Optimize the Industrial Water and Wastewater as an Aqueous Resource

Mahmoud Abdel-Rahman[1,] Ezzat Ahmed El-Fadaly[1], Mohammad Kamal Fattah[1] Hannan Farouk Tantawi [2]

1- Environmental Studies and Research Institute (ESRI),University of Sadat City, Egypt
2- National Research Center, Egypt

Abstract

The removal of toxic heavy metal from aqua solution using ceramic residuals as a low-cost sorbent was studied by use of ceramic residuals as non-expensive material in removal of heavy metal Change parameter to get best condition for removal cadmium and lead.In ancient time there are many ways to remove heavy metal from water such as chemical perception, electro-chemical, Ionic ex-change and adsorption among other. However, due to their high cost or difficult applying or non-availability material or added new source of pollution or low efficiency of removal at trace levels. Adoration is seen as low-cost ways and realistic solution. In my study, parameter such as PH, time, size of sorbent used were evaluated for each material ion in order to optimize the sorption uptake condition. The result shows that the metal uptake increased when the ceramic residuals area exposed also increased. The optimum PH for cadmium and lead was PH 6.0. This is favorable because it is near the PH of most natural water.

Keywords: Ceramic residuals; heavy metal; PH; cadmium; Lead.

Introduction

Pollution can be defined as any additional of substance or any form of energy to the environment. It has many types of pollution air pollution [1], water pollution [2], land pollution [3] and others. Water pollution happen when harmful substances accumulate in water system [4]. There are many effects of water pollution on human and health [5]. Among source of water pollution is heavy metal pollution [6]. Heavy metal was defined in the past which have a high atomic weight and high density which is five times more than water but recently definition concentrate on toxic nature of this elements [7]. Heavy metals have many characters as naturally

present in water (small amounts), toxic nature even at the low concentration [8], non-degradable the body of human haven't ability to metabolize these elements. So, it accumulated in body tissue. There are many sources of heavy metal pollution. Heavy metals influence ecosystem soil [9,10] on water [11,12] and air [13,14]. Heavy metals cause big problem for the ecosystem especially human, so we need to remove these metals. Many metals used for this purpose as carbon foam [15], activated carbon [16], clay minerals [17,18] organic polymers [19] and fly ash [20]. Water treatment residuals [21,22] and ceramic residuals . Ceramic residuals as materials has many advantages as low-cost, availability, easy use, have high ability in removal of heavy metals, high sorption capacity and does not cause a new source of pollution. Ceramic residuals has many good properties which help in removing of heavy metals as Ion exchange and adsorption properties [23,24]. Ceramic residuals can synthesis from low-cost material. There are many ways used in removal of heavy metals but the best one is adsorption [25]. This paper discusses adsorption by synthesis ceramic residuals . For removal of heavy metals (lead and calcium as example) by changing parameters (PH, time, Ceramic residuals dose) to obtain best condition for synthesis ceramic residuals in removal of heavy metals.

Materials And Methods

Materials and reagent

Arsenazo III (A.R grade) was obtained from Fluka AG (Buchs, Switzerland). Metal ion stock solution (concentration: 1000 mg L^{-1}) was prepared from cadmium nitrate $(Cd(NO_3)_2 \cdot 4H_2O)$ and $Pb(NO_3)_2$ supplied by Alfa Aesar. Cd(II) and Pb(II) were determined by atomic absorption spectrometry (AAS) GBC Avanta-EGf 3000, German. All other chemicals were obtained from Prolabo, and were used as received.

Characterization of materials

Fourier transform infrared spectra were recorded with the KBr disc method (using a Nexus 870 FTIR spectrometer, Nicolet, Thermo Fisher Scientific, Waltham, MA, USA). X-ray diffraction (XRD) patterns were measured using a Philips X-ray generator model PW 3710/31 (Philips, Japan). Nanocomposite structure of functionalized MCS was characterized using TEM (JEOL-2100, Tokyo, Japan). Textural properties (specific surface area and pore volume) were analyzed using a Quantachrome Nova 3200 (Quantachrome Instruments, Boynton Beach, FL, USA); the samples were degassed in vacuum, at room temperature, overnight, before analysis.

Metal sorption and desorption

Batch experiments were carried out by contact of 0.05 g of Ceramic residuals sorbent with 50 mL of aqueous solution (metal concentration, C_0: 20.92 mg Cu L^{-1} and C_0: 14.53 mg Pb L^{-1}) in a stopper conical flask. The samples were agitated (at 150 rpm) for 24 h at room temperature (25 $\pm$ 1°C). After equilibration and phase separation, the residual uranium concentration (Ceq, mg U L^{-1}) in the aqueous phase was determined. The amount of metal sorbed by Ceramic residuals was calculated using the following Eq. (1).

$$q_e = (C_o - C_e) \times \frac{V}{M} \tag{1}$$

The Removal efficiency is another specific parameter that gives an evaluation of the separation efficiency of the sorbent for the target metal:

$$\text{The Removal efficiency, (RE, \%)} = \frac{(C_o - C_e)}{C_o} \times 100 \tag{2}$$

where q_e is the metal uptake (mg/g), C_o and C_e are the initial and equilibrium metal concentrations in (mg/L), respectively, V is the solution volume (0.05 L), and M is the mass of biosorbent (0.05 g).The optimization of the process requires investigating a series of steps such as: study of pH effect from 2 to 8 using 0.1 N solution of HCl and NaOH, (b) the effect of Ceramic residuals dose (12.5, 25.0, and 50.0 mg/50 mL), and (c) kinetic data were obtained at designated time points (0 min to 1440 min).

Results And Discussion
Sorption properties

Effect of pH

The effect of pH on metal sorption may be influenced by different parameters, including metal speciation, metal precipitation (beginning with the formation of colloidal species), protonation/deprotonation of reactive groups, and sorbent stability (this may be at pH below 1.0) [26-27]. Figure 1 shows the effect of initial pH on removal efficiency and sorption capacity of Cd (II) and Pb (II). The sorption capacity increases almost linearly with initial pH for both metal ions. Maximum sorption of metal (II) ions was found to be at pH 6.0 with a removal efficiency 97.8 % for both metal ions. The sorption capacities are stabilized around 20.46 mg Cd g-1 and 14.21 mg Pb g-1. At lower pH, the surface charge of the adsorbent became positive, which inhibited the approach of positively charged metal ions. In addition, protons in the solution competed with metal ions for binding sites, thereby decreasing the interaction of metal ions with the adsorbent [27,28]. When the pH was increased, protons began to be desorbed, and the metal ions hooked up the free binding sites. Hence, the metal adsorption increased on the surface of the adsorbent. Similar phenomenon was obtained by other researchers during their investigations [26-29]. Under alkaline conditions at pH values greater than 7, deprotonation of the heavy metals binding

sites and precipitation of Metal (II) ions as insoluble hydroxides or hydrated oxides due to increasing concentration of OH-[29].
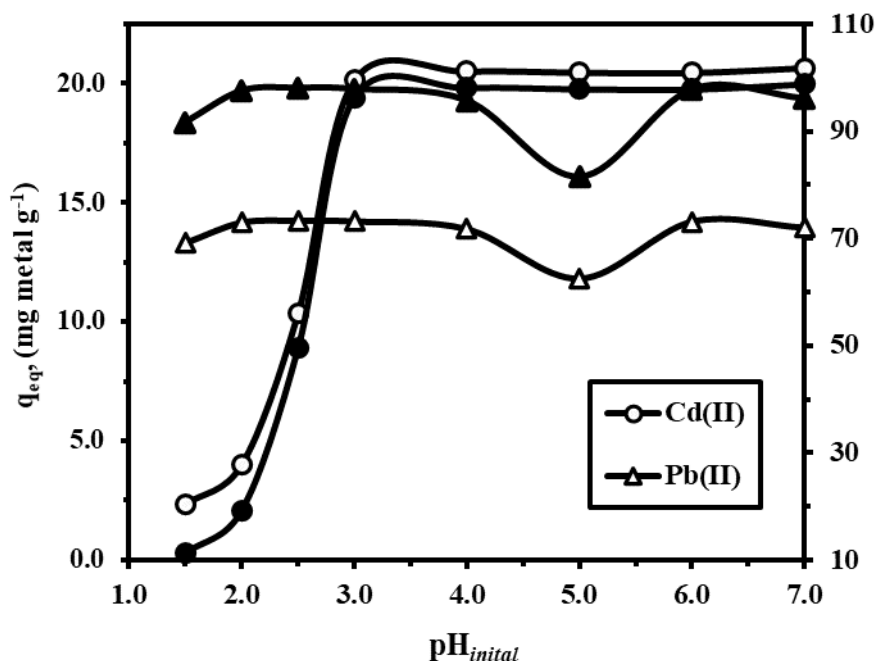

Figure 2. Effect of pH on the sorption of metal (II) ions using Ceramic residuals sorbent particles: sorption capacity versus initial pH (open symbols) and initial pH versus removal efficiency (RE, %) (closed symbols).

Effect of equilibration time and biosorption kinetic studies

Figure 2 shows of Cd (II) and Pb (II) ions sorption was investigated at different contact time from 0 to 480 min. Preliminary studies have shown that an extended contact time (extended up to 24 h) does not significantly change sorption performance. Figure 2 shows a plot of the sorption capacity qt (mg/g) versus time (t), the plot reveals that the kinetics of Cd(II) and Pb(II) ions adsorption mainly consists of two stages: an initial very rapid stage related to the instantaneous external surface adsorption of metal ions, that takes place for the first 15 min of contact and represents more than 99% of the total amount adsorbed, indicate that the metal(II)ions adsorption process proceeded fast and reached saturation levels gradually due to the strong affinity of the Cd(II) and Pb(II) ions for Ceramic residuals (correlated to both the affinity of these reactive groups for uranyl ions and to the increased number of reactive groups) [29-30].

Several kinetic models are needed to examine the mechanism of biosorption process from a liquid phase on EPSs and to interpret the experimental data. Pseudo-first-order rate equation (PFORE) and pseudo-second-order rate equation (PSORE) are used to explain the kinetics of biosorption to investigate the mechanism of adsorption [28-30].
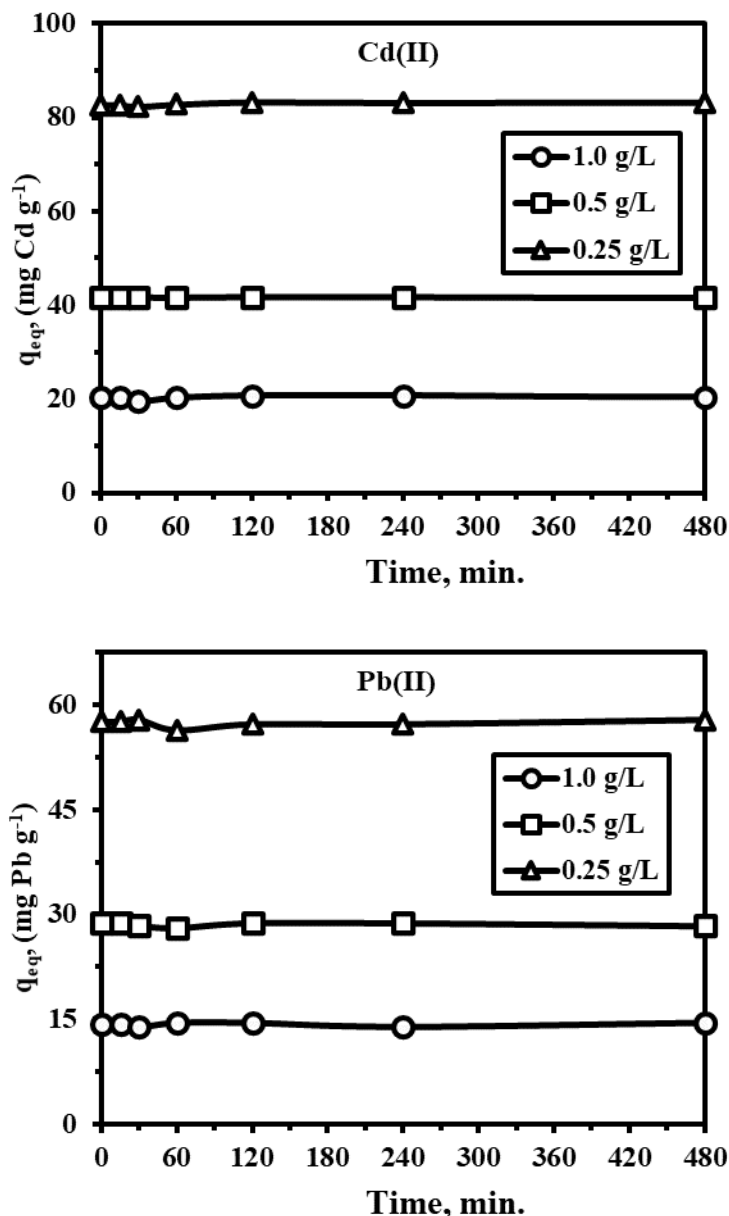
Figure 3. Effect of time on the sorption of Cu (II) and Pb(II) ions using Ceramic residuals sorbent particles at different sorbent dose (0.25 g L-1, 0.50 g L-1, and 1.0 g L-1) :

Effect of the Ceramic residuals dose

Figure 2 shows the effect of Ceramic residuals dosage on the sorption and removal of Cd (II) and Pb (II) ions. With the increase of sorbent dose, removal efficiency was first increased for both metal ion; reaching a maximum (98.8 %) at 15 min. and 1.0 g L-1and then slightly decreased. The result may be attributed to the increasing available binding sites. While increasing the sorbent dose after reaching the maximum, EPSs molecules would be partially aggregated and form bridging bonds, which resulted in a decrease in effective surface area and sorption sites for metal (II) ions leaving metal ions free [31]. Therefore, the optimum Ceramic residuals dose of 1.0 g L-1 was selected for next experiments.

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