Cyanide	0.07
10	Ammonia	29.5
11	Total Hardness	700.7
12	Arsenic	0.06
13	Pesticides	0.042

Table 1: Analysis of sample water before treatment.

Parameters (mg/L)	Day 1	Day 5	Day 10	Day 15	Day 25
Colour	-	-	Diminishing	Diminishing	Colourless
Odour	-	-	Diminishing	Diminishing	Agreeable
Suspended Solids	150.2	144.5	138.8	131.1	124.8
Phosphate	2.91	2.43	2.15	1.65	1.48
Sulphide	86.4	71.7	66.3	40.1	32.5
Chloride	320	314.2	306.8	298.4	255.6
Cyanide	0.065	0.062	0.057	0.052	0.05
Ammonia	24.2	19.4	15.3	12.7	11.3
Total Hardness	652.6	554.8	528.7	490.6	465.4
Arsenic	0.055	0.052	0.049	0.045	0.04

Table 2: Waste water analysis after treatment with Fe (VI) (0.005mg /L) AT PH -9.

SL. NO	No. of days	BOD {mg/L}	COD {mg/L}
1	5	20.0	151.3
2	10	18.3	142.6
3	15	15.2	125.4
4	20	13.1	116.5
5	25	11.5	86.2
6	30	9.2	65.9

Table 3: Variation of cod, bod of waste water with Fe (VI) Treatment.

added slowly & 3ml of alkaline potassium iodide solution. Stopper the bottle & shake well, allow the precipitate to settle one test tube of concentrated sulphuric acid is added slowly & mixed well to dissolve the precipitate completely. 100 ml of this solution is pipette into a clean conical flask & titrated slowly against standard sodium thiosulphate solution using 2ml starch indicator.

The BOD the sample is calculated from the equation

Mass of dissolved oxygen / dm^3 = Normality of oxygen solution * Equivalent mass of oxygen

Determination of COD

COD is the amount of oxygen consumed in the chemical oxidation of organic and inorganic wastes present in 1 litre of waste water.

Procedure

50ml of sample was taken into a refluxing flask and several boiling stones were added. 0.1g HgSO_4 was added to the solution. 5ml of concentrated H_2SO_4 was also added to the solution. To ensure that HgSO_4 dissolved completely, the solution was swirled slowly while adding Sulphuric acid. 0.1g of Ag_2SO_4 was added to this solution. Finally Potassium dichromate was added. Thorough mixing of the solution was ensured by swirling the flask in a water bath to recover any volatile substances that may have escaped from the liquid state. The flask was then attached to the condenser and further cooling was done. 20ml of Sulphuric acid was added to the solution in the flask continuing, cooling and swirling to mix the solution. The solution was refluxed for 1hour. A blank run (using 50 ml distilled water instead of sample) was simultaneously conducted with the same procedure after cooling, the solution was transferred to an Erlenmeyer flask.

The reflux flask was rinsed thrice, pouring the rinsing water to the Erlenmeyer flask. The solution was diluted to about 300ml and about 8 drops of Phenanthroline ferrous sulphate was added to the solution as an indicator. The solution was titrated against the Mohr's salt and the

titre volume required for the colour change from blue-green to reddish blue was noted. The procedure was repeated for the blank run.

The COD is determined by following formula

$$\text{COD} = \frac{N_{\text{FAS}} * (X - Y) * 8}{1000}$$

Where 'X-Y' is amount of potassium dichromate consumed by water.

Determination of total hardness

The total hardness is due to the presence of bicarbonates sulphates and chlorides of calcium & magnesium.

These are estimated by titrating a known volume of water sample against standard EDTA using 3-4 drops of eriochrome black indicator in presence of alkali buffer.

Chloride determination

Chloride is major inorganic anion present in natural and waste waters. A high content of chloride accelerates the corrosion process of metallic pipes and structures. It has harmful effects on agriculture; at high it imparts disagreeable taste to water.

It is estimated by titrating a known volume of water with standard silver nitrate solution using potassium chromate indicator.

Fluoride determination

Flouride concentration affects water quality. Concentration excess

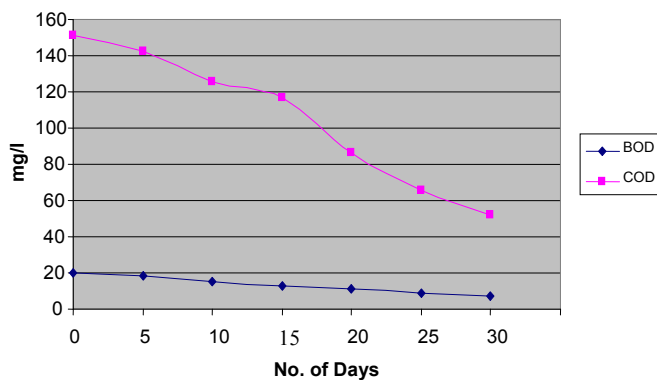


Figure 1: Variation of COD, BOD with Fe (VI) treatment.

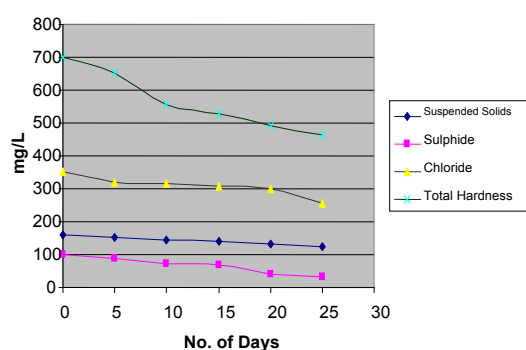


Figure 2: Variation of Suspended Solids, Sulphide, Chloride, Total hardness with Fe (VI) treatment.

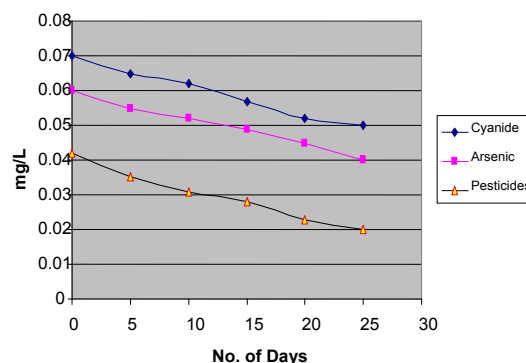


Figure 3: Variation of Cyanide, Arsenic, Pesticides, with Fe (VI) treatment.

of 1mg/l causes fluorosis and mottling. It is estimated colorimetrically using SPANDS reagent.

Determination of phosphate

The phosphate is estimated colorimetrically using Ammonium molybdate solution in presence of Dihydrogen phosphate sulphuric acid and sodium sulphide solution. The absorbance of solution was measured.

The phosphate estimation may be affected by slight changes in concentrations of reagents and presence of interfering substances.

Results

The pond water is contaminated by sanitary wastes, plant wastes, detergents & also by human activities. The water is made free from suspended solids colloidal impurities etc., by primary treatment & then treated with Fe (VI) for a period of 30 days. The parameters are measured before and after treatment of Fe (VI) and listed as shown in the following table.

Conclusions

The study reveals that Fe (VI) replaces several chemical impurities like sulphides, ammonia, phosphate, urea, arsenic, organic compounds, nitrous compounds, organic sulphur compounds etc.,

The aggressive orders are formed by ammonia, sulphides, etc. The Fe (VI) oxidizes Sulphides to Sulphates, Ammonia and nitrous compounds to nitrates which can be precipitated as non hazardous Iron compounds which diminishes the disagreeable smell. The coloured compounds are oxidised hence the colour also diminishes after the treatment. Thus the waste water can be treated with Fe (VI) which forms non hazardous by products. The phosphate is removed in the form of Ferric phosphates. The reduction in COD, BOD results by the oxidation of organic compounds.

It is observed that, after treatment with Fe(VI) {0.005 mg/L} at pH-9 over a period of 25, COD is decreased to about 65.7%, BOD to 64%, Suspended solids to 22%, phosphate to 57.7%, sulphide to 67.5%, chloride to 28.5%, cyanide to 15%, ammonia to 61.7%, total hardness to 33.5%, arsenic to 33.3%.

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