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Removal of heavy metal from industrial sludge by inorganic acid

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Abstract

The removal of heavy metal from sludge before disposal or application to farmland is a necessary step to achieve a more safe sludge usage or disposal.

Sludge refers to the residual, semi-solid material left from industrial wastewater or sewage treatment processes. It can also refer to the settled suspension obtained from conventional drinking water treatment and numerous other industrial processes. The term is also sometimes used as a generic term for solids separated from suspension in a liquid. For the extraction of heavy metal like Lead, Copper and Phosphorous the samples were collected from industrial sludge at different pH and reaction time from different places near Jalandhar city of the Punjab (India). In order to analyze the sludge, the physiochemical parameters like pH, Moisture and heavy metals like LEAD and COPPER from the industrial sludge. Results revealed that solubilization of metals using inorganic acids achieved its maximum extraction efficiency lead removal was noted to be 82.0% from the sludge sample, copper removal was noted to be 72.0% and phosphorous removal 69.0% from Industrial sludge. The present study depicts that organic acid remove heavy metal from sludge and can be used for the industrial waste management and other environmental maintenance.

Keywords: Metal, industrial sludge, inorganic acid

Introduction

Heavy metals present in waste water and industrial effluent is major concern of environmental pollution. Most heavy metals are well-known toxic and carcinogenic agents and it represent a serious threat to the human population and the fauna and flora of the receiving water bodies. Heavy metals have a great tendency to bio-accumulate and end up as permanent additions to the environment. Heavy metals are considered to be the following elements: Copper, Silver, Zinc, Cadmium, Gold, Mercury, Lead, Chromium, Iron, Nickel, Tin, Arsenic, Selenium, Molybdenum, Cobalt, Manganese, and Aluminum. Heavy metals like Zn, Cu, Ni are known to have toxic effects at very low concentrations as well as very high concentration. The removal of heavy metals from industrial sludge has recently become the subject of considerable interest owing to strict legislations. There are several techniques to remove heavy metals from sludger such as filtration, electro coagulation etc but there is some limitation such as long treatment time. Various biological treatments, both aerobic and anaerobic can be used for heavy metal removal. One of the most influential parameters controlling the solubility of metals is pH. In the single extraction process of heavy metals from sludge, the inorganic acids such as nitric, hydrochloric and sulfuric and organic acids such as citric and oxalic have been widely used (Wong and Henry, 1998; Marchioretto *et al*., 2002; Dacera and Babel, 2006) [13, 9, 3]. In this work the chemical leaching process was applied to assess the mobilization of Zn, Cu, Cr, Ni, Pb in the sludge and the possibility of using chemical leaching as an applicable part of the treatment aiming at these heavy metals removal from sewage sludge. In this way, inorganic acids (Nitric, Hydrochloric were tested at different conditions of pH and reaction time.

Due to the discharge of large amounts of metal-contaminated wastewater, industries bearing heavy metals, such as Cd, Cr, Cu, Ni, As, Pb, and Zn, are the most hazardous among the chemical-intensive industries. Because of their high solubility in the aquatic environments, heavy metals can be absorbed by living organisms. Once they enter the food chain, large concentrations of heavy metals may accumulate in the human body. If the metals are ingested beyond the permitted concentration, they can cause serious health disorders (Babel and Kurniawan, 2004) [2]. Therefore, it is necessary to treat metal contaminated wastewater prior to its discharge to the environment. Heavy metal removal from inorganic effluent can be achieved by conventional treatment processes such as chemical precipitation, ion exchange, and electrochemical removal. These processes have significant disadvantages, which are, for instance, incomplete removal, high-energy requirements, and production of toxic sludge (Eccles, 1999) [4].

Material and Methods

The study was carried out at biotechnology laboratory, Department of biotechnology, CT institution of pharmaceutical sciences Jalandhar.

Different parameters of sludge

1. Moisture test
2. pH test
3. Lead test
4. Copper test
5. Phosphorus test
6. Solid test

Sample collection

Sludge samples were collected from different industerila drains like Maqsudan, Kala Singhia, Chaheru, Basti Bawa and Hamira near Jalandhar City.

Sludge characterization

The sludge sample was analyzed in terms of its physical and chemical characteristics, including heavy metals content using Colorimeter.

Heavy metal removal from inorganic acid: Removal of heavy metals from industerial sludge by inorganic acids was performed, four acids were attempted separately Nitric and hydrochloric. Samples of 7 g sludge were prepared with 150 ml distilled water in 500 ml Erlenmeyer flask different dosage of acids were added to sludge solution to adjust pH from 1 to 4 ±0.1 for Nitric and hydrochloric.

Result and Discussion

The samples were taken from various drains surrounding Jalandhar as well as from the dumping site of industries. Then they were analyzed for physico-chemical properties such as pH, moisture content, phosphorus and heavy metal like lead and copper). The pH of the sludge was varied according to their origin ranging between 5.6 to 8.9. The ph was determined by using calibrated ph meter. The higher value of moisture and solid were observed in sample collected from Hamira and Kala sanghian drains. The data was observed for the uptake of metal ions for different concentrations.

Wenyi Deng1 *et al*. (2010) reported on Moisture distribution in sludges based on different testing methods in which Moisture distributions in municipal sewage sludge and dyeing sludge and paper mill sludge were experimentally studied based on four different methods, i.e., drying test, thermo gravimetric. The results indicated that the moistures in the mechanically dewatered sludges were interstitial water, surface water and bound water.

Oleszkiewicz J.A. *et al*. (1986) [10] described the moisture content by dry method of sludge in which sludge drying is really a necessity, through discussing the results of sludge drying, the process of sludge drying, types of dryers, sludge dryer localization, suitable range of sludge drying, energy consumption and costs of sludge drying, and finally pointing out some problems connected with sludge drying application. Sludge drying process diminishes volume of sludge making the transportation cost lower and the sludge storage easier; increases sludge calorific value; makes it hygienic (Without pathogen microorganisms); stabilizes it and improves its structure.

Zespół *et al*. (2004) explained about economical factors of sludge by using dry method. Sludge utilization options often indicates sludge drying as the best option. The final decision should take into consideration not only economical factors but also others like: reliability of the solution, easy service, ease of storage and transportation or whether the considered solution is environmentally friendly. The metal removal efficiency increased with increase in time. Solubilization of metals using inorganic acids (HNO_3, HCl) started at pH values around 2, achieved its maximum extraction efficiency of lead, copper, Phosphorus, removal was estimated 82.0, 72.0 and 69.0% respectively pH of active sludge effluent was 8.0 and atmospheric temperature was 25 °C.

Wei chu *et al*. (1998) Department of Civil and Structural Engineering, carried a study of sludge which was recycled using a chemical precipitation process to promote the removal of lead metal in sludge, lead removal rates increased from 79% to 96–98%.

Shiro Yoshizaki *et al*. (2000) [11] worked on Principle and Process of Heavy Metal Removal from Sewage Sludge. The sufficient removal of heavy metals from sewage sludge remains to be achieved. Heavy metals that exist on the cell surfaces of the microorganisms in the sludge seem to be dissolved by acid treatments. This study shows that heavy metals in sewage sludge can be removed easily by treating a sludge filter cake with phosphoric acid containing hydrogen peroxide for 1 h at room temperature. Phosphoric acid of 8% concentration with hydrogen peroxide showed good removal rates of heavy metals comparable to those by 1 N hydrochloric acid. Copper is easily removed from the sludge in the presence of hydrogen peroxide.

Zeng L. *et al*. (2004) [15] discus about the potential adsorbent for phosphorus removal Alum sludge refers to the byproduct from the processing of drinking water in Water Treatment Works. In this study, groups of batch experiments were designed to identify the characteristics of dewatered alum sludge for phosphorus adsorption. Air-dried alum sludge (Moisture content 10.2%), which was collected from a Water Treatment Works in Dublin, was subjected for artificial P-rich wastewater adsorption tests using KH2PO4 as a model P source.

Zheng *et al*. (2009) described the Sludge Phosphorus Tests in Phosphorus is an essential element for plant growth and development, as it plays key roles in plant metabolism, structure and energy transformation.

Physicochemical characteristics of sludge

The main physico-chemical properties of the raw sludge are presented in graph 1. The pH values ranged from 7.1 to 8.21 which indicate that the sludge is slightly alkaline. The tested samples of sewage sludge have a high percentage of organic matter and nitrogen which may be present in the ammonium, nitrate and organic forms. As regarded cationic macroelments, calcium is the most abundant, followed by magnesium, potassium and sodium in all the sludge tested samples. All the parameters closely reflect those found by the bibliography of sludges of similar characteristics, some of which have been used for soil amendment Total metal concentrations of Zn, Cu, Cr, Ni and Pb in sewage sludge are presented in graph 2. Concentrations are expressed on a dry mass basis. Graph 2 also includes comparisons with sludge legal standard established by U.S.EPA-40 (2000) and standard by EU Commission (1986). According to table the total metal concentrations ranged from 555 to 1026 mg/kg for Zn, 256-802 mg/kg for Cu, 125-510 mg/kg for Cr, 170-385 mg/kg for

Ni and 100-215 mg/kg for Pb. the sludge contain a high concentration of Al (3210 - 8570 mg/kg), Fe (2114 - 5650 mg/kg) and Mn (50-241 mg/kg). These data show a wide variation of the concentration ranges of heavy metals that may be due to irregular input from the industrial waste water. Also sludges are exceeding the allowed limits of the EU Commission standard, (with exception of Zn). In contrast, according to U.S.EPA-40, the sludge could be disposed to agricultural land. It is also noted that EU Commission, U.S.EPA-40 standards does not contain the legal values of all metals like (Al, Fe, Mn). Chemical leaching of heavy metals from sewage sludge.

Effect of leaching agent

The effect of the pH on the heavy metals extraction with Nitric (HNO_3), Hydrochloric (HCl), Citric ($C_6H_8O_7$), and Oxalic ($C_2H_2O_4$) acids. There was a wide variation of removal efficiencies for all metals at different pH at the same acid contact times of 1hour. Solubilization of metals using inorganic acids (HNO_3, HCl) started at pH values around 2, achieved its maximum extraction efficiency (Cr-88%, Cu-82%, Ni-71%, Pb-94%, Zn-89%) at pH value around 1. when a complexing agent like citric acid, oxalic acid are applied, metals start solubilization at a higher pH value (3-5) than when a strong acid such as $HNO_3$and HCl are applied at the same pH. Both oxalic acid and citric acid have increased heavy metal extraction at mildly acidic pH but citric acid has better prospects because oxalic acid is removed from solution by precipitation as calcium oxalate. The calcium oxalate precipitates causes that oxalate become less available for heavy metals leading to a lower extraction for metals compared to citric acid. The organic acids efficiency in metal solubilization was not so high; the maximum extraction efficiency achieved was 66% for Zn using citric acid at pH 3. This might be due to the low pH value required for the metals to solubilize and or to the short acidification time applied in these experiments. Effect of time on leaching with citric acid. The effect of leaching time and pH on the efficiency of citric acid in extracting heavy metals from sewage sludge. For Cr, maximum removal (90%) achieved at pH 2 after 5 day of contact with citric acid while at pH around 3 maximum removal of Cr (66%) attained at one day of contact. For Cu, one day of extraction duration is the optimum condition that achieve higher removal efficiency at pH 2 (86%) and at pH 3 (48%). For Ni, as shown previously in figure 1 change in the pH value (2-4) has no significant effect on the extraction efficiency of nickel but as the time passing the situation is different, that at pH 2 an increase in Ni extraction efficiency starts after one day duration to achieve higher removal efficiency (96%) after 5 day of extraction as shown in figure 2. For Pb, maximum removal efficiency (85%) achieved after 10 days contact with citric acid at pH around 2, while at pH 3 maximum efficiency of lead removal (66%) attained after 1 day of extraction. For Zn, optimum extraction time is one day duration it gives maximum efficiency (88%) at pH around 2 followed by pH 3 (68%).

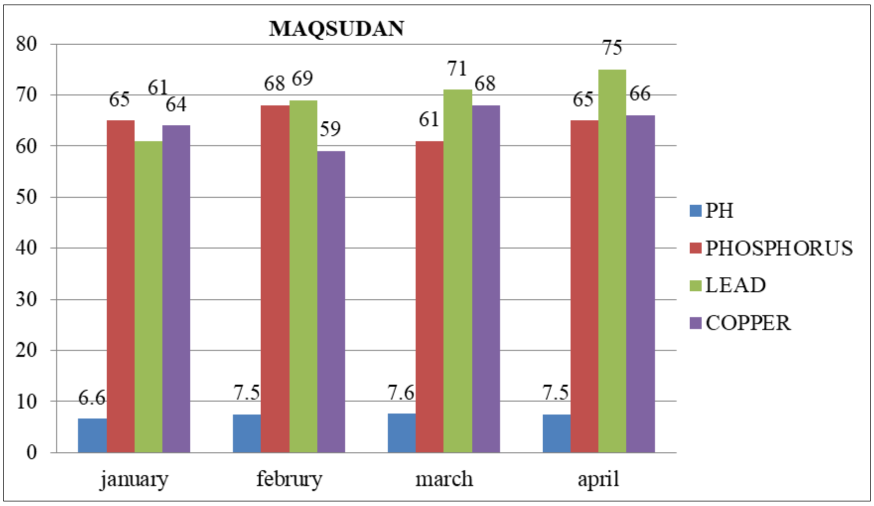


Fig 1: Maqsudan

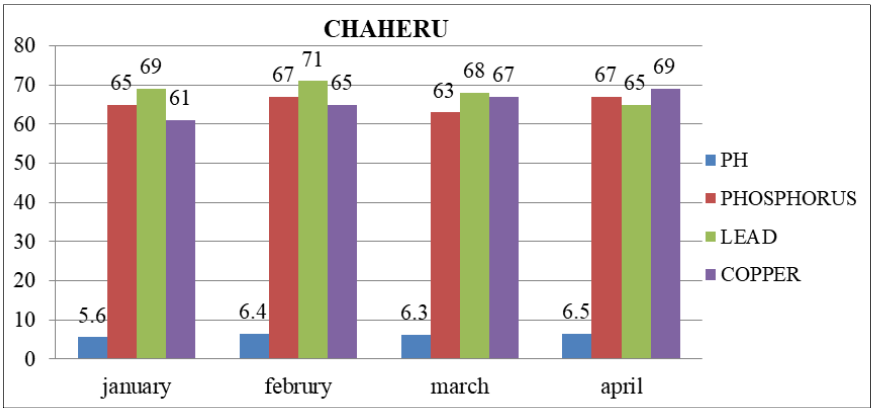
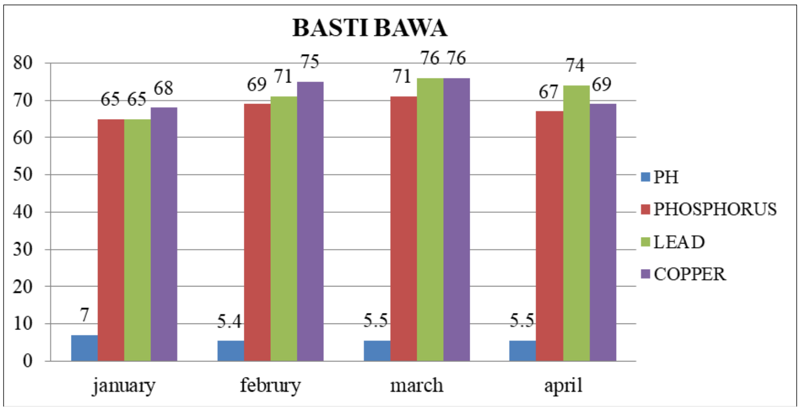
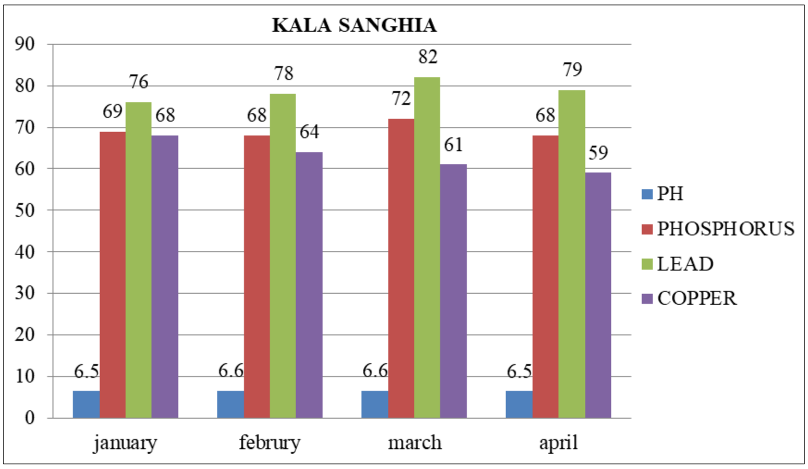


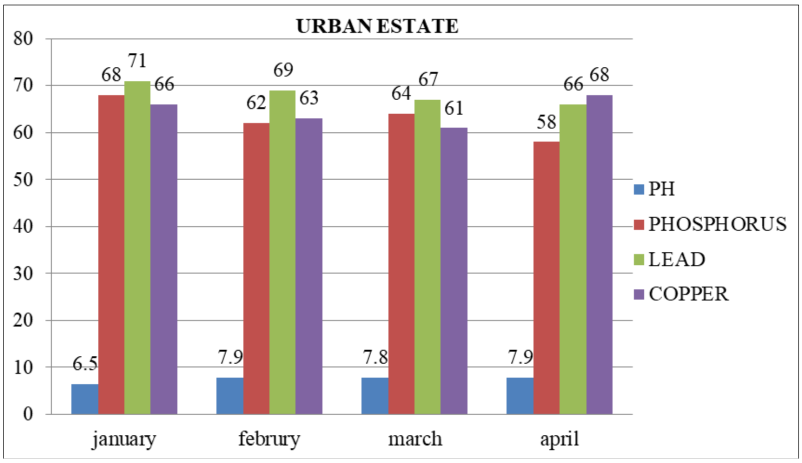
Fig 2: Chaheru



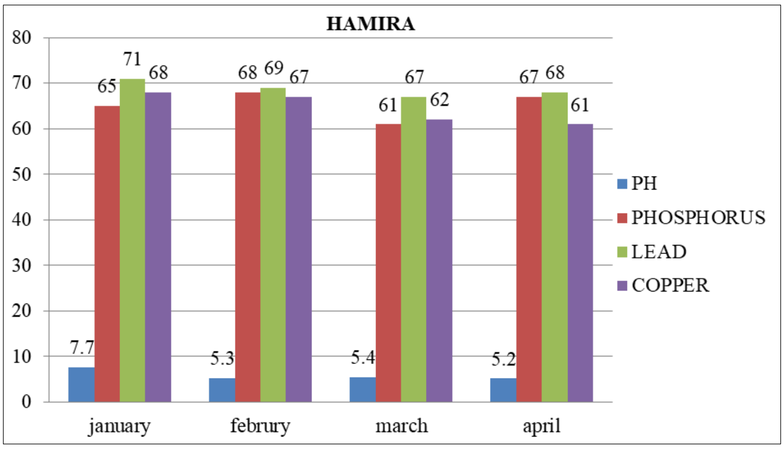
Graph 1: Basti Bawa



Graph 2: Kala Sanghia



Graph 3: Urban Estate



Graph 4: Hamira

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Conclusion
It can be concluded from the present study that to analyze the sludge, the physiochemical parameters like pH, Moisture and heavy metals like LEAD and COPPER from the industrial sludge. Results revealed that solubilization of metals using inorganic acids achieved its maximum extraction efficiency lead removal was noted to be 82.0% from the sludge sample, copper removal was noted to be 72.0% and phosphorous removal 69.0% from Industrial sludge. The present study depicts that organic acid remove heavy metal from sludge and can be used for the industrial waste management and other environmental maintenance.

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