Adsorption Of Heavy Metals Onto Wastewater Treatment Plant Sludge

Sukru Aslan, Prof. Dr.
Cumhuriyet University, Turkey

Abstract

Heavy metals containing wastewater can cause serious environmental pollution problems for aquatic life. Adsorption is a well-established technique for pollutants removal and activated carbon is a widely used adsorbent material. However, use of activated carbon can be expensive due to the regeneration required and loses in the application processes. Biosorption is a recent technology used to remove heavy metal ions from aqueous solutions. In recent years investigators have studied inexpensive alternative materials for removal of heavy metal from wastewaters. Significant amount of waste sludge is produced in the industrial and municipal waste water treatment plant. Waste sludge disposal is one of the most important problems in the world. The waste activated sludge provides an excellent opportunity for removal of heavy metals by biosorption because of its availability and free use. Usage of the waste sludge as biosorbent was evaluated in this study.

Keywords: Biosorption, Heavy metals, Waste Biosludge

Introduction

Heavy metals in the wastewater effluents cause serious environmental problems in water body and soil and it has been a great motivation for the increasing number of research on effluent treatment processes (Buema et al., 2013). Heavy metals, which are called trace elements, may negatively affect the soil ecology, agricultural production or quality, and ground water quality (Nazir et al., 2015). The ultimate source of the body trace elements is generally rocks and concentration of trace elements is varying by rock type in the area.

Metal ions can be incorporated into food chains and accumulated in aquatic organisms to a level that affects their physiological state. Due to the trace heavy metals such as Zn, Cu and Fe play a biochemical role in the life processes of all aquatic plants and animals, they are essential in the aquatic environment (Saeed and Shaker, 2008).

The main sources of heavy metals contamination of drinking water are industrial wastes and agriculture activities. Additionally, the old pipe systems in some areas have another source from the corrosion of water pipes (Salem et al., 2000). Pollution of the aquatic environment by heavy metals has been considered a major threat to the aquatic organisms (Saeed and Shaker, 2008). The disposal of wastewater effluents containing heavy metals is related to a great number of industrial processes, such as: electroplating, chemical manufacture, leather tanning, oil refining, mining and mineral processing (Hammaini et al., 2007).

Heavy metals are highly accumulated in sediments than water (Saeed and Shaker, 2008; Hamed, 1998; Nguyena et al. 2005) and they are non-biodegradable. Heavy metals tend to accumulate in organs of aquatic organisms and transfer to consumers, leading to various health problems (Celekli and Bozkurt, 2011; Kumar et al., 2011; Nuhoglu and Oguz, 2003; Salem et al., 2000). Some heavy metals tend to accumulate different organs of fish, for example; the concentration of heavy metals in fish gills and liver is much higher than that in muscles (Saeed and Shaker, 2008; Jobling, 1995).

Because of the serious problem in water environment, heavy metals should be removed from the effluents wastewater. Although, the conventional treatment methods such as chemical precipitations, filtration, ion exchange, evaporation, reverse osmosis, solvent extraction, electrochemical and membrane technologies are widely used for heavy metal separation, these methods are either inefficient or expensive when the water contains trace amounts of heavy metals. Many researchers have been investigated new methods to remove heavy metals in wastewaters (Kumar et al., 2011). Among these process, adsorption is the most widely method to remove heavy metals from water contain trace concentrations of heavy metals.

The activated carbon has been widely used to remove heavy metals from wastewater and waters (Kadirvelu et al. 2001; Karnib et al., 2014; Kobya et al., 2005). Due to the high cost of activated carbon, the application of waste materials has been much attention in last decades (Aslan et al., 2016).

Municipal Wastewater Treatment Plants (WWTP)

Most of the WWTPs contain anaerobic, aerobic and anoxic stages to remove organic and inorganic compounds (mechanical/primary treatment is not considered). A biological treatment process is carried out by microorganisms in suspension or attached to media to remove biodegradable organic material, nitrogen compounds and phosphorous in the wastewaters. Part of the organic material is oxidized to carbon dioxide and other end products. The remainder of organic materials is converted to microorganisms.

A yield coefficient (Y) of heterotrophic and autotrophic bacteria were proposed between as 0.30–0.58 mg VSS/mg COD (Sykes, 1975; Tchobanoglous et al., 2004) and 0.02–0.12 mg VSS/mg NH_3-N (Aslan and Gurbuz, 2011 Eckenfelder, 1989; Tchobanoglous et al., 2004).

Significant amount of waste sludge was produced in the WWTP. Dry solids sewage sludge production was about 9 millions tonnes in 2005 (Laurent et al., 2010). The waste sludge management is one of the most important environmental problems in Turkey. After dewatering, dry waste sludge, which contains about 60-70% water, is transferred to a landfill site or incinerated. Landfill deposition increases the costs for the treatment plant because sludge management can reach 60% of total operation costs, even though its volume accounts for only 1–2% of the total volume of treated effluent (Alexandre et al., 2015).

Activated sludge mixture contains mainly floc forming bacteria and protozoa (Jianlong et al., 2000). Bacterial cells (the general empirical formula is $C_5H_7O_2N$) are highly complex structures containing a variety of carbohydrates, proteins, fats, and nucleic acids, some with very high molecular weights (Rittmann and McCarty, 2001). Bacterial cell walls contain acidic functional groups. Cationic pollutants like heavy metals could be adsorbed onto the walls of cell (Ginn and Fein, 2008). The protozoa are unicellular, motile and relatively large eucaryotic cells that lack cell walls. Bacteria and protozoa can adsorb components through their outer membranes (Jianlong et al., 2000). Comparing with other types of biosorbents, dried sludge of WWTP represents a low cost, easily available and well sedimenting material with a large specific surface area which is suitable for the removal of toxic metals (Remenarova et al., 2012).

In recent years, waste sludge is applied as adsorbent to remove heavy metals in the wastewater. This novel approach is considered as competitive, effective, and cheap (Nuhoglu and Ogus, 2003). Experimental results indicated that it could be successfully applicable dried sludge of wastewater treatment plant for heavy metal adsorption in water solution (Table 1).

Table 1. Heavy metal biosorption onto waste sludge

Heavy metals	q_e (mg heavy metal/g adsorbent)	References
Cr^{6+}	86.2	Ozdemir et al. (2003)
Cd^{2+}	37.3	
Cu^{2+}	32.6	
Cd^{2+}	157	Pagnanelli et al. (2009)
Pb^{2+}	30.2	
Cd^{2+}	57.3	Remenarova et al. (2012)
Zn^{2+}	35.2	
Zn^{2+}	17.86	Yang et al. (2010)
Cu^{2+}	18.9	Hammaini et al. (2007)
Cd^{2+}	28.1	
Zn^{2+}	15.7	
Ni^{2+}	8.8	
Pb^{2+}	143	
Cd^{2+}	107.6	Laurent et al. (2010)
Cu^{2+}	156	Pamukoglu and Kargi (2006)
Zn^{2+}	82	Kargi and Cikla (2006)
Zn^{2+}	5.9	Bux et al. (1999)
Cu^{2+}	294	Gulnaz et al., (2005)
Cu^{2+}	87.7	Wang et al. (2006)
Pb^{2+}	131.6	
Cu^{2+}	18.4	Ong et al. (2013)
Cd^{2+}	9.6	
Ni^{2+}	18.6	

The dead cell contains organic and inorganic matters and experimental results indicated that organic and inorganic compounds such as organic matter, NH_4-N, Ca^{2+} and Mg^{2+} are released from the cell into the water solution (Aslan et al., 2016; Aslan and Topcu, 2015; Laurent et al., 2010). Temperature and pHs of the solution affect the concentrations of released compounds in the water.

Conclusion

Wastewater sludge disposal is a big problem in the world. Land application, land filling and incineration are widely applied for sludge disposal. However, these methods cause various environmental problems. Laboratory studies indicated that waste sludge after drying successfully applied for heavy metal removal.

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