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The Effect of Temperature and pH on the Removal / Recovery of ZN^{++} from Solution by Chemical Coagulation

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Abstract

This work was conducted to study the treatment of industrial waste water, and more particularly those in the General Company of Electrical Industries.This waste water, has zinc ion with maximum concentration in solution of 90 ppm.

The reuse of such effluent can be made possible via appropriate treatments, such as chemical coagulation, Na2S is used as coagulant.

The parameters that influenced the waste water treatment are: temperature, pH, dose of coagulant and settling time.

It was found that the best condition for zinc removal, within the range of operation used ,were a temperature of 20C o a pH value of 13 , a coagulant dose of 15 g Na2S /400ml solution and a settling time of 7 days. Under these conditions the zinc concentration was reduced from 90mg/l to 0.003 mg/l.

Introduction

Heavy metals today have a great ecological significance due to their toxicity and accumulative behavior[1]. These elements contrary to most pollutants are not Bio-degradable and undergo a global eco-biological cycle in which natural water are the main path way. The determination of the concentration level of heavy metals in this water as well as the elucidation of the chemical forms in which they appear (i.e. its specification) is a prime target in environmental research today because of the close relation between toxicity and specification.

Zinc is very rarely present in natural water, but not so rare in water when it is drawn at consumers' taps because of the use of galvanized iron piping and tanks. Zinc should not exist in water consumed in quantities in excess of 15 ppm. Some waters will readily take up zinc, especially in cooking process and zinc containers for food should not be used. Another danger is the collection of drinking water from galvanized iron roofs for isolated supplies. Hard chalk waters attack the zinc of galvanized piping, forming loose deposits of zinc carbonate, and the zinc in solution in such waters, as supplies to the consumers may be found to exist up 3.0 ppm[2].

Zinc salts are also used in the inorganic pigments industry and high Zinc levels have been reported in acid mine drainage water.

The primary source of zinc in wastewaters from plating and metal product is after removal from pickling or plating baths.

Treatment process employed for wastewater zinc removal may involve either chemical precipitation, with disposal of the resultant sludge, or recovery process include ion exchange and evaporative recovery, but may also be precipitation process, where relatively pure zinc sludge is reclaimed. Recovery of plating wastes frequently proves to be more economical on an overall basis than conventional precipitation and sludge disposal [3].

This investigation was conducted to study the effects of the variables on the zinc removal by chemical coagulation method using Na2S as a coagulant[4].

The variables studied were : Temperature, pH, coagulant Dose Settling time, These variable were correlated to Zinc concentration remained in the treated wastewater to obtain the optimum condition for treatment process in order to obtain water with metal concentration not exceeding health standards as set by the Environmental Protection Agency[5,6,7].

Experimental Work

The experimental work entailed the treatment stage by chemical coagulation method using Na2S as a coagulant and analysis of the wastewater before and after treatment. The study includes the effect of the pH, temperature, dose and settling time on the operation.
The wastewater polluted with zinc, was obtained from the General Company for Electrical Industries, where zinc is used as pigment to the cover of electrical parts.
The experiments were carried out at :
(i) Temperatures of 20,30,40,50, and 60C0
(ii) pH of 3,5,7,10and 13
(iii) Coagulant Dose of 2.5,3.5,5,10,and 15 mg/400ml solution
(iv) Settling time of 0,1,2,3,4,5,6 and 7 days

Zinc Treatment Procedure

400ml solution was poured in a beaker then coagulant dose was added to the sample. NaOH and HCL were used to control the pH degree of the sample which was measured by digital pH meter. This sample with known dose and pH was placed in water bath with temperature control. Then the sample was stirred by using jar test or agitator for a period of (1/4 -1/2) hour. After this was completed, the sample was left quiescent for (1-7) day during which settling occur. Finally the sample was analyzed.

Zinc Analysis Procedure

Titration method was used to measure zinc concentration in the sample after the treatment process (coagulation, flocculation, and settling) was finished. At first, the sample was filtered by filter paper (to remove any solid impurities) then, a 100 ml from the sample was taken and put in a titration beaker. The pH of this sample was then adjusted to a value of 10 by adding NaOH or HCl (A pH of the sample equals to 10 is known as optimum for titration).

A few drops of the indicator of Erio chrome black T indicator were added to the sample to convert color to wine red. Then the sample was titrated with 0.1 M of EDTA solution until the color of the sample is blue. The titration was stopped and the volume of EDTA used for the titration was recorded. This volume was used to calculate the concentration of Zink in the samples. This analysis was repeated for all treated samples which come from treatment process at different conditions [8,9].

Results and Discussion

There are many kinds of processes to remove zinc from industrial wastewater like ion exchange, biological method, liquid membrane, and absorption methods, besides coagulation process. The coagulation process was chosen to remove zinc from industrial wastewater because it is simple, economical, uses cheap substances and simple devices. There are many substances which can be used as a coagulant; Na2S was chosen in this work because. it is cheap and widely found with low coagulation time (1/4-1/2) hour.

The Effect of Temperature: The results obtained here are shown in Figures(1-5) .The Figures show the effect of increasing the temperature in removing zinc from a waste solution.
It is obvious that increasing the temperature will decrease the amount of zinc removed. As it can be seen from Figure (1), the amount of zinc removed at 20°C is more than that removed at 30, 40, 50 and 60ºC. In general zinc removal, gradually decreases when the temperature was rising (other variables are constant). This behavior of zinc concentration in the treated solution sample and the temperature is a result of the solubility of the salt ZnS in water. Where increasing the temperature will increase the reverse dissociation and zinc ions will form again as shown in the chemical equation

$$Zn^{+2} + Na_2S \rightleftarrows ZnS + 2Na^{+1}$$

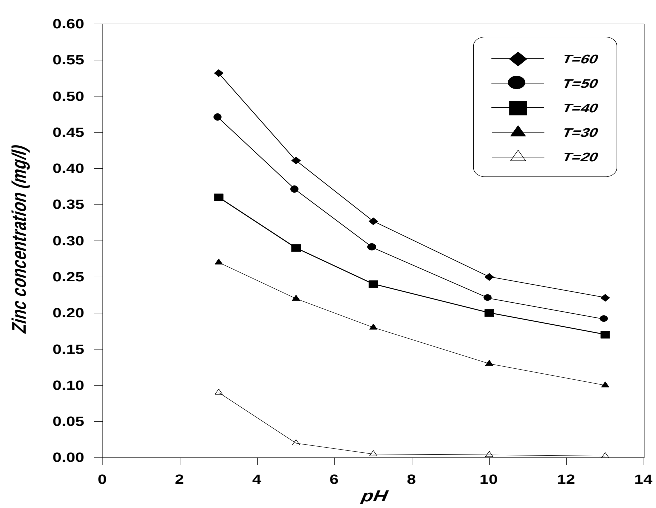

Fig.1: The relation between the pH and the zinc concentration for different temperature values at constant dose (15g), constant settling time (7 day)

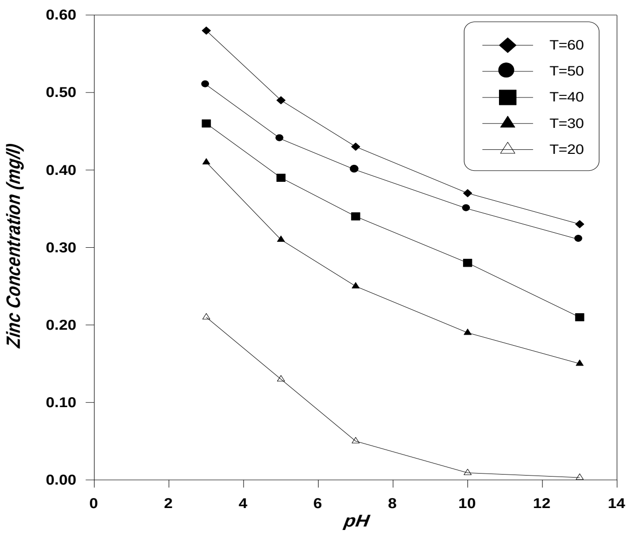

Fig. 2: The relation between the pH and the zinc concentration for different temperature values at constant dose (10g), constant settling time (7 day)

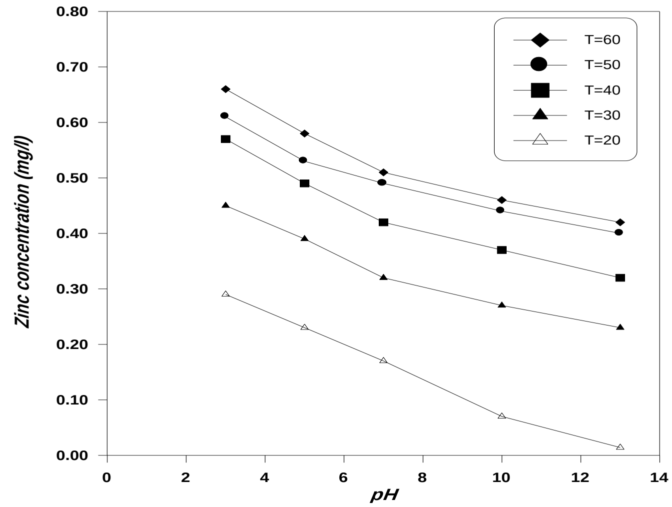

Fig. 4: The relation between the pH and the zinc concentration for different temperature values at constant dose (3.5g), constant settling time (7 day)

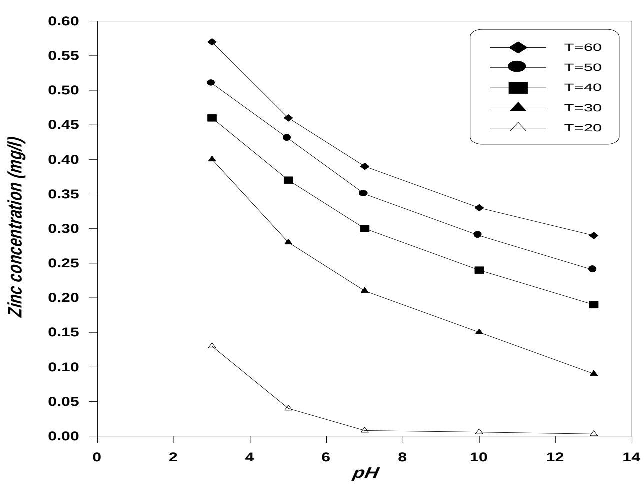

Fig. (3) The relation between the pH and the zinc concentration for different temperature values at constant dose (5g), constant settling time (7 day)

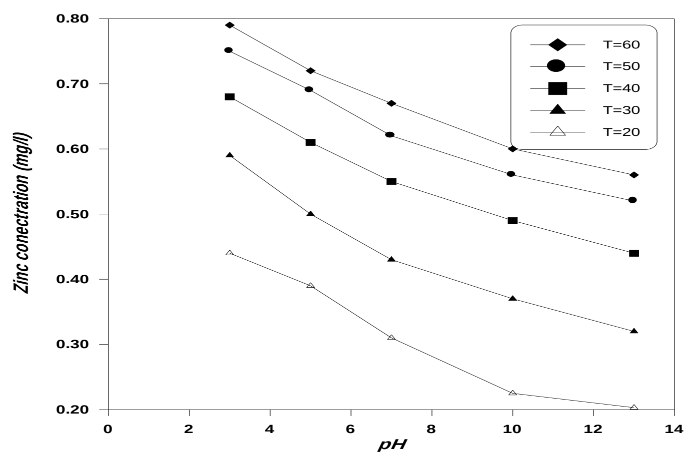

Fig. 5: The relation between the pH and the zinc concentration for different temperature values at constant dose (2.5g), constant settling time (7 day)

The Effect of pH:

The results obtained here shown in Figures (6,). These figures show that when the pH increases, at constant temperature, dose, and settling time the zinc amount removed also increased. The amount of zinc removed when the PH is above 10 is more than the amount of zinc removed at other pH values, this difference in the quantity of zinc removed is due to the effect of the change in the pH on the zeta potential and solubility curve. When the pH increases, the zeta potential decreases, therefore, the coagulation will increase (i.e. zinc removal increases). Also, at high values of pH the solubility of ZnS will decrease , so that the amount of zinc removed will increase then the concentration of zinc in the treated solution will decrease .For example at constant temperature (20°C) , Na2 S dose (15 g), and settling time (7 days), zinc concentration left in solution after treatment is 0.0022, 0.0038, 0.005, 0.02 and 0.09 mg/l at pH values of 13,10,7,5 and 3 respectively (see also table 1) .

The Effect of Dose:

The results obtained here are shown in Figures (7,8) the results show the effect of adding Na2S dose on zinc removal. When the dose increases, the amount of zinc removed also increases, as it can be seen. The amount of zinc removed from the treated solution when the dose is (15 gm) was more than the amount of zinc removed when the Na2S dose is 2.5 gm (other parameters are constant). This behavior is due to requirement of the quantity of the Na2S (chemical coagulant) to remove the zinc and forming the ZnS salt according to the chemical equation $Na2S+Zn+2 \longrightarrow 2Na+ZnS$. At high value of chemical coagulant dose, ZnS formed will increase, so that the rate of zinc removal will, also, increase, i.e. concentration of zinc in the treated solution will decrease. For example at constant temperature (20°C),constant pH(13) ,and for settling time (7days)for dose (15g) the zinc concentration in the solution is (0.0022 mg/l),while for dose (2.5g) the zinc concentration in the solution is (0.253mg/l).

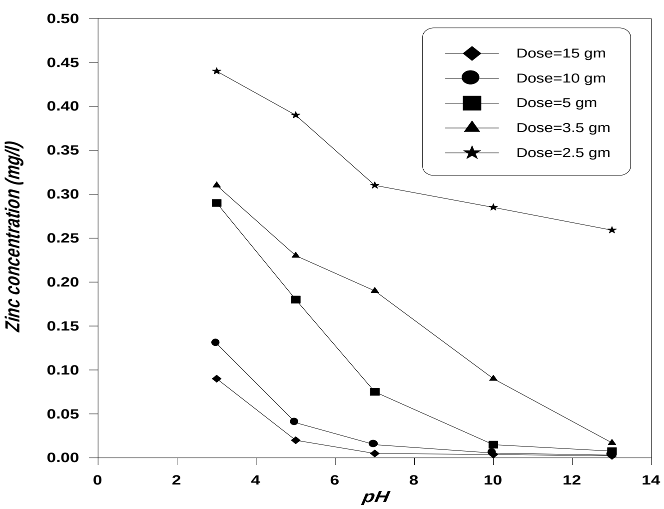

Fig.6: the relation between the pH and the zinc concentration for different dose at constant temperature (T=20), constant settling time (7 day)

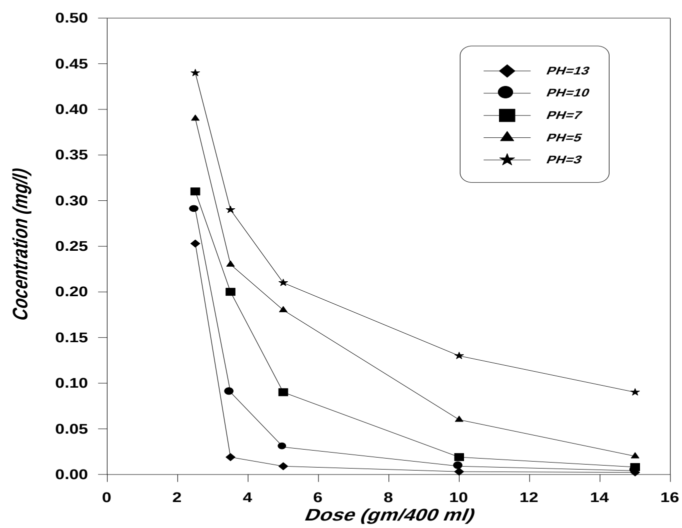

Fig.7: The relation between the dose and the zinc concentration for different PH values at constant temperature (T=20 oC), constant settling time (7 day)

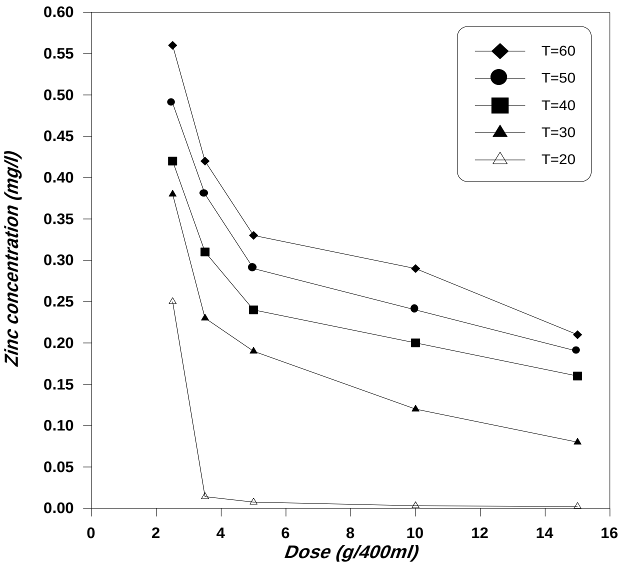

Fig.8: The relation between the dose and the zinc concentration for different temperature values at constant (pH=13), constant settling time (7 day)

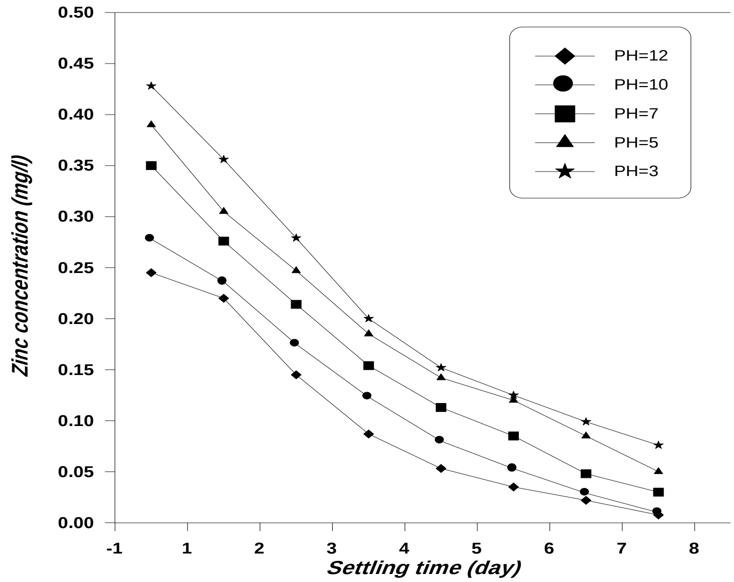

Fig.9: the relation between the settling time and the zinc concentration for different pH value at constant dose (10g), constant temperature (20 Cº)

The effect of settling time

The result obtained here are shown in Figures (9,10) which show the effect of settling time on the zinc removal from treated water.

When the settling time increased, the quantity of zinc removed also increased as it can be seen. The quantity of zinc removed increased gradually with the time from one to seven days. This behavior is due to the effect of increasing the size of the particles because of coagulation as well as the settling of the finer particles at longer times. For example at constant temperature (20°C) , constant pH (13) and dose (15 g Na_2S/400ml solution) the value of zinc concentration was (0,172 mg/l)while it decreased to(0.144 mg/l) for the second day then to (0.1 mg/l) for the third day, and in the seventh day zinc concentration is only (0.003 mg/l) .

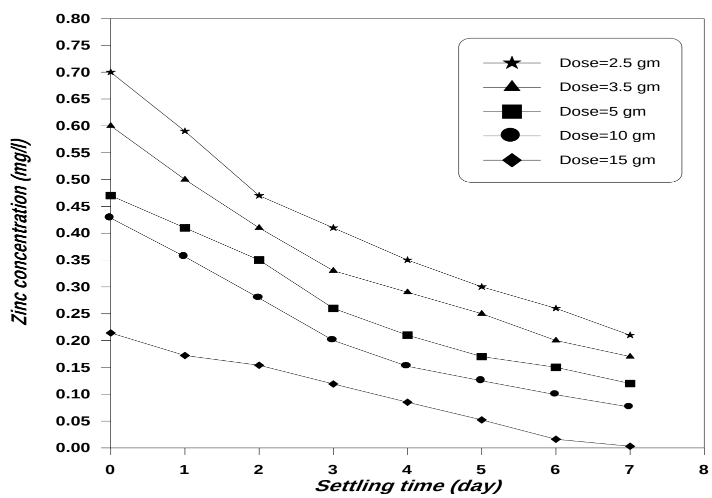

Fig.10: the relation between the settling time and the zinc concentration for different dose values at constant (pH=13), constant temperature (20Cº)

Table 1 Zinc ion concentration left in solution after treatment (Temp. =200C; Settling time = 7 days)

Na2S Dose (g/400 mls.)	15	15	15	15	15	2.5
pH	3	5	7	10	13	13
Concentration mg/l)	0.09	0.02	0.005	0.0038	0.0022	0.253

CONCLUSIONS

The following conclusions could be drawn from the present investigation

1- It was found that the best pH value for zinc removal was 13.
2- It was found that the temperature effect on zinc removal by Na2S show that zinc removal increased when the temperature decreased and the best temperature was 20°C for removing the zinc from treated solution.
3- It was found that the best dose for zinc removal from the wastewater was 15 gm Na2S/400 ml polluted solution.
4- It was found that the zinc removal increased when the settling time also increased.

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