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RESEARCH ARTICLE

COMPARATIVE STUDY ON THE REMOVAL EFFICIENCY OF CADMIUM AND LEAD USING HYDROXIDE AND SULFIDE PRECIPITATION WITH THE COMPLEXING AGENTS

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Abstract

Human activities and consequent developments have brought about the spectre of an overwhelming degradation of all facets of the natural environment-physical, chemical, biological and social. Environmental pollution, especially by chemicals, is one of the most significant factors in the degradation of the biosphere components. Among all chemical contaminants, heavy metals are believed to be of special ecological, biological and health significance. Unlike organic pollutants, the majority of which are susceptible to biological degradation, metal ions do not degrade into harmless end products. Chemical precipitation is a simple and economical method, and hence, has been widely used. Among the chemical precipitation methods, hydroxide precipitation is the conventional method of removing heavy metals form wastewater, but it suffers from a few shortcomings such as high solubilities, amphoteric properties of metal hydroxides and their ineffectiveness in the presence of chelating agents. Sulphide precipitation is an extremely effective process for the removal of heavy metals. A comparative study of the removal of heavy metals by hydroxide and sulphide precipitation was carried out. The precipitation was carried out in the presence and absence of complexing agents such as ammonium chloride, tartrate and citrate.
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Keywords: Heavy metals, hydroxide precipitation, sulphide precipitation, complexing agents

Introduction

Water pollution due to heavy metals has been a major cause of concern since long. Several past episodes of mishaps, due to heavy metal contamination in aquatic environment, have increased awareness about their toxicity. For instance, the outbreak of Itai-itai (Ouch-ouch) disease among Japanese farmers, due to the cadmium bearing Jintsu river water and Minamata disease in Japan due to the bioaccumulation of mercury in human body through the food chain, particulary through fish (Rai et al 1998), are well known incidents. The continuous use of heavy metals for centuaries have resulted in increased heavy metal contamination of the globe, beyond the tolerable limits causing various hazardous effects on the humans and animal kind. The majority of metal wastes generated in country are characteristic toxic metal wastes and wastes that result from electroplating and metal treating processes (Peters and Ku 1987). Heavy metals are non-biodegradable in nature (Srivastava et al 1996) and are accumulated by micro-organisms. Eventually, the toxic elements will get transferred to humans via the food chain (Cheung et al 2001, Lark et al 2002, Bowen 1966, Chandra 1988, Friberg et al 1974, Kjellstrom et al 1979 and Sitting 1980). The toxic heavy metals entering the ecosystem may lead to geoaccumulation, bioaccumulation and biomagnifications (Olaniya et al 1998). They form stable complexes and cause undesirable effects. Heavy metals are widely used in variety of industrial activities and the wastes from these industries constitute a major source of heavy metal pollution in the environment (Singh et al 1996). The main task is to adopt appropriate measures and develop suitable techniques either to prevent the metal pollution or reduce it to acceptable levels. Precipitation of heavy metals lowers the concentrations of all metals. The solubility of precipitated metal compounds is the key to this method's success; if a metal can form an insoluble compound, then the compound can be removed via clarification and filtration. Of the few precipitation methods, hydroxide and sulfide are the two main methods currently used, and hydroxide precipitation is by far the most widely used method (Dr.Mahmood M. BrbootI et al 2010).

Materials and methods

Materials

All chemicals used were of Analytical Reagent (AR) grade. Double distilled water from an all glass still was used for preparing reagents.

Instruments

The instruments used for the study were pH meter (LI 120 ELICO make), high speed stirrer (model RW 16 B IKA Labortechnik), magnetic stirrer (model RH IKA Labortechnik) and Atomic Absorption Spectrophotometer (AAS) (Analytic Jena (AJ) Vario 6).

Hydroxide precipitation technique

For hydroxide precipitation, pH of 200 mL of heavy metals solution (500 ppm) was raised from 7 to 11 using 1N NaOH. The contents were allowed to settle for 30 minutes. The supernatant was filtered through a Whatman No.42 filter paper and analysed using atomic absorption spectrophotometer for the presence of cadmium, copper and lead. The precipitation was carried out in the presence and absence of complexing agents such as ammonium chloride, tartrate and citrate.

Sulphide precipitation technique

For sulphide precipitation, variation of pH, sulphide dose and reaction time were done on 200 mL of heavy metalssolution (500 ppm). Initially, pH was optimized using 1N sodium hydroxide or 1N suphuric acid with heavy metals solution by the addition of sulphide under rapid mixing conditions. The contents were allowed to settle for 30 minutes. The supernatant was filtered through a Whatman No.42 filter paper and analysed using atomic absorption spectrophotometer for the presence of cadmium, copper and lead. Similarly, the sulphide dose was also optimized. The precipitation was carried out in the presence and absence of complexing agents such as ammonium chloride, tartrate and citrate.

Results and Discussion

Experiments carried out for the removal of heavy metals using hydroxide and sulphide precipitation at the optimum conditions at a reaction time of 5-60 minutes did not show any variation in the efficiency of heavy metal removal. Hence, 10 minutes was considered as the optimum reaction time.

Hydroxide precipitation

Effect of pH

The effect of pH on the removal efficiency of cadmium and lead is studied in the pH range 7-11. The effect of pH on the removal efficiency of cadmium and lead in the absence and presence of complexing agents are illustrated in the Figure 1.1 and Figure 1.2. It is observed that the removal efficiency increases with pH. The removal efficiency followed the order: absence of complexing agent>presence of ammonium chloride>tartrate>citrate. Thus, the effect of complexation is felt at all pH values.

Sulphide precipitation

Effect of pH

The effect of pH on the removal efficiency of cadmium and lead is studied in the pH range 1-11. The effect of pH on the removal efficiency of cadmium and lead in the absence and presence of complexing agents are illustrated in the Figure 1.3 and Figure 1.4. It is observed that the removal efficiency increases with pH. However, after pH 8 the efficiency almost a constant. Hence, pH 8 was considered optimum for the removal of cadmium by the sulphide precipitation method. The removal efficiency followed the order: absence of complexing agent>presence of ammonium chloride>tartrate>citrate. Thus, the effect of complexation is felt at all pH values.

Effect of sulphide dose

The effect of sulphide dose on the removal efficiency of cadmium was studied by varying the

Figure 1.1 Effect of pH on cadmium removal by hydroxide precipitation

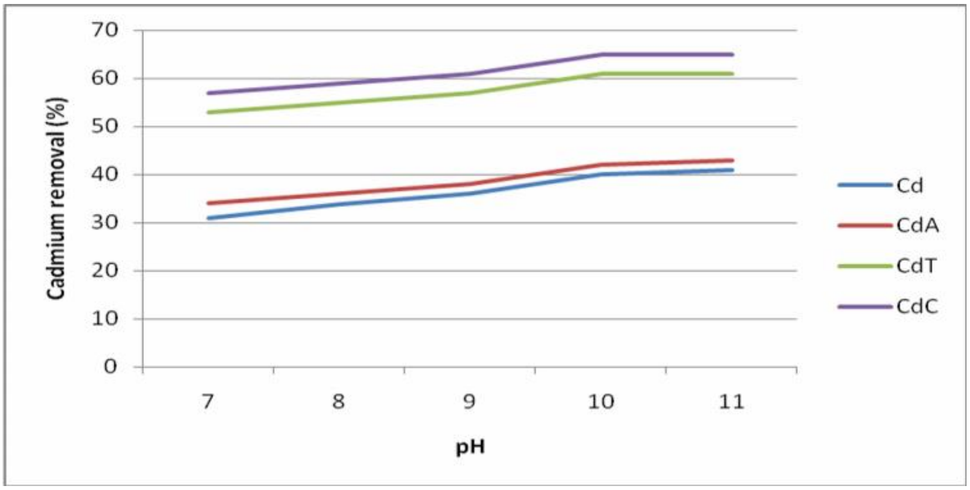


Figure 1.2 Effect of pH on lead removal by hydroxide precipitation

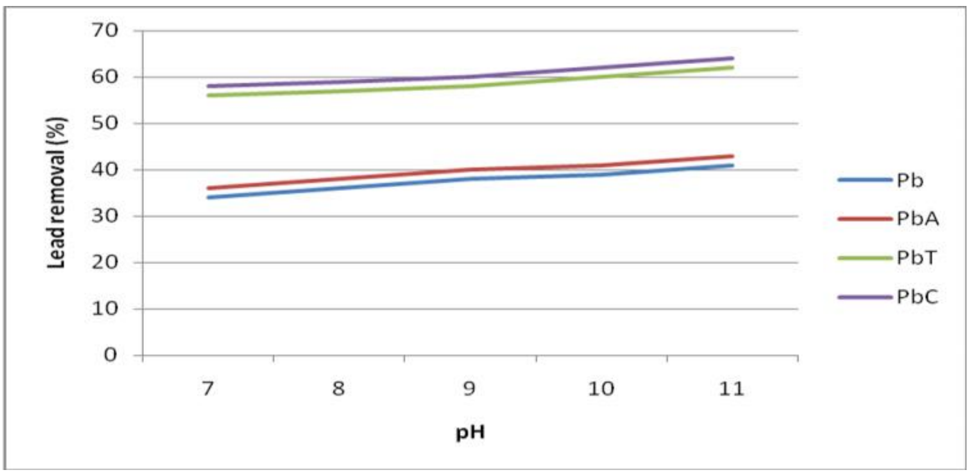


Figure 1.3 Effect of pH on cadmium removal by sulphide precipitation

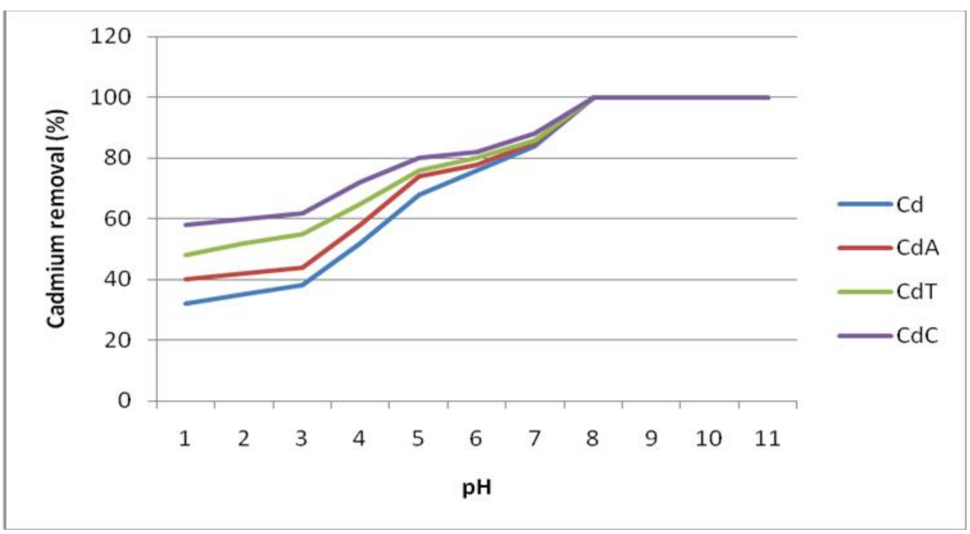


Figure 1.4 Effect of pH on lead removal by sulphide precipitation

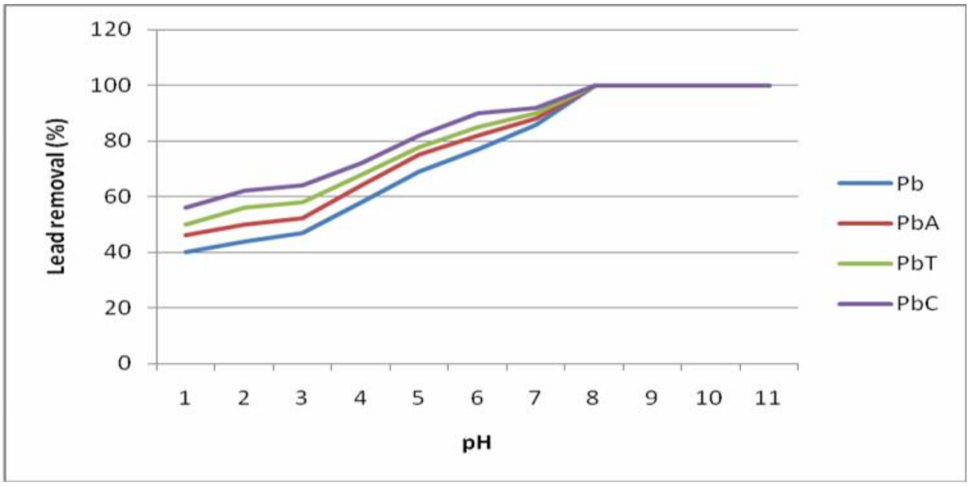


Figure 1.5 Effect of sulphide dose on cadmium removal by sulphide precipitation

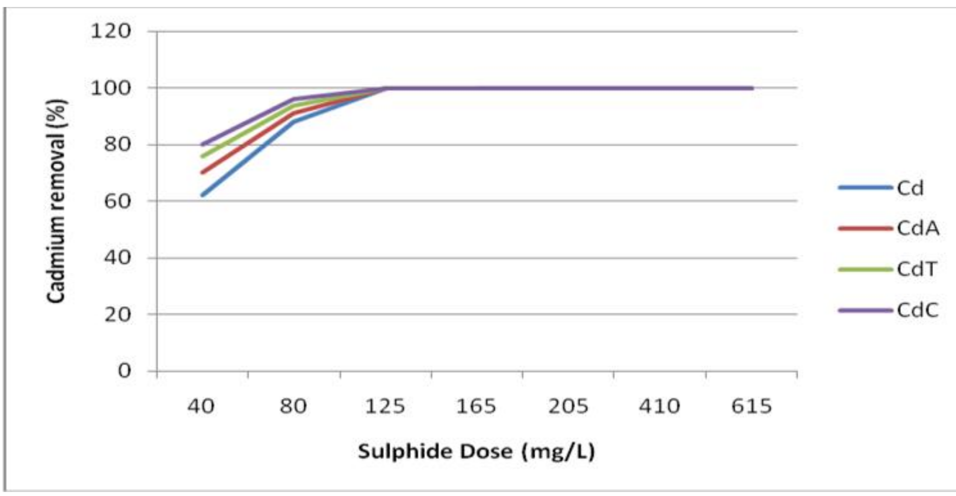
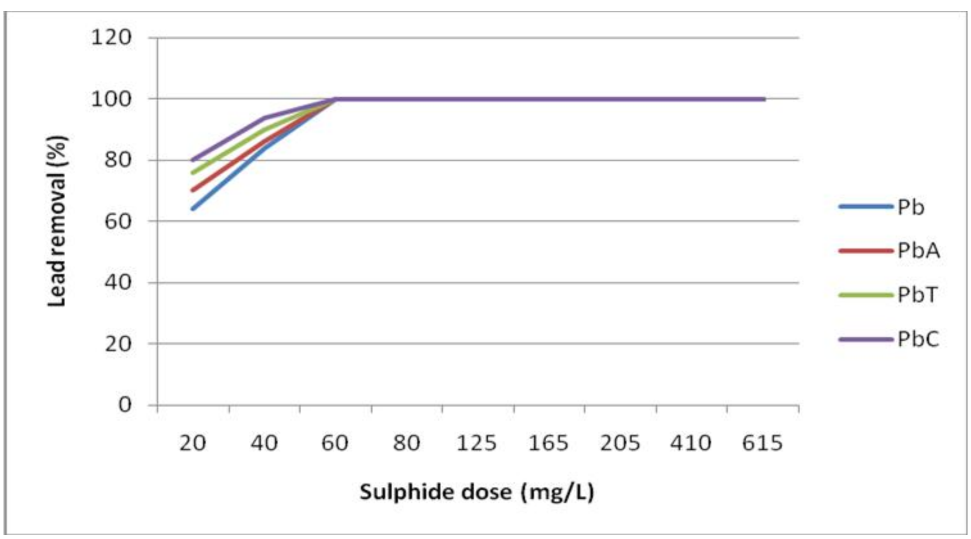


Figure 1.6 Effect of sulphide dose on lead removal by sulphide precipitation



dose from 40 mg/L to 615 mg/L and keeping the pH at the optimum pH of 8. The results are shown in figure 1.5. The removal efficiency increased with increase in sulphide dose and leveled off after a critical dose of 125 mg/L. At lower doses the removal efficiency followed the order: absence of complexing agent>presence of ammonium chloride>tartrate>citrate.

The effect of sulphide dose on the removal efficiency of lead was studied by varying the dose from 20 mg/L to 615 mg/L and keeping the pH at the optimum pH of 8. The results are shown in figure 1.6. The removal efficiency increased with increase in sulphide dose and leveled off after a critical dose of 60 mg/L. At lower doses the removal efficiency followed the order: absence of complexing agent>presence of ammonium chloride>tartrate>citrate.

Conclusion

Sulphide precipitation method is used to achieve the superior metal removal required by the discharge limits. Sulphide precipitation removes the dissolved metal contaminants to the lowest levels possible while using the least amount of treatment chemicals and generating the least amount of sludge. It is a viable technology to remove complexed metals from wastewater.

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