Sorption Of Heavy Metals On Biosludge

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Abstract

Biosorption of Ni (II) and Cu (II) on the dead cell, which was obtained from the municipal wastewater treatment plant, was studied at various temperatures and pHs. It was found that the heavy metal sorption on the microorganisms was a function of initial solution pH. The lowest q_e values were observed at the pH value of 2.0. However, Increasing the pH value of 5.0, sorption capacities increased significantly. The sorption capacity of dead cell was not significantly changed with temperatures. Release of organic materials and ammonium from the cell was also determined in the solution.

Keywords: Biosorption, Copper, Nickel, Waste Sludge

Introduction

The conventional treatment methods which are used to remove heavy metals from aqueous solutions are chemical precipitations, filtration, ion exchange, evaporation, reverse osmosis, solvent extraction, electrochemical and membrane technologies. However, these methods are either inefficient or expensive when heavy metals exist in trace amounts. Consequently it is important to find new methods for removing heavy metals from water and wastewaters (Kumar et al., 2011). Heavy metals are non-biodegradable and tend to accumulate in aquatic organisms and transfer to consumers, including humans, leading to various health problems (Celekli and Bozkurt, 2011; Nuhoglu and Oguz, 2003; Kumar et al., 2011). Copper and nickel are toxic to aquatic organisms even at low concentrations in natural water.

Biosorption of heavy metals by dead cell has been much attention in recent years (Aksu and Donmez, 2001; Cojocaru et al., 2009; Gupta et al., 2006; Kapoor and Viraraghavan, 1997; Lokeshwari and Joshi, 2009; Nguema, et al., 2014; Pagnanelli et al., 2009; Rao and Bhagavi, 2013). Bacterial cell walls contain acidic functional groups and can bind significant amounts of cationic pollutants include heavy metals (Ginn and Fein, 2008).

This experimental study is focused on Cu(II) and Ni(II) removal from aqueous solutions using dried non-living waste sludge as biosorbents. Experiments were carried out at various pHs and temperatures. Especially, Cu (II) and Ni (II) sorption capacities and organics and NH_4-N release from the dead cell under different conditions were determined.

Materials and Methods

Biosorbent Preparation

Activated sludge biomass was used for the adsorption of Cu(II) and Ni(II) from synthetic wastewater. After being drawn from the settling tank of Sivas Wastewater Treatment Plant (WWTP), the activated sludge was repeatedly washed with tap and pure waters to remove impurities and dried at about 60 ^{0}C. The dried and dead biomass which was 0.1 g was added to the water solution of 100 mL. The pH of water solution was adjusted to target values using H_2SO_4 and NaOH solutions. The final pHs of the samples were measured after completing the experiments.

Sorption Experiments

The stock solutions of Cu(II) and Ni(II) were prepared at the concentration of 1000 mg/L using analytical grade of $NiCl_2.6H_2O$ and $CuCl_2$ in demineralized water. These stock solutions were used for the preparation of test solutions by dilution. The dried biomass was added to the solution (1.0 g/L) and the suspension was maintained under agitation (at the velocity of 150 rpm) on an orbital incubator shaker (Gerhardt) for 2 hours. Samples were collected and centrifuged at 4000 rpm for 10 min (NF800, NUVE). Concentrations of Ni(II) and Cu(II) in the solutions were determined by using a Merck photometer (PHARO100). Spectraquant analytical kits (Merck, 14785 and 14767) were used to measure Cu(II) and Ni(II) concentrations in the initial and final solutions. COD concentrations of the influent and effluent samples were determined according to standard methods (APHA, 1995). Concentrations of NH_4-N in the clear sample was determined with Merck photometer (PHARO 100) using analytical kits; NH_4-N (14752). The analysis of samples was carried out at the ambient temperature.

The equilibrium adsorption capacity of the organisms was determined by the Equation I.

$$q_e = \frac{(C_0 - C_e) \times V}{m} \quad (1)$$

Where q_e is the sorption capacity, E is the removal efficiency, C_o and C_e are the initial and final concentrations of heavy metals in the solution, V(L) is the volume of solution and m (g) is the sorbent amount.

Results and Discussion

Effects of pH

Since the value of pH effect the heavy metal speciation in the solution, the acidity of solution is an important parameter for the sorption of heavy metals from aqueous solutions (Chojnacka et al., 2005). The sorption of Ni(II) and Cu(II) were investigated as the function of pH value of 2.0, 3.0 and 5.0.

Significant variation between initial and final pH values were not observed during the study. The sorption capacity of dead cell is presented in Figure 1. As can be seen from the figure that, heavy metal sorption on the microorganisms was a function of initial solution pH. The lowest q_e value of 4.2 mg Cu(II)/ g sorbent and 3.3 mg Ni(II)/ g sorbent were observed at the pH value of 2.0. Increasing the pH value of 5.0, sorption capacities increased significantly to 18.6 g Cu(II)/g and 11.5 mg Ni (II)/g sorbent. It was assumed that the ionization degree of Cu(II) and Ni(II) and the surface property of the dead cell might be affected by the pH and q_e values for the studied metals were increased.

The dead cell contains organic matters and nitrogen. After adding the cell into the solution, organic matter and nitrogen are release from the cell compounds (Aslan and Topcu, 2015). Organic contents and NH_4-N concentrations in the water at various pHs are presented in Figure 2. The highest concentration of 158 mg COD /L was determined at a pH of 2.0. However, average ammonium-nitrogen concentration of 2.5 mg/L was measured throughout the experimental studies.

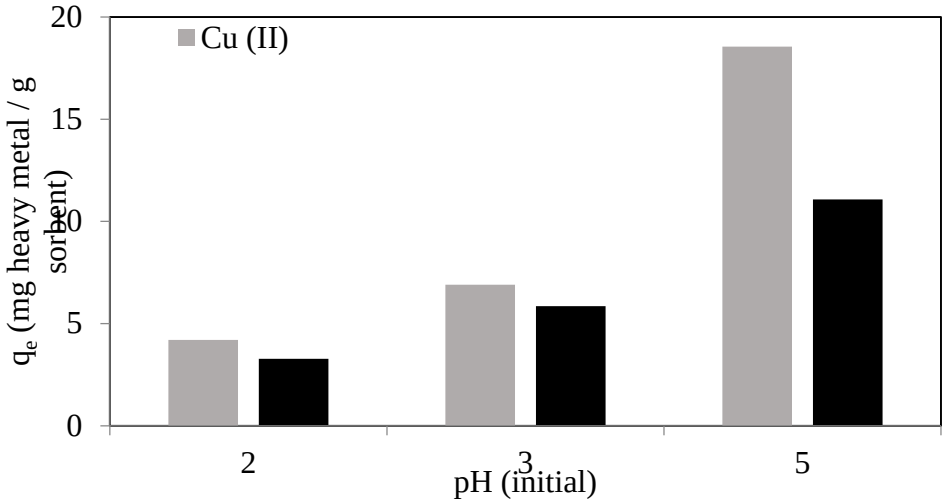

Figure 1. Effects of pH on the sorption capacities (Temperature = 40^0C)

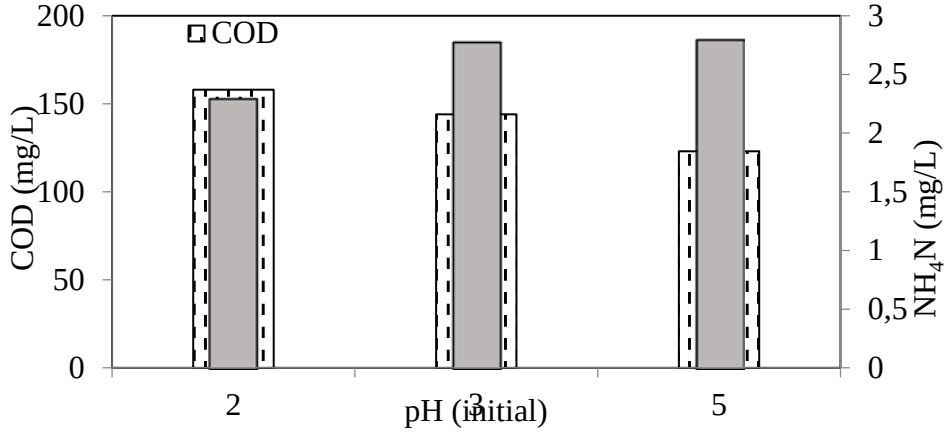

Figure 2. Variations of COD and NH_4-N concentrations under different temperature (Temperature = 40^0C).

Effects of Temperature

The sorption capacity of dead microorganisms was not significantly changed with temperatures. Average sorption capacities were 18.4 mg Cu(II)/g sorbent and 10.4 mg Ni (II)/ g sorbent were observed at a temperature of 30 ^{0}C. It was increased to about 18.9 mg Cu(II)/g sorbent and 11.0 mg Ni(II)/ g sorbent at a temperature of 50 ^{o}C (Figure 3). It was assumed that the cell components are released easily by the dead cell into the solution under low temperature conditions. The concentrations of COD and NH_4-N in the water are depicted in Figure 4. Elevating the temperatures from 30 to 50 ^{0}C, the release of organic contents into the aqueous solution increased from about 70.4 to 92 mg COD/L. However, NH_4-N concentrations in the solution were just increaed from 2.1 to 3.0 mg NH_4-N/L by increasing the temperature from 30 ^{0}C to 50 ^{0}C, respectively.

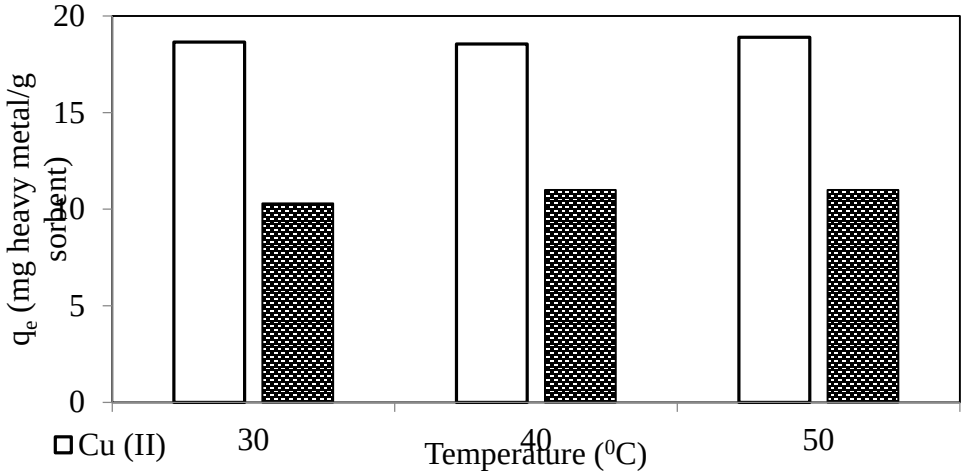

Figure 3. Temperature effect on the sorption capacity of dead cell.

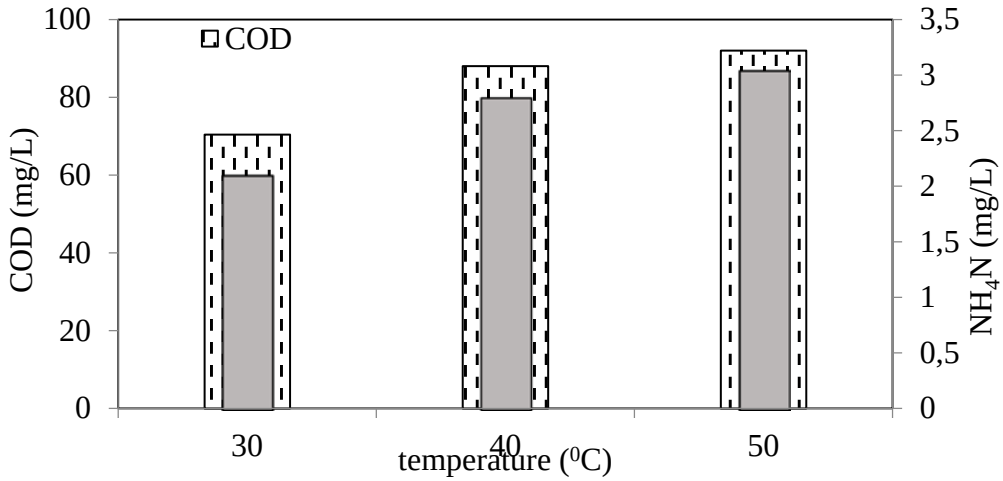

Figure 4. COD and NH_4-N concentrations variation under different tempeartures (initial pH= 5.0).

Conclusion

In this experimental study, the possibility of use of dead cell which was obtained from WWTP to remove Cu (II) and Ni (II) ions from aqueous solution was investigated. Experimental results indicating that the dead cell could be applied to remove heavy metal from aqueous solution. The highest q_e value was obtained at the pH value of 5.0. Biosorption of Cu(II) and Ni(II) was not temperature dependent. It was found that the cell components were easily released from the biosolid at the studied temperatures.

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