

Removal of Lead wastewater from the thermal stabilizer industry by chemical precipitation

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Resumen

En este trabajo de investigación se pretende remover el plomo presente en las aguas residuales de una industria de estabilizantes térmicos. Se utilizó el método de precipitación química, utilizándose un coagulante natural como el mucilago de nopal. La muestra fue obtenida desde las afueras del vertido de agua residual de la industria ubicada a 20 metros afuera de sus instalaciones. Se hizo el análisis preliminar de caracterización del efluente del proceso industrial con el fin de confirmar la contaminación por plomo, la cual contenía una concentración de plomo de 51,68 mg/L, luego se realizaron los ensayos de laboratorio, utilizando un coagulante natural como el mucilago de nopal, hasta lograr una reducción considerable, de 1,76 mg/L de plomo en el agua residual.

Palabras clave: aguas residuales, plomo, precipitación química.

Abstract

This research pretend to show the remove the lead present in the wastewater of a thermal stabilizer industry. The chemical precipitation method was used, using a natural coagulant such as the nopal mucilage. The sample was obtained from the outskirts of the wastewater of the industry located 20 meters outside its facilities. The preliminary characterization analysis of the industrial process effluent was carried out to confirm lead contamination, which contained a lead concentration of 51.68 mg / L, followed by laboratory tests using a natural coagulant the mucilage of cactus, until achieving a considerable reduction, of 1.76 mg/L of lead in the residual water.

Keywords: lead, precipitation chemistry, water waste.

1. Introduction

Population growth, as well as urbanization and industrialization, have led to major pollution problems affecting the ecosystems of rivers, seas, lakes, lakes and soils (Valverde, 2017). In the case of wastewater, these, because they are not treated according to their different industrial processes, cause a serious problem of contamination to the receiving body, causing harmful effects on water and soil currents, and consequently to people. Wastewater discharged to the sewer daily in Peru, of 2.2 million cubic meters (m^3), only 32% are treated before have contact with natural water bodies (sea, rivers, lakes, creeks). And in the case of the capital of Peru, Lima, where 1.2 million m^3 of sewage is generated for sewage, only 20% are properly treated, complying with the Environmental Quality Standards (OEFA, 2014).

Lead is used in the manufacture of thermal stabilizers for use in the plastics, mining, agriculture and paint industries. For this reason, it is very important that this industry treat wastewater, as these waters are used for irrigation of soils around the industrial area.

To recover solids from the pumping water of the fish industry, natural coagulants and flocculants can be used (Paredes, 2008). Ferric chloride removes heavy metals through the chemical precipitation process (Pereda, 2007)

Lead is a metal considered as an ecotoxicological pollutant available in soil and dust. Its use generates a significant environmental contamination and its exposure by inhalation and by ingestion can cause liver, kidney, endocrine and, in the central nervous system, human beings (Manzanares et al., 2006). In natural waters, lead precipitates at alkaline pH, such as carbonate, and in reducing media it forms insoluble sulphides. (Domenech and Peral, 2006). Lead's concentration can reduce with air Micronanobubbles (Garcia and Valverde, 2017).

Precipitation Reactions

The precipitation reaction is a common type of aqueous solution reaction where an insoluble or precipitated product is formed. A precipitate is an insoluble solid which is separated from the solution in the precipitation reactions generally involving ionic compounds. (Chang, 2002, p 108).

Colloidal systems are non-homogeneous systems in which the constituent particles of one or more of their components (dispersed or dispersed phase) have a size in the range of 1 nm. until 100 nm. These colloidal systems are transcendental from the practical point of view because the colloids take part in numerous industrial and biological processes. Colloids intervene in industrial processes such as the paints, printing inks, dyeing of textile factories and leather tanning, in the preparation of lubricants, colored plastics and rubbers, etc. they also intervene in biological processes, such as digestion. Most of the hormones, enzymes, vaccines and multiple pathogenic microorganisms have colloidal size (Valenzuela, 1995).

Chemical precipitation is an effective treatment process for the removal of many contaminants, being one of the most common processes used to treat water. Waters treated with this process have produced a wide range of efficiency. Coagulation with alumina, ferric sulfate or ferrous sulfate employs chemical precipitation. The reduction of the contaminants of the waste water depends on several aspects or characteristics, as the solubility of several compounds formed in the water. (Letterman, 2002). For the removal of suspended matter there are many processes and operations, where in most cases chemical additives, called chemical-physical treatment, are used. To know which additive to use it is necessary to know well the characteristics of the particles to be eliminated (size, density, shape, etc.) as well as their concentration.

The coagulants that are used are mostly chemicals with electric charge contrary to the colloidal particle. Salts with high charge / mass (Fe^{3+} , Al^{3+}) cations are often used in conjunction with organic polyelectrolytes, which help to promote flocculation. Similar to suspended matter, dissolved matter can also have very diverse characteristics and concentrations: from large amounts of dissolved organic inorganic salts (organic matter biodegradable in the food industry) to extremely small amounts of inorganic (heavy metals) and organic (pesticides) but necessary its elimination given its dangerous character. The most frequent of the treatments that is recommended is the precipitation where it is sought to eliminate an undesirable dissolved substance, adding a reagent that helps to form an insoluble compound with the same, facilitating its elimination of the suspended matter. (Rodriguez, et al., 2006, pp. 22-24). The nopal is a linear polymer composed of polysaccharides related to the pectins. (Sáenz, 2006). Nopal mucilage (Hidrocoloides) is extracted from the leaves, is a heteropolysaccharide of high molecular weight, can have about 30,000 subunits of arabinose (35-45%), galactose (20-25%), raminose (7-8%), xylose (7-8%) and galacturonic acid (19-31%), where it is known that mucilage molecules have

large negative charges, are soluble natural polymers that trap mud particles in physical form so as to form bodies heavier than water (Sáenz, 2006).

2. Materials and Methods

The research design is experimental with a pre-experimental approach. The population is the residual water generated in its processes by the Thermal Stabilizers industry, where lead is basically used as feedstock. This industry produces an average of 45 liters of wastewater per week. A sample of 3 liters of residual water was taken.

Procedures for obtaining results

Stage I: Collection of the sample. We proceeded to obtain a sample of 3 liters of water in a plastic bottle.

Stage II: Characterization of the sample. After obtaining the sample, the pH 6.0 of the sample was measured. The sample was preserved by adding 5 mL of nitric acid (HNO₃) to the wastewater to bring it to a pH less than 2, as indicated by the water preservation method with lead. Then the lead concentration was analyzed to a certified laboratory.

Stage III: Treatment of the sample by chemical precipitation.

Preparation of the Natural Coagulant. We used the penca or cladodium of the name tuna commonly known, its scientific name is *Opuntia ficus indica*. Within the cladodium we find a drool that contains glucose, which is soluble in water and, therefore, traps contaminants.

The bark of the cactus leaf is washed and peeled with a knife, until there is no residue of the bark. It is cut into small bursts and allowed to be macerated in beakers with 500 mL of distilled water for 24 hours to promote extraction. Three concentrations of the coagulant are made, the first with 100 g in 500 mL of distilled water, the second with 200 g in 500 mL of distilled water and the last with 300 g in 500 mL of distilled water. After standing for 24 hours, a fine sieve is passed to each of the concentrations the pellet is discarded and the supernatant is filled in glass vials. Choosing the 60% weight / volume concentration of the coagulant cactus flocculant that corresponds to 300g of the nopal mucilage with 500mL of distilled water, since by observation and theoretical reference, it was suggested as more efficient.

Treatment of the sample

The sample at pH 2 was alkalinized. 10% sodium hydroxide (w/v) was then used for the titration of three samples of 250mL, being brought to an alkaline pH of 10, 11 and 12 with magnetic stirrer help.

After alkalinizing the sample, the natural coagulant (nopal mucilage) was applied. 20 mL of the nopal mucilage was added to the 250 mL samples of residual water, and placed on the automatic agitator (jars), giving a speed of 150 rpm by 3 minutes for coagulation. Then to form the floccules was led to a slow stirring at 50 rpm by 18 minutes. The samples were left to stand by 24 hours, then filtered and taken to the laboratory where the lead concentration was analyzed.

3. Results and discussion

The data and results obtained in conducting the lead removal of waste water from a thermal stabilizer industry are shown.

Pre-treatment results

The lead concentration turbidity and pH were determined in the residual water sample, with an initial concentration of 51.68 mg/L lead turbidity of 5.56 NTU and pH equal to 6.

Table 1: Characterization of the Sample

N°	Parameter	WQS* for wastewater for irrigation	Results
1	Lead	0.05 mg/L	51.68 mg/L
2	Turbidity	100 NTU	5.56 NTU
3	pH	6.5 – 8.5	6

Note: * Supreme Decret N° 015-2015-MINAM for is Environmental Quality Standard (EQS).

Alkalinization of samples

The alkalinization of samples was performed at room temperature of 23 °C

Table 2. Results of Alkalinization with Sodium hydroxide (NaOH)

	Dose (mL)	pH	Turbidity (NTU)
Sample 1	3.5	10	60.0
Sample 2	4.5	11	22.2
Sample 3	6.0	12	2.39

The first sample was brought to pH equal to 10 using 3.5 mL. of NaOH, obtaining a turbidity of 60 NTU.

The second sample was brought to pH equal to 11 using 4.5 mL of NaOH, obtaining 22.2 NTU.

The third sample is brought to pH equal to 12 using 6 mL of NaOH, obtaining 2.39 NTU

Coagulation / Flocculation

After alkalinizing the samples, 20 mL of the natural coagulant (nopal mucilage) was added to the three 250 mL samples. The samples were allowed to stand for 24 hours in the laboratory. It was observed, after this time, that the sample three of pH equal to 12, which had a turbidity of 2.39 NTU, smaller than the other samples, remained the most transparent. Filtration was then performed with filter paper and the turbidity again measured, resulting in 1.49 NTU.

The sample was taken to the laboratory to be analyzed and to know when it has reduced lead concentration to 1.76 mg/L lead.

Table 3. Comparison of the initial and final results of the Treatment Process of Sample 3

Parameter	Initial results	Final results
Lead	51.68 mg/L	1.76 mg/L
Turbidity	5.56 NTU	1.49 NTU
pH	2	12

Efficiency Calculation in the removal of lead

$$\frac{\text{Final Value} - \text{Initial Value}}{\text{Final Value}} \times 100$$

$$\frac{51,68 - 1,76}{51,68} \times 100 = 96,59 \%$$

The efficiency calculation in the lead removal was 96.59.

Calculation of turbidity efficiency

$$\frac{5,56 - 1,49}{5,56} \times 100 = 73,2 \%$$

The calculation of turbidity efficiency was 73.2 %

4. Conclusions

- The residual water of the thermal stabilizer industry exceeds the Environmental Quality Standards of the Peruvian Legal Regulations, being the parameter of lead, in category 3 for irrigation of vegetables, 0.05 mg / L, being the sample of the residual water in 51.68 mg / L lead.
- In the alkalization of the sample, it was concluded that pH with greater removal of lead was found in pH equal to 12; this is due to the result obtained from turbidity (2.39 NTU).
- In laboratory tests, the efficiency of the natural coagulant was observed since the turbidity measurement is an indicator of removal of contamination (1.49 NTU), having a percentage effectiveness of 73.2%.
- There was a significant removal of lead in the residual water by applying the chemical precipitation method obtaining a 96.59% removal of the pollutant, but this did not allow to comply with the Environmental Quality Standards.

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