ZANCO Journal of Pure and Applied Sciences
The official scientific journal of Salahaddin University-Erbil
https://zancojournals.su.edu.krd/index.php/JPAS

ISSN (print):2218-0230**, ISSN (online):** 2412-3986**, DOI: http://dx.doi.org/10.21271/zjpas**

RESEARCH PAPER

Heavy metal ions removal from wastewater using various low-cost agricultural wastes as adsorbents: a survey

Bnar M. Ibrahim

Department of Chemistry, College of science, University of Raparin, Iraq.

A B S T R A C T:
Toxic heavy metals have an important role in water pollution. Because of their toxicity and non-biodegradability which affects humans, animals, and also plants. Researchers in the field of environment used various heavy metal removal methods, such as ion exchange, precipitation, evaporation, membrane filtration and adsorption. Low cost, high efficiency and easy regeneration make the adsorption process as an effective technique in the heavy metal removal. The purpose of this review is to gather sufficient information about various agricultural waste adsorbents and their removal capacity for heavy metals.

KEY WORDS: heavy metals, adsorption, agricultural waste adsorbents.
DOI: http://dx.doi.org/10.21271/ZJPAS.33.2.8
ZJPAS (2021) , 33(2);76-91 .

1. INTRODUCTION :

Elements that have atomic masses between 63.5 - 200.6, and a density higher than five are considered heavy metals. In developing countries because of more industries such as metal plating, mining processes, fertilizer industries, tanneries, batteries, paper industries and pesticides, etc., heavy metals released into the environment directly or indirectly. Organic contaminants are biodegradable and do not accumulate in living organisms unlike heavy metals, which are toxic or carcinogenic. Industrial wastewaters need treatment when contaminated with toxic heavy metals such as zinc, copper, nickel, mercury, cadmium, lead and chromium (Fu and Wang, 2011).

* **Corresponding Author:**
Bnar Mahmoud Ibrahim
E-mail: bnar.mahmoud@uor.edu.krd
Article History:
Received: 13 / 12 /2020
Accepted: 30/01/2021
Published: 18 /04 /2021

Various diseases considered due to exposure to heavy metal ions such as birth problem, kidney damage, skin infections and cancer (Hokkanen et al, 2018). Because of their health problems the World Health Organization (WHO) are recommended their removal from wastewater (Mara, 2003).

Chromium has various oxidation numbers, chromium (VI) and chromium (III) are mostly used in industrial sewage (Mohhan and Pitman, 2006). Chromium (III) is safer than Cr (VI) and Cr (VI) is an oxidising agent, carcinogenic in nature and is also has a negative impact on plants and living organisms (Renu et al, 2017). Chromium (VI) exposure causes cancer in the lungs, abdomen pain, nausea, and severe diarrhoea, throw up and haemorrhage (Mohanty et al, 2006).

International Agency for Research on Cancer (IARC) listed cadmium as a Category-I carcinogen and its major sources include smelting, mining, plastic industry, metal refinery and

photographic industry (Ghare et al, 2013). Copper is important for enzyme synthesis, tissue and bone maturity but Cu (II) is carcinogenic and poison when it is taken in high concentration and causes head acke, vomiting, nausea, liver and kidney failure and inhaling disorders (Lan et al, 2013). Important sources of copper are smelting, drilling, electroplating, surface finishing, electric devices, electronic pieces (Bilal et al, 2013). Nickel is considered as human carcinogen and causes various health effects including renal and lung disorders, abdominal pain and skin irritation. (Borba et al, 2006). Zinc is also important for human's body but high intake amount of zinc causes skin infections, belly contraction, vomiting and anaemia (Oyaro et al, 2007). More importantly, lead and mercury have adverse effects on human health and can affect nervous system, kidney damage, brain, liver and reproductive system (Ding et al, 2010, Namasivayam and Kadirvelu, 1999). Arsenic may also cause pain in the skin, lung, kidney, muscles, lack of appetite and nausea (Mohan and Pittman, 2007).

Various methods have been utilized for eliminating toxic heavy metals from wastewater like physical, chemical, biological and a combination of several techniques (Zhou et al, 2004). In recent years, adsorption as an effective and inexpensive water remedy has been used (Stephen et al, 2011).

For the first time activated carbon was used as an efficient and standard adsorbent for waste water remediation from toxic metal ions as a result, of its small fragment sizes and active free valences (Kurniawan et al, 2006). But high cost and difficult regeneration of activated carbon restricted its use, regeneration of AC need expensive chemicals and high temperature (Babel and Kurniawan, 2003).

As a substitute for existing expensive methods of r emoving heavy metals from solutions, the use of l ow-cost sorbents has been studied.

Recently, various types of natural materials or wastes and biopolymers have been utilized as adsorbents for the adsorption process due to their efficient adsorption capacities; either used naturally or with some modifications (Abas et al, 2013).

The increasing number of publications on adsorption using low cost adsorbents concludes increasing interest in finding suitable adsorbents for the adsorption process. In this article, an overview of the adsorption process using low cost adsorbents for heavy metal removal is presented by highlighting the applicability of adsorbents and adsorption capacity.

The main objective of this survey is to display information about adsorption process and reusing agricultural waste as adsorbents for heavy metal removal.

2. Adsorption operation

In recent times, the adsorption system has an important technique in metal ions removal and it used for a long time. Today adsorption is a basic method because of its adaptability in design and easy process instead of getting to perform adsorptions, which are perceived as impractical employing most conventional techniques.

The "adsorption" process can be defined as a weight transfer technique by way that a material is moved from the liquid segment to the floor of a stable and linked by using physiochemical reactions (Babel and Kurniawan, 2003).

The benefits of the adsorption operation in casting off or minimising the heavy metals even at low concentration enhance the utility of adsorption as one practical treatment. The efficacy of the adsorption method is specifically affected by the form of the solution in which the pollutants are dispersed, the molecular size and the pollutant polarity, as well as the kind of adsorbent used. Adsorption is also present due to the appealing interactions among a floor and the species being adsorbed at certain molecular level (Monser and Adhoum, 2002).

In addition, Adsorption can be categorised into two; physical and chemical adsorption. Physical adsorption is a reversible process as a consequence of intermolecular forces of enchantment among molecules of the adsorbent and the adsorbate. Chemical adsorption is an irreversible phenomenon and its a consequence of the chemical reaction between the solid and the material adsorbed (Yadla et al, 2012).

High physical adsorption occurs at a temperature s imilar to the critical temperature of a given gas in t erms of temperature, even though chemical adsorp tion occurs at temperatures much higher than the c

ritical temperature. Both processes may occur concurrently under certain conditions (Dabrowski, 2001).

3. Mechanism of adsorption

Adsorption mechanisms are not easy and there is no theory that completely explains how metal ions adsorb on the external part of the adsorbent. Various models have been described as mechanism between the adsorbate and the adsorbent. In order to explain the sorption isotherms both Langmuir and Freundlich models are mostly utilized while sorption kinetics is presented by using pseudo first order and pseudo second order kinetic models (Abas et al, 2013).

3.1Adsorption isotherm

Isotherms are mathematical equations used to explain the behaviours of adsorption of a particular adsorbent-adsorbate combination (Al-Madhoun et al, 2005).

The adsorption isotherm shows how the adsorbed molecules, when the adsorption cycle enters equilibrium state are dispersed among the liquid state and the solid state. Analysing isothermic data by appropriating them into various isothermic models is an essential way of identifying the right rule that can be utilized for layout purpose (Nawabanne and Igbokwe, 2008). There are several simple isothermic models including: Langmuir, Freundlich, Temkin, BET, D-R model and others (Otun et al, 2006). The adsorption models Langmuir and Freundlich are commonly used because they are easy to explain experimental findings in a wide range of concentrations (Peric et al, 2004).

3.1.1 Langmuir isotherm

The simplest physically possible isotherm is depended on three hypotheses:

(i) Adsorption cannot extend beyond monolayer cover.

(ii) All sites are identical and have a uniform surface area.

(iii) The molecules capability to adsorb at a provided site does not depend on the occupation of adjacent sites (i.e., there are no reactions among adsorbed particles) (Atkin and Paula, 2006).

Langmuir isotherm model can be written in the following (Hussain et al, 2009, Mehdi and Mehdi, 2014, Zawaniz et al, 2009):

$$\frac{C_e}{Q_e} = \frac{C_e}{Q_{max}} + \frac{1}{K_L Q_{max}} \qquad \text{----------(1)}$$

Where,

Q_{max} (mg/g) refers to maximum monolayer coverage adsorption,

K_L (L/mg) refers to Langmuir constant related to sorption strength,

Ce is the metal ions quantity in the solution (mg L^{-1}) and

qe is the metal ions quantity on the adsorbent sites (mg g^{-1}) at equilibrium.

3.1.2 Freundlich isotherm

Freundlich isotherm rule states that the adsorbed molecules heterogeneously cover the adsorbent surfaces. This isotherm is widely utilized to characterize the adsorption on a wide variety of adsorbents of organic and inorganic compounds (Febrianto et al, 2009).

For Freundlich equation, it is written as:

$$\ln q_e = \ln K_F + 1/n \ln C_e \qquad \text{----------(2)}$$

While K_f is the Freundlich isotherm constant whereas 1/n is the diversity factor that is described the adsorption capability and strength and C_e is the equilibrium concentration (mg L^{-1}). This model states that when the adsorbate quantity increase, also the quantity of adsorbate on the adsorbent surface will be increase and thus sorption intensity decreases exponentially with the accomplishment of the adsorbent sorption centre (Karakaya, 2011). Langmuir and Freundlich isotherm rules are also applied to explain the short term, single-element adhesion of metal ions by various materials (Zhang et al, 2000).

4. Adsorption kinetics

In terms of kinetic energy, contacting time from practical data's can be applied to research the rate-limiting stage in the adsorption operation. The adsorption action can be managed by one or more stages such as pore diffusion, surface diffusion or more than one phase combination. The first order statement of Lagergen's and the second order equation of Ho's are some examples of kinetic models widely used to characterize certain kinetic models of adsorption (Ho, 2006).

The Lagergren models first-order kinetic pseudo-equation is given as such equations:

$$\ln (q_e - q_t) = \ln q_e - K_1 t \quad \text{----------(3)}$$

While q_e and q_t are the quantity of adsorbed waste (mg/g) in equilibrium and at any time *t* (min) and k_1 is the constant rate of pseudo first order adhesion (min ^{1}) (Deng et al, 2015). First order Pseudo statement refers to the concept of the rate of change in the uptake of solute over time that is directly proportional in concentration of saturation and the quantity of solid take over time (Khaled et al, 2009). The kinetic statement of second order pseudo is given as (Yang and Jiang, 2014,Wang et al, 2015):

$$\frac{t}{q_t} = \frac{1}{k_2 qe^2} + \frac{t}{q_e} \quad \text{----------(4)}$$

The second order pseudo rule is depending on the hypothesis that the rate limiting stage that drive from chemisorption including valence powers by exchanging electrons among the adsorbent and the adsorbate molecules (Ho and McKay, 1999).

Adsorption capacity qe was calculated using the following equation (Katsumata et al, 2003):-

$$q_e = \frac{C_0 - C_e}{m} V \quad \text{----------5}$$

While C_0 and C_e are the initial and equilibrium metal ions quantity (mg L^{-1}), respectively. *V* (L) is the volume of solution and *m* (g) is the adsorbent mass.

5. Factors affecting the adsorption capacity

There are various factors, which affect adsorption capacity such as temperature, shaking time, adsorbent dose and pH. Among the above-mentioned factors pH has been described as the most significant variable concerning metal adsorption on adsorbent (Srivastava et al, 2006).

The solutions pH influences the surface charge of the adsorbents as well as the degree of ionization and speciation of the various contaminants, the change of the pH affects the adsorptive mechanism by dissociating the reactive groups on the adsorbents surface active sites.

This contributes to improvements in the adsorptio n system's reaction kinetics and equilibri um characteristics (Katsumata et al, 2003).

This is partially because adsorbate competes intensely with hydrogen ions themselves (Ozcan et al, 2005). Various anionic and cationic species adsorption on the adsorbents surface can be explained on the basis of the competitive adsorption of $H3O^+$ and OH^- ions with the adsorbate. It is commonly observed that the surface adsorbs anions at lower pH due to presence of $H3O^+$ ions, while the adsorbent surface is active for the adsorption of cations at higher pH due to the deposition of hydroxyl ions (Katsumata et al, 2003).

Metal uptake depends on both the active sites and the composition of the solutions metal ions. $H3O^+$ predominates and occupies the binding sites of the adsorbent at low pH while the concentration of $H3O^+$ decreases at elevated pH and that of hydroxyl ions increases on the adsorbent surface. Thus the adsorbents surface charge changes to negatively charged sites, resu lting in greater cation attraction (Chakravarty et al, 2008,Kailani et al, 2009).

6. Adsorption on Agricultural Wastes

Recently, an incredible deal of interest in the research for the elimination of heavy metals from commercial effluent has been focused on the use of agricultural wastes as adsorbents (Barakat, 2011). The use of agricultural wastes in bioremediation of heavy metallic ions, is known as bio-sorption. Bio sorption is a physiochemical method that occurs naturally in po sitive biomass, which lets in it to passively listen and bind contaminants onto its cellular structure. Many researchers agree with that this phenomenon will offer an economical opportunity for putting off poisonous heavy metals from industrial wastewater and resource in environmental remediation (Wang and chen, 2009)

The elimination of metal ions from sewage water by applying agricultural fabric is refers to bio

sorption (Renu et al, 2016). Bio sorption method has a sorbent and solvent and this solvent include species, which have to be adsorbed on sorbent surface. These sorbents have affinity for metal ions species. These ions are attracted through sorbent and bound in complicated manner. Agricultural waste substances consist of cellulose and lignin and other components are hemicellulose, lipid, protein, water, starch, ash etc and many extra compounds. Cellulose is an organic compound, a polysaccharide together with linear chain of numerous hundred to many thousand of β related D-glucose units (Demirbas, 2008). However, Lignin is a complex polymer of fragrant alcohols called monolignols.

It is maximum usually derived from wooden and it's far an integral part of the secondary cell partitions of flora and a few algae. These compounds includes functional organizations such as, carbonyl, amido, amino, phenolic, carboxyl group, alchohols, ester and sulphydryl (Gupta and Ali, 2000). These functional groups have ability of complicated formation. Table 1 displays various agricultural waste substances which have been used for heavy metals removal.

Table 1 Various biomass of plant origin for removal of poisonous metal ions from wastewater

Biomass	**Adsorption capacity (mg/g)**	**Optimum pH**	**Adsorption isotherm**	**Reference**
Spent green tea	Pb^{2+} 90.10	------	L	Zuorro and Lavecchia, 2010
Tea waste	Pb^{2+}65.00	5-6	L,F	Amarasinghe and Williams, 2007
Mango peel	Pb^{2+}99.05	5.0	L	Iqbal et al, 2009b
Banana peel	Pb^{2+}2.18	5.0	L	Anwar et al, 2010
Moringa oleifera bark	Pb^{2+}34.60	5.0	L	Reddy et al, 2010
Rhizophoraapiculata tannin	Pb^{2+}31.32	5.0	L, F, S	Oo et al, 2009
Shell carbon	Pb^{2+}30.00	-----	-------	Sekhar, 2008
Hazelnut shell	Pb^{2+}28.18	6,7	L	Pehlivan et al, 2009
Cicerarientinum	Pb^{2+}20.00	6.0	L	Mohammad et al, 2010
Almond shell	Pb^{2+} 8.08	6,7	L	Pehlivan et al, 2009
Wheat bran	Pb^{2+}87.00	4-7	L	Bulut and Baysal, 2006
Coir pith waste	Pb^{2+}263.00	5.0	L	Kadirvelu and Namasivayam, 2000
Spent black tea	Pb^{2+}129.90	-----	L	Zuorro and Lavecc

				hia, 2010
Maize cope and husk	Pb^{2+}456	------	-------	Igwe et al, 2005
Cocoa shells	Pb^{2+}6.2	2.0	-----	Meunier et al, 2003
Orange Lemon Banana Water melon	Pb^{2+}91% Pb^{2+}94% Pb^{2+}92% Pb^{2+}96%	2.0	L	Jena and Sahoo, 2017
Rise husk modified with orthophosphoric acid	Pb^{2+}138.89	-----	L	Dada et al, 2013
Lemon peel modified with Citric acid	Pb^{2+}93.83%	6.0	F	Tovar et al, 2018
Acacia leucocephala bark	Ni^{2+}294.10	5.0	L	Subbaiah et al, 2009
Orange peel	Ni^{2+}158.00	6.0	L	Ajmal et al, 2000
Pomegranate peel	Ni^{2+}52.00	5.5-6.5	L	Bhatnagar and Minocha, 2010
Mango peel	Ni^{2+}39.75	5-6	L	Iqbal et al, 2009a
Activated carbon prepared from Cicer arietinum	Cu^{2+}18.05 Zn^{2+}18 Pb^{2+}20	7.0 7.0 6.0	F	Ramana et al, 2010
Coir pith	Ni^{2+}15.95	5.3	L	Parab et al, 2006
Tea waste	Ni^{2+}73.00	-----	L,F	Ahluwalia and Goyal, 2005
Tea waste	Ni^{2+}15.26	4.0	L	Malkoc and Nuhoglu, 2005
Cicerarientinum	Zn^{2+}20.00	6.0	L	Mohammad et al, 2010
Wheat bran	Zn^{2+}16.40	6.5	L	Dupont et al, 2005
Tea waste	Zn^{2+}8.90	4.2	-----	Wasewar et al, 2009
Mango peel	Zn^{2+}28.21	5-6	L	Iqbal et al, 2009a
Maize cope and husk	Zn^{2+}495.9	------	------	Igwe et al, 2005

Natural rice husk	Cd $^{2+}$73.96	6.0	L,F,D-R	Akhtar et al, 2010
Maize cope and husk	Cd $^{2+}$493.7	-----	-----	Igwe et al, 2005
Rice husk modified with Sulphuric acid	Cd $^{2+}$101	5.4	L	Ozer, and Pirinc, 2006
Wheat bran	Cd $^{2+}$15.82–22.78	5.0	L	Nouri et al, 2007
Wheat straw	Cd $^{2+}$11.60–39.22 Cd $^{2+}$0.1032 mmol/g	6.0 5.0	L	Farooq et al, 2001,Tan and Xiao, 2009
Puresorbe	Cd $^{2+}$285.70	7.0	L, F	Pino et al, 2006
Coir pith	Cd $^{2+}$93.40	5.0	L	Kadirvelu and Namasivayam, 2003
Copra meal	Cd $^{2+}$4.99	5.0	L	Ho and Ofomaja, 2006
Orange peel	Cd $^{2+}$47.60	7.0	L	Sha et al, 2009
Mango peel	Cd $^{2+}$68.92	5.0	L	Iqbal et al, 2009b
Banana peel	Cd $^{2+}$5.71–35.52 Cd $^{2+}$2.18	8.0 3.0	L	Memon et al, 2008a, Anwar et al, 2010
Pomelo peel	Cd $^{2+}$21.83	5.0	L	Saikaew et al, 2009
Raw date pit	Cd $^{2+}$35.90	4.0	-----	Kahraman et al, 2008
Raw coffee powder	Cd $^{2+}$15.65	7.0	L	Azouaou et al, 2010
Tea waste	Cd $^{2+}$11.29	5.5	F	Cay et al, 2004
Pinus roxburghii bark	Cd $^{2+}$3.01	7.0	L	Padmini and Sridhar, 2007
Rice husk ash	Cd $^{2+}$3.04	6.0	F	Srivastava et al, 2008
Coffee residues blended with clay	Cd $^{2+}$ 17.5–17.9	7-9	L	Boonamnuayvitaya et al, 2004
Coffee husks	Cd $^{2+}$6.9	6.0	L	Oliveira et al, 2008
Coffee beans	Cd $^{2+}$3.80	8.0	L	Kaikake et al, 2007
Apple pomace modified with	Cd^{2+}4.45,91.74	5-6	L	Chand et al, 2014

Succinic anhydride				
Apple pomace modified with xanthate	Cd^{2+}112.35	4.0	L	Chand et al, 2015
Olive stone modified with zinc chloride	Cd^{2+}95%	> 6	L,F	Kula et al, 2008
Rice husk modified with Sulphuric acid	Cd^{2+}41.15 and 38.76	6.0	L	El-Shafey, 2007
Melon husk modified with H2SO4, NaHCO3	Cd^{2+}96.8%	------	F	Giwa et al, 2013
Rice husk	Cr^{6+} 0.79	2.0	F	Bishnoi et al, 2003
Egg shell	Cr^{6+} 1.45	5.0	L,F	Daraei et al, 2015
Wheat straw	Cr^{6+} 21.34	1.0	F	Wang et al, 2010
Banana peel	Cr^{6+} 131.56	2.0	L	Memon et al, 2009
Bael fruit	Cr^{6+} 17.27	2.0	L	Anand kumar and Mandal, 2009
Groundnut husk	Cr^{6+} 7.00	3.0	F	Dubey and Gopal, 2007
Almond shell	Cr^{6+} 3.40	3.5	L	Pehlivan and Altun, 2008
Hazelnut shell	Cr^{6+} 8.28	3.5	L	Pehlivan and Altun, 2008
Walnut shell	Cr^{6+} 8.01	3.5	L	Pehlivan and Altun, 2008
Pinus roxburghii bark	Cr^{6+} 4.15	2.0	F	Sarin and Pant, 2006
Banana peel	Cr^{6+} 93.35%	3.0	------	Tejada-Tovar et al, 2018
Coconut coir pith modified with hexadecyltrimethyl ammonium bromide surfactant	Cr^{6+} 76.3	2.0	L, F, D-R	Namasivayam and Suresh kumar, 2008
Silica derived from rice	Cr^{6+} 63.69	2.0	L	Oladoja et al,

husk modified with Iron oxide				2013
Rice husk modified with Ozone	Cr^{6+} 8.7–13.1	2.0	F	Sugashini and Begum, 2015
Orange peel modified with potassium carbonate	Cr^{3+} 80%	3.0	L	Arslan et al, 2017
Wheat bran	Cu^{2+} 6.85–17.42	6.0	L,F	Aydın et al, 2008
Orange peel	Cu^{2+}50.94	7.0	L	Sha et al, 2009
Mango peel	Cu^{2+}46.09	5-6	L	Iqbal et al, 2009a
Peanut hull	Cu^{2+}9.00–21.25	5.5	L	Zhu et al, 2009
Peanut hull pellet	Cu^{2+}12.00	5-7.5	L	Johnson et al, 2002
Cicerarientinum	Cu^{2+}18.00	6.0	L	Mohammad et al, 2010
Chestnut shell	Cu^{2+}12.56	5.0	L	Yao et al, 2010
Casuarina	Cu^{2+}16.58	5.0	L, F	Mohan and
equisetifolia bark				Sumitha, 2008
Rhizophoraapiculata tannin	Cu^{2+}8.78	5.0	L, F, S	Oo et al, 2009
Tobacco fibre	Cu^{2+}10.5	----	L, F	Demirbas, 2008
Cotton boll	Cu^{2+}11.4	5.0	L	Ozcoy and Kumbur, 2006
Pomegranate peel	Cu^{2+}1.31 Pb^{2+}13.87	5.8 5.6	L	EL-ASHTOUKHY et al, 2008
Tea waste	Cu^{2+}8.64–48.00	5.5	F	Cay et al, 2004
Banana peel	Cu^{2+}20.37	6.5	L	Hossain et al, 2012
Corn stalk modified with: 1. nitric acid 2. diethylenetriamine 3. phosphoric acid 4. corn cob silica with alginate	Cu^{2+} 20.65 Cr^{6+} 200 Zn^{2+}79.21 Cu^{2+}4.73, Cd^{2+}4.60	4.5 2.4 ----- 7.0	F L L L	Vafakhah et al, 2014 Chen et al, 2011 Buasri et al, 2012 Shim et al, 2014

Orange peel waste modified with methyl acrylate	Cu^{2+}289	7.0	L	Feng et al, 2009
Orange peel waste modified with methyl acrylate	Pb^{2+}476.1 Ni^{2+}162.6 Cd^{2+}293.3	5.0	L	Feng et al, 2011
Orange peel modified with KCl	Cu^{2+}59.77 Cd^{2+}125.63 Pb^{2+}141.84 Zn^{2+}45.29 Ni^{2+}49.14	5.0-5.5	L	Xueyi et al, 2011
Orange peel	Cu^{2+} 3.65 Co^{2+}1.82 Ni^{2+}6.01 Zn^{2+}5.25 Pb^{2+}7.75	6.0-8.0	F	Annadurai et al, 2002
Banana peel	Cu^{2+}4.75 Co^{2+}2.55 Ni^{2+}6.88 Zn^{2+}5.8 Pb^{2+}7.97	6.0-8.0	F	Annadurai et al, 2002
Calcined banana peel	Cu^{2+}49.5 Pb^{2+}45.6 Cd^{2+}30.7 Cr^{6+} 25.2	4.0	L	Li et al, 2016
Sugarcane bagasse modified with succinic anhydride	Cu^{2+}114 Pb^{2+}189 Cd^{2+}196	5.5 5.0 6.0	L	Karnitz et al, 2007
Maize husk Maize husk modified with EDTA	Cd^{2+}−151.51 Pb^{2+}−217.39 Zn^{2+}−3330.0 Cd^{2+}833.3 Pb^{2+}714.29 Zn^{2+}769	7.5 --------	F F	Igwe and Abia, 2007
Suger beet pulp	Pb^{2+}5.60	5-5.5	F	Pehlivan, et al,

	Cd^{2+}7.16			2008
Rose waste	Pb^{2+}151.51 Co^{2+} 27.62	5.0 6.0	F	Javed et al, 2007
Phosphorylated orange waste	Cu^{2+}67.35 Pb^{2+}251	4.5 4.4	L	Ghimire et al, 2008
Grape bagasse	Cd^{2+}53.84 Pb^{2+}42.27	7.0 3.0	L	Farinella et al, 2007

7. Conclusions

Toxic metal ions, which pollute wastewater, considered as a major essential nature issues at some point of the globe. Various, remedy technology have been used for heavy metal elimination from sewage water. In this review we demonstrate adsorption as a more effective technique depending on the published articles. It is shown from this review that most of research's indicated that the adhesion or removal with the aid of inexpensive polymer adsorbents is identified as a powerful and thrift technique for the contaminate water treatment than expensive activated carbon.

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