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Removal of Heavy Metal Ions from Polluted Waters by Using of Low Cost Adsorbents: Review

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Abstract: Adsorption is a fundamental process in the physicochemical treatment of wastewaters which industries employ to reduce hazardous organic and inorganic wastes in effluents. In recent years the use of low-cost adsorbents has been widely investigated as a replacement for the currently costly methods of removing heavy metal ions from wastewater. It is well-known that cellulosic waste materials can be obtained and employed as cheap adsorbents and their performance to remove heavy metal ions can be affected upon chemical treatment. In this study, the use of some of low cost adsorbents for the removal of heavy metals from wastewater has been reviewed.

Keywords: adsorption, heavy metals, low cost adsorbents, waste water

INTRODUCTION

In the past century there has been a rapid expansion in industries. This has led to an increase in the complexity of toxic effluents. Several industrial processes generate metal containing wastes. One of polluants is heavy metals. Heavy metals constitute a very heterogeneous group of elements widely varied in their chemical properties and biological functions. The term “heavy metals” defined as commonly held for those metals, which have specific weights more than 5g cm^{-3}[1]. Heavy metals are kept under environmental pollutant category due to their toxic effects in plants, human and food. Some of the heavy metals. Arsenic (As), Cadmium (Cd), Lead (Pb), Mercury (Hg) are cumulative poison. These heavy metals are persistence, accumulate and not metabolized in other intermediate compounds and do not easily breakdown in the environment. These metals are accumulating in food chain through uptake at primary producer level and then through consumption at consumer level. Metals are entering the human body either through inhalation or injection.Heavy metals such as Cd, Ni, As, Pb pose a number of hazards to humans. These metals are also potent carcinogenic and mutagenic. Copper and zinc serve either as cofactor as an activator biochemical reactions & enzymatic for information of enzyme/ substrate metal complex [2].The high concentration intake of cadmium cause disease and mercury intake lead to minamita disease and other heavy metals cause poisoning due to drinking water contamination.Heavy metals have largest availability in soil and aquatic ecosystem and to relatively smaller proportion in atmosphere at particular vapors. Metal toxicity to plants varies with plants species, specific metals, concentration, chemical form, soilcomposition, pH and many metals considered to be essential for plants growth.

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Heavy metals pollution can originate from natural and anthropogenic sources. Heavy metal pollution of surface and underground water sources results in considerable soil pollution and pollution increases when mined ores are dumped on the groundsurface for manual dressing. Activities such as mining & smelting operation and agriculture have contaminated the air of some of extensive areas of world.

In animal body, metals are entering through animals' feeds, green fodder, drinking water, pharmaceutical medicines, and etc. Other sources are accidental access to limed field, mineral supplements with high content of trace metal and licking of painted surfaced containing metallic pigments.The tolerance limits of some heavy metals are shown in Table 1. Heavy metals can be classified into four major groups on their health importance.

*Essential:*Cu, Zn, CO, Cr, Mn and Fe. These metals also called micronutrients [3] and are toxic when taken in excess of requirements [4].

*Non-essential:*Ba, Al, Li and Zr

*Less toxic***:** Sn and Al

*Highly toxic:*Hg, Cd and Cd. Heavy metals are also called trace element due to their presence in trace (10mg Kg^{-1}) or in ultra-trace (1μg kg^{-1}) quantities in the environmental matrices.

Table 1: The tolerance limits of some heavy metals in air, soil and water.

Heavy metal	**Max conc. in air (mg/m3)**	**Max. conc. sludge in (soil) (mg/ Kg or ppm)**	**Max. conc. in drinking water (mg/l)**	**Max conc. in H20 supporting aquatic life (mg/l or ppm)**
Cd	0.1-0.2	85	0.005	0.008
Pb	- -	420	0.01 (0.0)	0.0058
Zn	1, 5*	7500	5.00	0.0766
Hg	- -	<1	0.002	0.05
Ca	5	Tolerable	50	Tolerable >50
Ag	0.01	- -	0.0	0.1
As	- -	- -	0.01	- -

Because of reasons that were said, therefore they must be removed before discharge. Chemical precipitation, ion-exchange, electro flotation, membrane separation, reverse osmosis, electro dialysis, adsorption, solvent extraction, etc. are type of removal method. Adsorption is a process that uses solids for removing substances from either gaseous or liquid solutions. Adsorption phenomena are operative in most natural physical, biological, and chemical systems. The process of adsorption involves separation of a substance from one phase accompanied by its accumulation or concentration at the surface of another. Physical adsorption is caused mainly by van der Waals forces and electrostatic forces between adsorbate molecules and the atoms which compose the adsorbent surface. Adsorption capacity depends on activated carbon properties, adsorbate chemical properties, temperature, pH, and etc. Several adsorbents can be used to treat industrial wastewater. Activated carbon is a well-known adsorbent and has proven to be useful for the removal of heavy metals. Nevertheless, the application of activated carbon for wastewater treatment is not feasible due to its high price and cost associated with the regeneration as a result of high-degree of losses in real process [5]. McKay and Carvalho *et al*. [6] used activated carbon to adsorb contaminants from wastewater. In addition, the use of other adsorbents such as synthetic polymeric and silica based adsorbents has been reported. Many activated carbons are available but few are selective. These are expensive as well. Therefore the research thirst over the years is leading to find improved and tailor-made materials, which will meet several requirements such as regeneration capability, easy availability, cost effectiveness, and etc.

Consequently, low-cost adsorbents have drawn attention to many researchers and characteristics as well as application of many such adsorbents are reported.

REVIEW OF COMMERICAL ADSORBENT

Activated Carbon

The most widely used adsorbent for industrial applications is activated carbon [7]. It is a well-known adsorbent due to its extended surface area, micro porous structure, high adsorption capacity and high degree of surface reactivity. The structure consists of a distorted three dimensional array of aromatic sheets and strips of primary hexagonal graphic crystallites .This structure creates angular pores between the sheets of molecular dimensions which give rise to many of the useful adsorption properties of activated carbon. Pore size ranges from 1 nm to 1000 nm, and the extensive porosity is responsible for the high surface area of the material usually 500 - 1500 m^2/g .Any carbon material can be used to make activated carbon; however, commercial activated carbon is manufactured from only a few carbon sources; wood, peat, coal, oil products, nut shells and pits. The activating chemical corrodes the carbon to form the pore structure and they are usually strong acids, bases or corrosives [8]. The final pore structure depends on the nature of the starting material and the activation process [9]. Macro- and mesopores can generally be regarded as the highways into the carbon particle, and are crucial for kinetics. The micro pores usually constitute the largest proportion of the internal surface of the activated carbon and contribute most to the total pore volume. Activated carbon has both chemical and physical effects on the substance where it is used as a treatment agent. Adsorption is the most studied of these properties in activated carbon [9]. Heavy metal removal by adsorption using commercial activated carbon has been widely used.However, high costs of activated carbon and 10-15% loss during regeneration makes its use prohibitive in the developing countries like South Africa.Commercial activated carbon also requires complex agents to improve its removal performance for heavy metals. Therefore this situation no longer makes it attractive to be widely used in small-scale industries because of cost inefficiency .This has led to a search for cheaper carbonaceous substitutes. In order to overcome the problems associated with the activated carbon, low cost adsorbents have been reported in the present work.

Silica gel

Silica gel is a non-toxic, inert and efficient support and is generated by decreasing the pH value of the alkali silicate solution to less than ten. The solubility of silica is then reduced to form the gel and as the silica begins to gel, cells in silica are trapped in a porous gel, which is a three-dimensional $SiO2$ network [10]. Porous silica gel is an inorganic synthetic polymeric matrix often used to entrap cells and its use for entrapment is called the sol-gel technique [11]. Reactive sites of silica gel exist in large numbers, and therefore, the number of immobilized organic molecules is high, which results in good sorption capacity for metal ions.

Activated alumina

Activated alumina is a filter media made by treating aluminum ore so that it becomes porous and highly adsorptive. It can also be described as a granulated form of aluminum oxide. Activated alumina removes a variety of contaminants that often co-exist with fluoride such as excessive arsenic and selenium [12]. The medium requires periodic cleaning with an appropriate regenerator such as alum or acid in order to remain effective. Activated alumina has been used as an effective adsorbent especially for point of use applications. The main disadvantage of activated alumina is that the adsorption efficiency is highest only at low pH and contaminants like arsenates must be peroxided to arsenates before adsorption. In addition, the use of other treatment methods would be necessary to reduce levels of other contaminants of health concern.

REVIEW OF LOW COST ADSORBENT

In the adsorption process activated carbon is most popular and widely used adsorbent in wastewater treatment throughout the world, but the high prices and regeneration cost of activated carbon limits their large-scale use for the removal of inorganic and organic pollutants, and has encouraged researchers to look for low cost adsorbing materials. Recently, adsorption of heavy metals using natural materials or the wastes products from industrial or agricultural operations has emerged as an option for developing economic and eco-friendly wastewater treatment processes. Numerous low-cost adsorbents have so far been studied for the removal of arsenic from water and wastewater. Lignin, fly ash, clay, zeolites, blast furnace slags,Sawdust andetc. are some of types of low cost adsorbents that are mentioned here.Loss of metal ions from their solutions in the presence of these materials may be due to the adsorption on surface and pores, and to complete by these materials.

Lignin

Lignin or lignen is a complex chemical compound most commonly derived from wood, and an integral part of the secondary cell walls of plants and some algae [13]. The term was introduced in 1819 by de Candolle and is derived from the Latin word lignum [14], meaning wood. It is one of the most abundant organic polymers on Earth, exceeded only by cellulose, employing 30% of non-fossil organic carbon [15], and constituting from a quarter to a third of the dry mass of wood. As a biopolymer, lignin is unusual because of its heterogeneity of a defined primary structure .Its most commonly noted function is the support through strengthening of wood (xylem cells) in trees [16]. In lignin structure there is an aromatic three – dimensional polymer structure containing a number of functional groups such as phenolic, hydroxyl, carboxyl, benzyl alcohol, methoxyl, and aldehyde groups,making it potentially useful as an adsorbent material for removal of heavy metals from water [17].Lagtah and his colleagues[18] have studied the use of lignin as an adsorbent and as a precursor of activated carbons (ACs) in order to remove Cd^{+2}, Cu^{2+} and Zn^{2+} ions from aqueous solutions.Guo and his colleagues [19] has studied adsorption of metal ions on lignin. Suhas and his colleagues [20] have reviewed the literature on lignin as a biosorbent. Sarivasta and his colleagues [21] obtained remarkably high uptake of Pb (II) and Zn (II), up to 1587 and 73 (mg / g) for Pb (II) and Zn (II),respectively, by using lignin extracted from black liquor.

*Flyash*Fly ash is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. Ash which does not rise is termed bottom ash. In an industrial context, fly ash usually refers to ash produced during combustion of coal. Fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys of coal-fired power plants and together with bottom ash removed from the bottom of the furnace is in this case jointly known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline) and calcium oxide (CaO), both being endemic ingredients in many coal-bearing rock strata (table.2). Toxic constituents depend upon the specific coal bed makeup, but may include one or more of the following elements or substances in quantities from trace amounts to several percent: arsenic, beryllium, boron, cadmium, chromium, chromium VI, cobalt, lead, manganese, mercury, molybdenum, selenium, strontium, thallium, and vanadium, along with dioxins and PAH compounds[22].

In the past, fly ash was generally released into the atmosphere, but pollution control equipment mandated in recent decades now requires that it be captured prior to release. In US, fly ash is generally stored at coal power plants or placed in landfills. About 43% is recycled [23], often used to supplement Portland cement in concrete production. Some have expressed health concerns about this [24]. In some cases, such as the burning of solid waste to create electricity ("resource recovery" facilities a.k.a. waste-to-energy facilities), the fly ash may contain higher levels of contaminants than the bottom ash and mixing the fly and bottom ash together brings the proportional levels of contaminants within the range to qualify as nonhazardous waste in a given state, whereas, unmixed, the fly ash would be within the range to qualify as hazardous waste.Fly ash material solidifies while suspended in the exhaust gases and is collected by electrostatic precipitators or filter bags. Since the particles solidify rapidly while suspended in the exhaust gases, fly ash particles are generally spherical in shape and range in size from 0.5 µm to 300 µm. The major consequence of the rapid cooling is that only few minerals will have time to crystallize and that mainly amorphous, quenched glass remains. Nevertheless, some refractory phases in the pulverized coal will not melt (entirely) and remain crystalline. In consequence, fly ash is a heterogeneous material. SiO_2, Al_2O_3, Fe_2O_3 and occasionally CaO are the main chemical components present in fly ashes [25]. Two classes of fly ash are defined by ASTM: Class F fly ash and Class C fly ash. The chief difference between these classes is the amount of calcium, silica, alumina, and iron content in the ash. The chemical properties of the fly ash are largely influenced by the chemical content of the coal burned (i.e., anthracite, bituminous, and lignite) [26]. In some of studies, efforts have been done to the use of fly ash as a low-cost adsorbent in the treatment of wastewater bearing heavy metals. Fly ash is strong alkali material, which exhibits pH of10–13 when added to water, and its surface is negatively charged at high pHs. Hence, it can be expected that metal ions can be removed from aqueous solutions by precipitation or electrostatic adsorption. In fact, a number of studies were conducted to show the effectiveness of fly ash in the removal of heavy metal ions [27–32]and organic materials from aqueous solutions. The adsorption capacity of fly ash very much depends on the surface activities, in other words, the specific surface area available for solute surface interaction, which is accessible to the solute. This phenomenon is expected, as the size of the particle decreases, surface area of the adsorbent increases, thereby the number of active sites on the adsorbent are better exposed to the adsorbate. Adsorption of metals on fly ash depends on both the initial concentration of metal ions and the contact time. It was reported that the initial concentration of metal ions has a strong effect on the adsorption capacity of fly ash. Generally adsorption capacity increases with an initial concentration of the solute. The effect of contact time on the removal of metals to reach equilibrium varies depending on the type of metals. As the time increases, more amounts of metal gets adsorbs onto the surface of the adsorbent and surface area available decreases. The adsorbate, normally, forms a thin one molecule thick layer over the surface. When this monomolecular layer covers the surface, the capacity of the adsorbent is exhausted. So fly ash can be used as low cost adsorbent. In continue, examples have been brought that are evidences that show fly ash is good adsorbent for removal of heavy metals. Heechan Cho and his colleagues [33] have investigated the possibility of the utilization of coal fly ash as a low cost adsorbent. Batch experiments were conducted to evaluate the removal of heavy metals from aqueous solutions by fly ash under various conditions of metal concentration, pH and fly ash dosage. The heavy metals used in this study were zinc, lead, cadmium and copper. Experiments were also conducted without fly ash to determine the extent of heavy metal removal by precipitation. Kinetic and isotherm experiments were also performed. Julia Ayala and his colleagues [34]considered the efficiency of fly ash in the removal of heavy metals (Cd and Cu). The removal phenomenon appears to be that the fly ash neutralizes the metal solution due to its alkaline nature. So there are evidence that fly ash can be used in industrial applications and waste water treatment.

Table2: chemical composition of fly ash

Component	**Bituminous**	**Subbituminous**	**Lignite**
SiO_2 (%)	20-60	40-60	15-45
Al_2O_3 (%)	5-35	20-30	20-25
Fe_2O_3 (%)	10-40	4-10	4-15
CaO (%)	1-12	5-30	15-40
LOI (%)	0-15	0-3	0-5

Clay

Clays are hydrous aluminosilicates broadly defined as those minerals that make up the colloid fractions of soils, sediments, rocks and water and may be composed of mixture of fine grained clay mineral sand clay – sized crystals of the minerals such as quartz, carbonate and mineral oxides. The adsorption capabilities of clay results from a net negative charge on the structure on fine – grain silicate minerals. This negative charge in neutralized by the adsorption of positively charges species, giving clay the ability to attract and hold cautions such as heavy metal[35].

Blast furnace slags

Similarly to a series of natural and synthetic inor- ganic sorbents, metallurgical slags possess sorption properties. The possibility of efficient removal of dissolved heavy metals by slags from ferrous and nonferrous metallurgy has been shown by Dushina his colleagues [36] and Yamashita his colleagues [37]. However, the sorption on these solid surfaces has not been sufficiently investigated. The great variety ore or iron pellets, coke and a flux (either limestone or dolomite) are melted together in a blast furnace. When the metallurgical smelting process is complete, the lime in the flux has been chemically combined with the aluminates and silicates of the ore and coke ash to form a non-metallic product called blast furnace slag (table.3). During the period of cooling and hardening from its molten state, BF slag can be cooled in several ways to form any of several types of BF slag products. In the recent years, of slags depending on their chemical, mineral and phase compositions and the absence of a definite opinion on the control and mechanism of the process makes the regulation of the sorption properties, and hence, the applicability of the slags as sorbents difficult.

Other authors have been noted that slags are, similarly to calcium silicate minerals, ion exchanging and even their low solubility in electrolyte solutions is associated with other interactions leading to changes in the sorbent active mass. In our opinion such effects and phenomena are specific and depend on the kind of the slag (its mineral and phase composition), the nature and concentration of sorbed metal ions as well as on the regime of the process. Blast FurnaceSlag is formed when iron

BFS was developed as an adsorbent. BFSs appear to have considerable potential as low cost sorbent of phosphorus lead [38], copper, and plumbuml from aqueous solutions. Kinetic sorption modeling [39] of Cu, Ni, Zn, Pb and Cr ions to blast furnace slag also have been studied. If the BFS is considered as a method for heavy metal removal, it is necessary to carry out a detailed research of its efficiency in a column process.

Table 3: Typical chemical composition of BFS

Component	**Percentage**
CaO	41.0
SiO2	35.0
Al2O3	14.0
MgO	7.0
S	0.8

Zeolites

Zeolites are micro porous, aluminosilicateminerals [40]. The term zeolite was originally coined in 1756 by SwedishmineralogistAxel Fredrik Cronstedt, who observed that upon rapidly heating the material stilbite, it produced large amounts of steam from water that had been absorbed by the material. Based on this, he called the material zeolite, from the Greek (*zéō*), meaning "to boil" and (*líthos*), meaning "stone". Zeolites have a three-dimensional structure constituted by (Si, Al) O4 connected by all their oxygen vertices forming channels tetrahedral the negative charge generated from the isomorphous substitution. The advantage of zeolites over resins, apart from their much lower cost, is their ion selectivity. Owing to zeolite's structural characteristics and their adsorbent properties, they have been applied as low cost adsorbents [41–42]. Several researchers have studied the removal performance and selectivity sequence of heavy metal ions by natural zeolites (clinoptilolite and chabazite) [43–50] as well as synthetic zeolites [51–54]. Ouki and Kavannagh [55] studied the performance of natural zeolites (clinoptilolite and chabazite) on the treatment of mixed metal effluents (Pb^{2+}, Cd^{2+}, Cu^{2+}, Zn^{2+}, Cr^{3+},Ni^{2+} and Co^{2+}).

Sawdust

Sawdust or wood dust is a by-product of cutting, grinding, drilling or otherwise pulverizing wood with a saw or other tool; it is composed of fine particles of wood. It is also the byproduct of certain animals, birds and insects which live in wood, such as the woodpecker and carpenter ant. It can present a hazard in manufacturing industries, especially in terms of its flammability. Sawdust is the main component of particleboard. It contains various organic compounds (lignin, cellulose and hemicellulose) with polyphenolic groups that could bind heavy metal ions through different mechanisms. An experiment on the efficiency of sawdust in the removal of Cu^{2+} and Zn^{2+} ions was conducted by Sˇc´iban and his colleagues[56]. Bryan and his colleagues [57] showed adsorption of hexavalent chromium by red fir sawdust taking place primarily on components such as lignin or tannin rather than onto the cellulose backbone of the sawdust. Adsorption capacity is very high. It was suggested that sawdust is a good adsorbent for the removal of chromium [58].

Carbon anode dust

Industrial waste is one of the potentially low-cost adsorbents for heavy metal and organic matter removal. Since these materials are locally available in large quantities, they are inexpensive. Many applications of carbon materials are strongly influenced by their surface chemistry. Thus their uses as adsorbents in aqueous solution, in catalysis or electrochemical process are three examples in which the surface chemistry, microporous structure, high adsorption capacity and high degree of surface reactivity can have an important relevance in the materials performance [59-60]. The carbon anode dust (CAD) originates from the baking and transporting of carbon electrodes - anodes in aluminum production industry and it is not recycled [61].

The remaining parts of spent anodes from the aluminum production are called anode butts. There are two anode butts, the raw anode butts and the pre-baked anode butts. The cleaned anode butts are crushed and reused in the production of new anodes (about 20 % of the anode is recycled). The carbon anode dust originates from the baking and transporting process of anodes and is not recycled [62-63]. This is non-toxic metallurgical waste material that has to be disposed of on the specially arranged landfill. This process is rarely applied; it is expensive and requires a lot of area. Therefore, it is necessary to find its use as a secondary raw material. Degree of surface reactivity can have an important relevance in the materials performance [64-

65].Štrkalj and his colleagues [66] have studied comparative adsorption performance for Ni (II) ions of acetic acid- modified, KOH modified and unmodified carbon anode dust.

Chitosan

Chitosan is a linear polysaccharide composed of randomly distributed β-(1-4)-linked D-glucosamine (deacetylated unit) and N-acetyl-D-glucosamine (acetylated unit). It has a number of commercial and possible biomedical uses.

Chitosan is produced commercially by deacetylation of chitin, which is the structural element in the exoskeleton of crustaceans (such as crabs and shrimp) and cell walls of fungi. A common method for the synthesis of chitosan is the deacetylation of chitin using sodium hydroxide in excess as a reagent and water as a solvent. This reaction pathway, when allowed to go to completion (complete deacetylation) yields up to 98% product [67]. Chitosan is water soluble and a bio adhesive which readily binds to negatively charged surfaces. This biopolymer is also being used for adsorption mainly because they are a cheap resource or a freely available resource [68]. The high porosity of this natural polymer results in novel binding properties for metal ion such as cadmium, copper, lead, uranyl, mercury and chromium. Chitosan has been used for about three decades in water purification processes. When chitosan is spread over oil spills it holds the oil mass together making it easier to clean up the spill. Water purification plants throughout the world use chitosan to remove oil, grease, heavy metals, and the fine particulate matter that cause turbidity in wastewater streams [69].Chitosan have the potential to reduce and solve some environmental pollution problems for creating `Greener ` environment and chitosan is a renewable polymer in this application. Some of the properties which are commercially attractive are polymeric, including natural decomposition, non-toxic to both the environment and human, with no side effects or allergic effects if implanted in the body. Chitosan occur naturally in the environment in large quantities and run second in abundance to cellulose. It has an amine functional group which is strongly reactive with metal ions. Considerable research has been done on the uptake of metal cautions by chitosan. Chitosan has been used successfully in Asia, Europe and North America to remove sediment from water. The amine groups on chitosan bind metal cations at pH close to neutral. At low pH, chitosan is more protonated and therefore it is able to bind anions by electrostatic attraction. [70]

Sewvandi and his colleagues [71] have studied factors affecting on the removal of chromium using chitosan synthesized from Sri Lankan shrimp shells.

*Waste mould sand*In foundry industry, millions tons of spent materials are disposed in the world [72]. Over 70 % of the amount of the dumped waste materials consists of sands. For many years, the spent sands generated by foundry industry were successfully used as landfill materials. But disposal by landfill of spent sands is becoming an increasing problem as legislation is getting tighter. Also the disposal costs by current practices increases rapidly [73]. This waste mould sand is composed of fine silica sand, clay binder, organic carbon, and residual iron particles (table.4). Because of their potential sorptive properties, waste mould sand can used as a low cost sorbent [74]. Zoren glaves and his colleagues [75] have studied removal of Cr on waste mould sand and compared it with adsorption of Cr on arc electric furnace slag and steel shot.Anita strakal and his colleagues [76] have used waste mould sand for removal of nickel and chromium ions from aquese solution.

Table 4 – Chemical composition of waste mould sand

Components	**SiO2**	**Al2O3**	**Fe**	**Ca**	**Mg**	**Mn**	**Ni**	**Cr**	**C**
wt, %	90.0	1.6	6.8	0.55	0.08	0.04	0.004	0.01	0.916

Other adsorbent

Here has been brought some of agricultural products that are used as low cost adsorbents. Agricultural products and by-products are abundant waste materials, and need proper disposal. When disposed by burning in situ, theygenerate CO_2 and other forms of pollutions. This creates a need for the conversion of agricultural products and by-products to useful, and hopeful, value-added products. One possible avenue could be as inexpensive ion exchange or sorbent material, which could remove toxic metal ions from aqueous solutions. The idea of using various agricultural products and by-products for the removal of heavy metal from solution has been investigated by number of authors. The obvious advantages of this method compared to other are lower cost involved when organic waste materials are used.The available literature as summarized in Table 5 shows that some of these non-covenantal adsorbents possess good adsorption capacity for heavy metal removal from industrial effluent.

Table 5. Heavy metal adsorption capacity (mg/g) of agricultural wastes

Material	**Adsorption Material capacity (mg/g)**						**references**
--------------	Cd^{+2}	Cr^{+3}	Cr^{+6}	Hg^{+2}	Pb+	Zn^{+2}	----------------------------
Douglas fir bark	-	-	-	100	-	-	[77]
Exhausted coffee	1.48	-	1.42	-	-	-	[78]
Untreated pinus sylvestris bark	-	8.69	-	-	-	-	[79]
Black oak bark	25.9	-	-	4.00	-	-	[81]
Redwood bark	27.6	-	-	250		6.8	[77]
Pinus pinaster bark	8	19.45	-	-	3.33	-	[81]
Dry redwood leaves -	-	-	-	175	-	-	[77]
Rice husk ash	20.24	-	-	66.66	-	-	[82]
Black gram husk	49. 74	-	-	-	-	-	[83]
Petiolar felt-sheath pf palm	10.8	-	5.32	-	11.4	6.0	[83]
Copper-coated moss	-	18.9	7.1	-	-	-	[84]
Orange peel	-	-	275	-	-	-	[77]

CONCOLUTION

This review shows that the study on low cost adsorbents for heavy metal removal has attracted the attention of more scientists. most studies were focused on the removal of heavy metal ions such as Pb(II) Zn(II), Hg(II), Ca(II) Ag(II), As(II), Cr(II) , Cd(III) and Cd(VI) ions. Low cost, effective, readily available materials can be used in place of activated carbon or ion exchange resins for the removal of toxic substances from solutions. This adsorbent is found highly efficient for heavy metal removal, not only for industries, but the living organisms and the surrounding environment will also benefit from the decrease or elimination of potential toxicity of the heavy metal. Thus, the use of low-cost adsorbents may contribute to the sustainability of the surrounding environment. Thus, the use of low-cost adsorbents may contribute to the sustainability of the surrounding environment. Undoubtedly low-cost adsorbents offer a lot of promising benefits for commercial purpose in the future.

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