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Sequestering heavy metals from wastewater using cow dung

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ABSTRACT

The presence of heavy metals (e.g., Zn, Cu, Pb, Ni, Cd, etc.) in aqueous solutions constitutes a major environmental problem. The present work represents a review of the recently published literature discussing the use of cow dung as adsorbent for the removal of metal ions from aqueous solution using batch experiments. The potential health and environmental hazards of metal ions in addition to the kinetic and isothermal models usually assessed to fit the biosorption experimental data were also reviewed. Conclusively, it was established that the use of cow dung is a promising adsorbent in the removal of heavy metals from waste waters and environment.

Contents

1. Introduction

The presence of inorganic pollutants such as metal ions in the ecosystem cause a major environmental problem. Toxic metal compounds coming to the earth's surface not only contaminate earth's water (seas, lakes, ponds and reservoirs),but can also contaminate underground water in trace amounts by leaking from the soil after rain and snow [1]. There are numerous metals which are significantly toxic to human beings and ecological environments, they include chromium (Cr), copper (Cu),lead (Pb),cadmium (Cd), mercury (Hg), zinc (Zn), manganese(Mn) nickel (Ni), etc [2]. Heavy metals constitute an important part of environmental pollutants and source of poisoning [3]. They are present (in various forms) in the soil, natural water and air and may become contaminants in food and drinking water [4]. Some of them are constituents of pesticides, paints and fertilizers application.

Due to the hazards associated with the contamination of water, there had been the development of various technologies for water purification such as filtration and ion-exchange, precipitation with carbonate or hydroxide [5].

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Concentration of metal beyond the tolerance level may be regarded as toxic if it affects the growth or metabolism of cells [6]. The lethal toxicity mechanism of a high concentration of heavy metal during a short term exposure disrupts the respiratory surface while during long term exposure; the metal gets accumulated in the internal organs [7]. Due to various advancements in industrial activities, the levels of discharge of these heavy metals have increased. Some of these toxic pollutants like Pb, Cr, Cd get processed into food through various ways [8].

Due to the numerous threats posed by heavy metals in the environment, it is very important to reduce the presence of these toxic metals in environment. Some of the methods which have been employed till date are electrolytic deposition, electro dialysis, electrochemical, evaporation, precipitation, ion exchange, reduction, reverse osmosis. [9]. However, most of these methods are associated with high instrumental and operational costs [10]. Thus, employing remediation biologically can be very cost effective and highly efficient. For this purpose, plants, microbes or biodegradable waste (e.g. dead leaves, vegetable peels) can be employed.

Several researchers have reported the potential use of agricultural by-products as good adsorbents for the removal of metal ions from aqueous solutions and wastewaters. This process attempts to put into use the principle of using waste to treat waste and become even more efficient because these agricultural by-products are readily available and often pose waste disposal problems. Hence, since they are waste products, they are more cost-effective when compared with the conventional adsorbents like activated carbon. Also, the use of agricultural by-products for wastewater treatment does not involve complicated regeneration process [11].

Many attempts to convert carbonaceous materials into activated carbon for heavy metals removal have been reported in the literature [12]. These include pecan shell [13], apricot stone [14], coconut shell [15], peanut shell [16], wheat bran [17], coconut and seed shells of palm tree [18], rubber wood sawdust [19], rice husk [20]and corncob [21]. Activating agents comprise steam, CO_2, $ZnCl_2$, H_2SO_4 and H_3PO_4,KOH and NaOH [12]. It has been reported that activation using $ZnCl_2$ demonstrate a small weight loss during the carbonization process [22]. A few researchers also utilize animal waste for the same reason [23]. The aim of the present review work is to investigate the use of cow dung as an adsorbent for removing heavy metals from aqueous solutions.

2. Effects of heavy metals

Water polluted with heavy metals from various industries has been a serious environmental problem for many years. Heavy metals are not biodegradable and hence accumulate in water bodies and aquatic creatures therein. They can easily enter the food chain because of their high solubility in water. Excessive consumption of these sources can cause a number of illnesses such as diarrhea, nausea, brain disorders, liver and renal dysfunctions, and cancers [24]. Thus, it is essential to remedy metal-contaminated effluents before they are discharged into the environment.

Metal ions are reported as priority pollutants, due to their mobility in natural water ecosystems and their toxicity [25]. The problem associated with metal ions pollution is that they are not biodegradable and are highly persistent in the environment. Thus, they can be accumulated in living tissues, causing various diseases and disorders [26]. Heavy metal toxicity can result in damage to or reduced mental and central nervous functions, lower energy levels and damage to blood composition, lungs, kidneys, liver and other vital organs [27]. The potential health hazards of some metal ions as given by the EPA [28] are summarized in Table 1.

Table 1
List of some heavy metals and their health hazards [28]

Contaminants	Potential health effects from long-term exposure above the maximum contamination level
Antimony	Increase in blood cholesterol; decrease in blood sugar
Arsenic	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer
Barium	Increase in blood pressure
Cadmium	Kidney damage
Chromium (total)	Allergic dermatitis
Copper	Short term exposure: Gastrointestinal distress. Long term exposure: Liver or kidney damage
Lead	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities Adults: Kidney problems; high blood pressure
Mercury (inorganic)	Kidney damage
Selenium	Hair or fingernail loss; numbness in fingers or toes; circulatory problems

3. Source of exposure

Heavy metals are released into the environment from many sources. Arsenic is introduced in water through natural and anthropogenic sources: release from mineral ores, probably due to long-term geochemical changes and from various industrial effluents like metallurgical industries, ceramic industries, dye and pesticides manufacturing industries and wood preservatives [29].

The major sources of antimony released into the environment through wastewater streams are industries such as lead-storage batteries, soldering, bearing and power transmission equipment, sheet and pipe metals,ammunition, flame retardants, ceramics, casting, pewter,enamels, and paints [30].

Wastewaters such as those generated during dyes and pigments production, film and photography, galvanometry, metal cleaning, plating and electroplating, leather and mining may contain undesirable amounts of chromium (VI) anions [31].

Cobalt, which is widely used in alloys (especially magnetic steels and stainless steels), electronics, porcelain and radioisotope therapy, is now commonly found in contaminated water [32].

Manganese is released into the environment by industries such as those involved in the production of fertilizer, petrochemicals, electroplating, tanneries, metal processing, and mining [33].

Mercury can be found in wastewater discharged from chlor alkali, paper and pulp, oil refinery, paint, fossil fuel burning, metallurgical processes, pharmaceutical and battery manufacturing [34].

Effluents from production of batteries,gasoline additives, pigments, alloys and sheets etc. Often contain high concentrations of lead ions [35].

Mining and metallurgy of nickel, stainless steel, aircraft industries, nickel electroplating, battery and manufacturing, pigments and wastewaters from ceramic industries contain high amounts of nickel ions [36].

Zinc can be found in wastewater from metallurgical processes, galvanizing plants, stabilizers, thermoplastics, pigment formation, alloys and battery manufacturing in addition to the discharges of municipal wastewater treatment plants [34].

Industrial wastewaters are a major source of pollution in the environment. They discharge toxic heavy metals into the environment and cause health problems among animals [37,38,39]. The discharge of toxic metal effluents by various industries resulted in both land and water pollution and the destruction of