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REVIEW ARTICLE

Green technology approach for heavy metal adsorption by agricultural and food industry solid wastes as bio-adsorbents: a review

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Abstract Heavy metal discharge from various metallurgical industries has been of particular concern in India over the last few decades. Similarly, management and disposal of wastes that are generated out of agricultural commodities processing is a huge task for processors. The researchers have been focusing on a new process for remediation of heavy metals, among which biosorption is an emerging technology. Adsorption using agricultural and food industry wastes (AFW) has shown a greater absorption rate than the conventional system due to the presence of the functional groups. In addition, these reported AFW exhibited better adsorption efficiency when modified with acid, alkaline, and other chemical solvents. In this context, utilization of agricultural and food waste as bio-sorbent could simultaneously benefit both water treatment and waste management. This review seeking to address the possibilities of using biosorption as green technological approach for removal of heavy metals and also focuses on various parameters that are required to use AFW as an efficient system for biosorption. However, commercialization and implementation of this process in industrial scale is necessary for successfully utilizing AFW as low-cost adsorbents.

Keywords Bio sorbent · Fluidized bed bioreactors · Chemical modification · Cost-effective

Introduction

Heavy metals can be considered as chemical compounds which occur naturally. They are spread broadly over the environment and can get into the food and water system, causing a considerable threat to food safety and the environment. The root causes of this issue are generally the increase of industrialization. Industries such as textiles, food, pesticides, chemical fertilizers in agriculture, etc., discharge a considerable amount of heavy metals into the environment in the form of pollutants (Sardar et al. 2013). On the contrary, the agricultural activities, processing of agricultural and food products leads to the production of agricultural and food industry waste (AFW). Waste generated from food and agricultural activities is utilized to extract value-added products and sometimes remains unutilized. About 21% of greenhouse gas is generated by the agriculture sector, causing a nuisance to the environment (Adejumo and Adebiyi 2020). Therefore, to decrease both issues as mentioned earlier and solve the problems associated with it, there has been a plethora of recent research is conducted on biosorption process. Biosorption techniques have gained increasing attention due to their cost-effectiveness, high-efficiency rate, and easy operation. Recently, numerous advances and strategies in biosorption have reinforced the attention of scientists

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to use AFW biomass as a low-cost adsorbent. Further, many researchers have reported the significant efficiency of AFW as bio-sorbents after being subjected to chemical pre-treatment/modification compared to its natural form. Thus, this review aims to put together accessible details of pre-treated agro/food solid wastes, which increase the adsorption capacity for heavy metal removal in the process of biosorption.

Heavy metals

Heavy metal particles can be considered metallic chemical elements, toxic even at low concentrations. They have atomic weight ranges between 63.5 and 200.6, with a specific gravity of 4.5–5.0 (Lakherwal 2014). When heavy metal intake exceeds its threshold limits, it causes several physiological, morphological, and genetic problems. Several studies have reported the accretion of these harmful heavy metal particles in water and other food commodities. Toxic heavy metals in wastewaters are copper, nickel, zinc, cadmium, lead, mercury, and chromium (Rai et al. 2019).

The conventional treatment system for the adsorption of these heavy metals is the precipitation of chemicals, oxidation, ultrafiltration, ion exchange, reverse osmosis, electrodialysis, nanofiltration, ultrafiltration, and chelation. Further, processes like coagulation, flocculation, floatation, and deposition are have been used for wastewater treatment. However, these methods are found to be expensive. At a low metal concentration of about 1–100 mg/L, these conventional technologies show less efficiency and generate toxic chemical sludge, which further creates problems in the disposal (Abbas et al. 2014). Thus, these constraints have created the need for potential alternative technology. One such alternative solution to the existing convention methods is biosorption.

Biosorption

Biosorption is a physiochemical process that utilizes the adsorbent, biological material to remove all the toxic metals or non-metals and other particles from wastewater. In a solution containing metal ions, the biosorbent should be suspended primarily. Then it has to be kept for a particular period to achieve the equilibrium condition. Once the equilibrium is obtained, separation of metal-enriched biosorbent occurs (Kanamarlapudi et al. 2018). The biosorption process is a low-cost method with less sludge discharge and high efficiency. Since there is no additional requirement for nutrients and fewer biological residues, this process benefits the conventional method. Biosorption does not depend on growth, and therefore, the physiological activities of living cells are not affected (Joshi 2018). However, a few drawbacks are identified as saturation of active sites in the ligands which bind the metal and the reversible nature of the biomass during the sorption process (Shamim 2018). Since the cells are not metabolizing, the probability for biological process refinement is limited (Abdi et al. 2015).

In the process of biosorption, the biological materials used as adsorbents are called sorbents. It is necessary to bring out biosorbents that should have the ability to bind the metal ions with more significant affinities. There are different non-conventional adsorbents, including biological adsorbents such as algae, fungi, bacteria, yeast, and from sources like chitin, peat, chitosan, and biomass generated from agriculture industrial waste particles (Ahmad and Zaidi 2020). To achieve the demand of industries, availability efficient biosorbents with appreciable adsorption capacity and economically feasible are needed. The process of biosorbents recognition is an excellent task. The materials used as adsorbents should be affordable, available easily in large amounts and re-formable (Shamim 2018).

Mechanism: biosorbent–sorbate interaction

The process of metal uptake by natural materials may involve several mechanisms based on metabolism and biosorbent type. Biosorption mechanisms are various and are not entirely understood because of the complexation of biosorbents in their biological nature. Factors such as environmental condition, stereochemical, chemical, and coordination features of metal, and the properties of biosorbents can contribute to controlling the mechanism (Kanamarlapudi et al. 2018). Different types of biosorption mechanisms according to various criterions are schematically presented in the Fig. 1. (Abbas et al. 2014; Kanamarlapudi et al. 2018).

Physical adsorption, chemical absorption, ion exchange, which are not associated with cell metabolism, show metabolism independent biosorption. In this, the functional group present on the surface of the microbial cell absorbs the heavy metals by physiochemical interaction. Precipitation may take place in both forms. Based on the metabolism type, precipitation occurs either by chemical interaction between the cell surface and metal ions or release of a compound that activates the precipitation due to the reaction between the active defence system of microorganism and metal ion (Kanamarlapudi et al. 2018).

Biosorption isotherms can analyze the biosorption efficiency of various adsorbents for various metal ions. Equilibrium adsorption isotherms interpret the interaction of metal ions on the surface of the biosorbent, and it also explains the quantity of heavy metals adsorbed (q) per unit mass of biosorbent (mg/g) and the remaining (C) concentration of heavy metal in the bulky medium (mg/l) at equilibrium under given temperature and concentration. There are

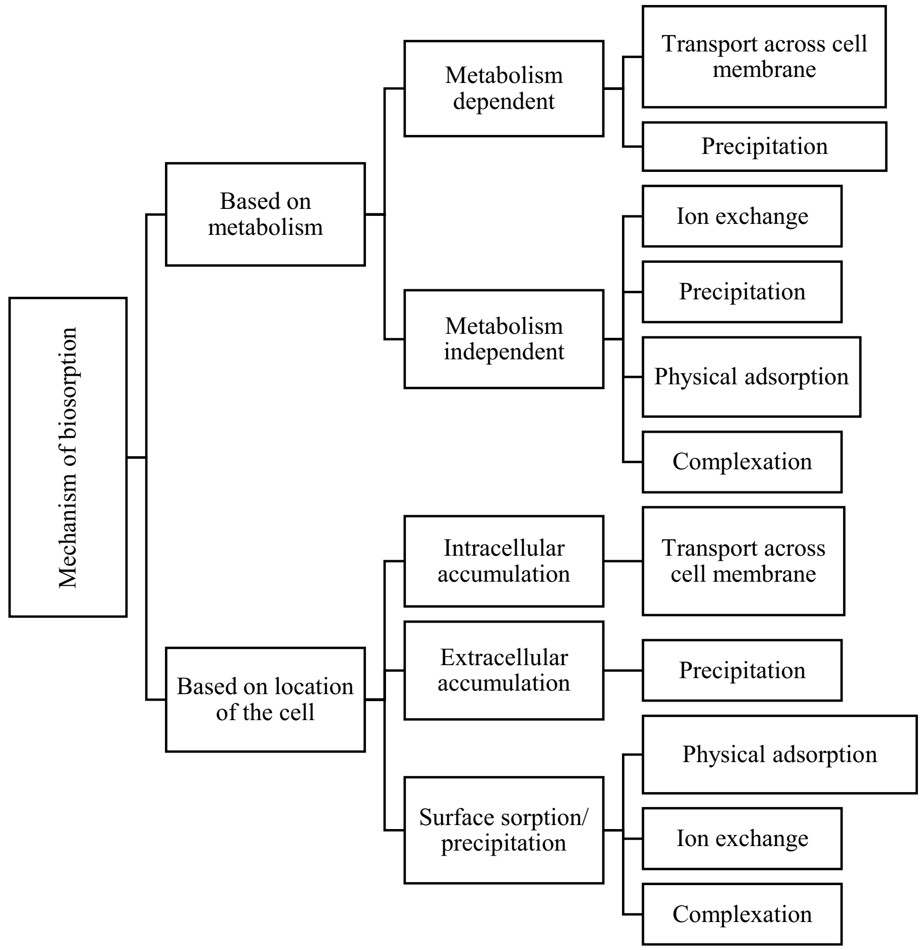

Fig. 1 Schematic presentation of different types of biosorption

numerous biosorption isotherm models available to interpret the parameters of experimental biosorption equilibrium, among these Freundlich, Langmuir, Temkin and Dubinin-Radushkevich isotherms are well known (Khatoon and Rai 2016). Similarly, Different analytical techniques like titration, Scanning Electron Microscopy having an Energy Dispersive X-ray Analytical system, Fourier Transform Infrared Spectroscopy and X-ray Photoelectron Spectroscopy are available to interpret the process of biosorption mechanism (Fig. 2).

Agricultural and food industry waste (AFW) as low-cost adsorbents

Agricultural and food industries are the primary source producing vast quantities of agricultural and food industry solid wastes through farming and food chain activities like production, processing, storage, etc. It is estimated that 39% of the food produced by food manufacturing industries worldwide goes to waste. Lack of by-product utilization, improper handling, dumping of solid waste, and indiscriminate burning causes a severe threat to the environment by producing toxic emission (Ahmad and Zaidi 2020). Therefore, utilizing these wastes for the metal removal from the effluents could solve the problem of waste management and water treatment as low-cost adsorbents at a reasonable cost providing a two-fold advantage. Agricultural waste can bind heavy metals due to the high cellulose and lignin content and polar functional groups like the alcoholic, phenolic, ether, amino, and carbonyl groups. These groups form complexes with metal ions by donating a lone pair of electrons (Ahmad and Zaidi 2020).

Various food and agro wastes like coconut coir have shown the highest adsorption efficiency of 263.00 mg/g for the removal of lead compared to other waste (Alalwan et al. 2020). Crab shell-based chitosan effectively sorbs arsenic (Zhan and Schiewer 2005). Similarly, husk obtained from rice and black gram showed 90% efficiency in removing lead and nickel (Saeed et al. 2005; Zulkali et al. 2006). Approximately 97% of adsorption capacity was seen in removing chromium using Sugarcane bagasse, maize corn cob, and jatropha oil cake (Garg et al. 2007). Furthermore, watermelon rind, rice husk, sugarcane bagasse, shells of nuts, wheat bran, coconut shell, and various fruits and vegetable peel have been reported as

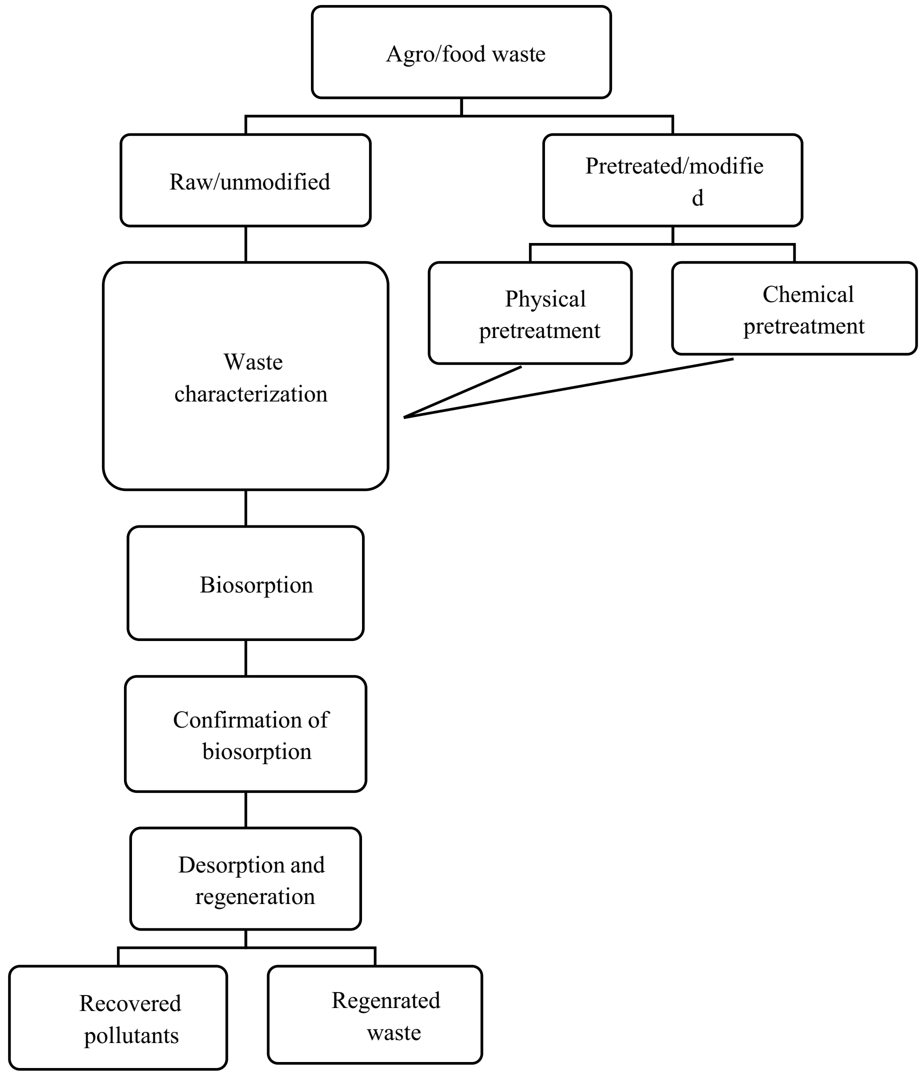

Fig. 2 Processing of agricultural and food wastes for adsorption (*Source*: Khatoon and Rai 2016)

effective biosorbents to immobilize various metal ions due to the high availability of cellulose, hemicellulose, and other functional groups in these waste (Ahmad and Zaidi 2020; Kanamarlapudi et al. 2018).

Pre-treatment/modification of AFW for efficient biosorption

Agricultural and food industry wastes (AFW) seem to be a promising option for the bioremediation of heavy metals due to their high efficiency to bind the heavy metals. The number of functional groups and their availability on the surface of the biosorbent affects the process of biosorption. Modification/pretreatment by changing the surface characteristic either by removing or concealing or by exposing the number of binding sites highly impact the biosorption ability of biosorbent used for the metal remediation (Khatoon and Rai 2016). In recent years, several pretreatment methods have been adopted to enhance the capacity of biosorbents for the removal of metals ions. Pretreatment of biomass enables its biopolymer rings to rupture, thereby enhancing the porosity and stability of the biosorbent (Khatoon and Rai 2016).

Mainly two types methods have been employed for pretreatment of waste, they are: (i) physical method which includes autoclaving, freeze-drying, heating, steam activation; and (ii) chemical method, includes acid/alkali treatment, organic chemicals treatment, washing with detergents and cross-linking with organic solvents. Chemical pretreatment is given more importance because of the increased stability and metal sorption capacity of biosorbents. On the contrary, physical pretreatment methods are not extensively used due to their least adequacy (Khatoon and Rai 2016). Physical or chemical treated biomass show variation in adsorption properties compared to the original biomass. Alluri et al. (2007) reported physiochemical and surface properties of an adsorbent, such as porosity, density, surface pH, temperature, metal affinity etc., affects the absorption rate. An adsorbent with surface homogeneity, higher surface area, potential adsorption capacity and fast kinetics is highly suggested to adsorb the pollutants from the waste water. To efficiently utilize agriculture waste as a biosorbent, most researchers choose chemical pretreatment over physical methods to modify the properties such as water absorbency, ion exchange, the conductivity of cellulosic materials, thereby enhancing the adsorption capacity of agriculture wastes (Khatoon and Rai 2016).

Chemical modification methods

The process of adsorption can be regarded as a surface technique. Chemical reactivation is carried out to improve the adsorption efficiency and specificity of a pollutant (Lesaoana et al. 2019). Among all the surface modifications, chemical surface modification is preferred since it directly affects the material's surface chemistry. It helps in increasing the accessible ion exchange capacity, binding sites, and uncomplicated functional groups formation, which approves the metal adsorption (Nguyen et al. 2013). Also, it helps to give a fundamental property of the surface of material because of the chemical interactions between the surface of the material and modifying agent (Abegunde et al. 2020).

Acid modification

Acid modification can be considered as a modification process of wet oxidation. This can be done by utilizing mineral acids and oxidants like H_2O_2, H_2SO_4, HCl, HNO_3, HCl, and H_3PO_4 as modifying agents. Among all the oxidation treatment methods, oxidation by nitric acid is the most commonly used one to increase the overall acidity level in wet oxidation treatment (Shim et al. 2001). During the oxidation process, oxygen-enriched features are formed on the surface of the carbon groups such as carboxylic, lactone, and phenolic hydroxyl. The acid treatment creates a positive charge on the surface and thus increases the uptake of metal ions which possess a positive charge.

Lasheen et al. (2012) reported that pretreating orange peel with 0.1 M HNO_3 increases the percentage of uptake to 61.37% in the adsorption of Cd (II). HNO_3 lowers the contesting between extra cations like K (I) and Ca (II) ions with Cd (II) ions by aiding in the removal of those extra cations on the surface of the orange peel. The study was done by Özer and Pirincci (2006) in the removal of Cu (II) shows that sulfuric acid pretreated wheat bran exhibits an adsorption capacity of 101 mg/g. Similar studies by Bhatnagar et al. (2015) showed the uptake of Cd (II) and Ni (II) by utilizing grapefruit peel as a bio-sorbent. The sorption capacity of unmodified grapefruit peel was found to be 42.09 and 46.13 mg/g respectively and increased to more than 97% when grapefruit peel used for adsorption of Cd (II) and Ni (II) was subjected to chemical modification by the usage of 0.1 M HCl, which helps in the release of cations and protons resulting in the ion exchange mechanism.

Alkali modification

Alkali modification is done using some essential reagents to improve the adsorption capacity. An adsorbent that is pretreated with alkali exhibits a positively charged surface and thus increases the adsorption efficiency of negatively charged species (Liu et al. 2018). Treatment with alkali mainly uses NaOH, KOH, Na_2SiO_3, LiOH, Na_2CO_3, and oxides. Miretzky et al. (2010) state that while comparing acid treatments and alkaline treatments with the same conditions, alkali treatment shows more effect in metal removal, which is carried out by resolving the cell matrix. So, the alkaline pretreatment helps in effective diffusion between the cell wall, and thus the functional groups become more stable and denser (Abdolali et al. 2014). The study done by Ofudje et al. (2015) reported that the coconut shaft, which is pretreated with KOH for the metal sorption of Pb (II), has an adsorption capacity of 22.1 mg/g. According to Karnitz et al. (2007), the sugarcane bagasse pretreated with sodium bicarbonate shows effective uptake of heavy metal ions like Pb, Cd, and Cu with a biosorption capacity rate of 194, 189, and 114 mg/g, respectively.

Oxidizing agents

Chemical modification can be done other than acid–base modifications, using various chemical substances like oxidizing agents, including hydrogen peroxide or potassium permanganate, and neutral agents such as $ZnCl_2$ or NaCl. On the adsorbents, oxidizing agents enhance the number of functional groups containing oxygen (Abegunde et al. 2020). Studies done by Zabihi et al. (2009) reported that walnut sawdust pretreated with $ZnCl_2$ for the removal of Hg (II) shows an adsorption capacity of 151.5 mg/g.

Organic compounds

Many organic compounds are also used to accelerate the capacity of metal uptake. Studies done by Garcia-Mendieta et al. (2012) found that the pretreated green tomato husk using 0.2% formaldehyde shows an increase in the metal sorption level of Mn (II) and Fe (II). According to Bhatti et al. (2011), pretreated red rose biomass using polyethyleneimine + glutaraldehyde and methanol shows an increased adsorption rate for Pb (II) and Co (II).

Impregnation

Impregnation is a process of filling an absorbent with metal substances in a solid state or through wet impregnation. In this process, a constant scattering of chemicals to the interior plane of porous material takes place. In dry and wet impregnation, sufficient and surplus solvent is attached to fill up the adsorbent pores, respectively (Abegunde et al. 2020). The substances used for impregnation should be metal or polymeric with no reaction on pH. Impregnating materials using metal solutions helps upgrade their adsorption capacity of heavy metals, which are in anionic form (Nguyen et al. 2013). Majumdar et al. (2013) reported that the adsorption percentage of Cr (V) utilizing unprocessed rice husk silica–carbon was increased from 74.7 to 85.9% when rice husk silica carbon was impregnated with iron. Studies done by Carvajal-Bernal et al. (2015) reported that the impregnation was done for the activated carbon with phosphoric acid to assist easy adsorption of 2,4-dinitrophenol, which shows an interchange in the carbon surface chemistry (Carvajal-Bernal et al. 2015). Similarly, several types of research concerning pretreatment of AFW using different modifying agents have been reported by various researchers and are reported in Table 1.

Selection of efficient biosorption operation mode

For the successful application of biosorption, selecting a proper mode of operation is an important parameter. Numerous types of bioreactors are used for biosorption process to meet different requirements with varying configurations the in industrial level. Individual bioreactors can be operated in continuous or batch mode or both based on the mode of reactor geometry and combination of substrate addition.

Fluidized bed bioreactors

This method has various phases to attain mixing and mass transfer in the reactor. This reactor is mainly carried out in batch mode (Sazali et al. 2020). It contains solid, liquid, and gaseous phases, where biosorbent act as solid. Mixing is created by permitting the gas molecules to get up the liquids. The liquid phase contains the metal ions, which move uphill through the reactor's middle and downward through the edges, forming a foundation effect. Liquid particles are constantly in motion and bring the whole mass to the column. Metal particles get attached to the biosorbent, and separation of target particles takes place. Clogging is reduced since particles are in continuous motion (Kanamarlapudi et al. 2018).

Table 1 Agricultural and food industry solid waste as bio sorbent for heavy metal removal

Agri solid wastes	Heavy metals	Modifying agents	Adsorption capacity (mg/g)	References
Avocado seed	Cr (II)	Concentrated sulfuric acid	333.3	Bhaumik et al. (2014)
Maize husk	Cu	Tartaric acid Phenol Methonic acid	35.714	Duru et al. (2019)
Corn stalk	Cu	Nitric acid	325 mmol/g	Vafakhah et al. (2014)
Cucumber peel	Cd (II)	Hydrochloric acid	58.14	Pandey et al. (2014)
Apple pomace	Cd (II)	Xanthate moiety	112.35	Chand et al. (2015)
Mentha piperita carbon	Pb (II)	$ZnCl_2$	53.2	Ahmad and Haseeb (2017)
Onion skin	Pb (II)	Thioglycolic acid	6.173	Olasehinde et al. (2018)
Cashew nut shell	Pb (II)	H_2SO_4 NaOH HNO_3	8.734	Nuithitilul et al. (2020)
Raw almond shell Activated almond shell	Hg (II)	Ortho-phosphoric acid and H_3PO_4	3.7 37.1	Taha et al. (2018)
Banana stem	Hg (II)	Formaldehyde	132.2	Mullassery et al. (2014)
Peanut hull powder	Hg (II)	Mercaptoacetic acid	83.3	Ding et al. (2014)
Rice husk	Hg (II)	Sulfuric acid	384.6	El-Shafey et al. (2010)
Soybean stalk	Hg (II)	Phenanthrene	674.9	Kong et al. (2011)
Pistachio nut shells and licorice residues	Hg (II)	Zinc chloride	147.1	Asasian and Kaghazchi (2013)
Orange fruit peel waste	Pb Ni Cd	Methyl acrylate	476.1 162.6 293.3	Feng et al. (2011)

Fixed bed bioreactors

These reactors can be used in both batch and continuous settings. It comprises a container and a bed include within. Using the fixed bed sorption method integrates the high sorption capacity with a low concentration of effluents. From the inlet of the column, adsorption can occur, and it extends to the exit, and a thus higher level of regeneration can be attained in one step procedure itself (Mukhopadhyay et al. 2011). Among the various reactors for wastewater treatment, a fixed column is usually regarded as the best one. Because the fresh adsorbent and wastewater are always in contact with each other, which provides a concentration incline for adsorbent and adsorbate for the adsorption process (Khatoon et al., 2016), two columns are mainly preferred, one for biosorption and the other for regeneration of finished biosorbent (Kanamarlapudi et al. 2018). After the extended functioning of this continuous fixed-bed column, sorption efficiency starts lowering. Therefore, to increase the efficiency, flow and mass transport conditions are practicable to change. Due to its lost cost for conservation, ease for enlarging, clarity in construction, and mechanized controlling and evasion of breakage, fixed bioreactor became one of the most widely used types (Mukhopadhyay et al. 2011).

Stirred tank bioreactors

A membrane system is used to discrete the liquid phase from the solid. Here operation cost is high because of its more energy demand, but the process is simple. The kind of bioreactor used, the type of biosorbent and mode of operation highly influence the efficiency of metal particle biosorption (Kanamarlapudi et al. 2018).

Desorption and regeneration

The recovery and reusability of bio-sorbent are essential for its industrial application. Regeneration is a process that involves the elution of adsorbate from the agriculture bio-sorbent after use. These regenerated bio-sorbents were found to be reverted from their original form. Thus, it can be reused in several cycles. The desorption process is carried out batch or column. Discarding spent bio-sorbent may lead to secondary sources of pollutants, which can cause environmental pollution. Therefore, reuse of spent bio-sorbent having regeneration ability is essential to reduce secondary pollutants and production of increases the sustainable use of biosorbents.

Various desorption process has been developed, among which the commonly used process is elution using solvents. Eluents separate the used-up bio-sorbent from the medium, followed by regeneration, and the potential eluent depends on bio-sorbent type and mechanism of biosorption (Sharma et al. 2018). The selected eluents must have an affinity to the adsorbent, the ability to separate easily from the adsorbent, not alter the adsorbent structure, and be cheap and eco-friendly.

Several studies have demonstrated the desorption process. Liu et al. (2012) reported that the regeneration of watermelon rind as biosorbent for the adsorption of copper, zinc, and lead was done using eluents like distilled water, 0.5 mol/L of HCl, HNO3, and 0.1 mol/L NaOH for10 hours and found to be reusable for subsequent three cycles of biosorption-desorption. Ofomaja et al. (2010) found a weak bond between the metal ion and biosorbent. When eluent used is in water, similarly if the strong acids then the metal ion attaches to biosorbent by ion exchange.

Industrial application of agricultural and food waste-based biosorption

Many researchers have ventured into biosorption technology to make it available at an industrial scale as a water treatment method. However, wastewater from the industries' effluents requires certain modifications in process set-up compared to a mono metal solution (Kanamarlapudi et al. 2018). Rao and Ikram et al. (2011) demonstrated column and batch process using gooseberry fruit waste for the biosorption of Cu from the wastewater obtained from electroplating plant, with the metal removal efficiency of 70–90%. According to Tsezos et al. (2012), a pilot plant for biosorption was first installed in the USA and Canada. In other study by Zouboulis et al. (2002), the usage of grape stalks from the winery industry was used for the biosorption of cadmium, copper, zinc, and nickel metals in an aqueous solution by biosorption floatation process. Ozcan et al. (2012) carried out the utilization of pomegranate peels for the adsorption of lead from the wastewater discharged from the textile processing industry in Turkey. These results shows that the AFW could be used as a potential adsorbent to treat waste effluents with heavy metals.

Current scenario and future recommendations

Under the current circumstance, developing a sustainable solution for wastewater treatment and waste management of AFW is extremely important. Although green chemistry approaches focus on converting AFW to biosorbent, as an alternative to a conventional system, to date, most of the published studies were demonstrated on a laboratory scale using batch tank reactors. Nevertheless, it has been discovered that the implementation of biosorption at the industrial level is minimal. The main reason would probably be the non-technical and scientific issue associated with it and the lack of information about the engineering of such material at pilot scale and field-scale systems. According to this, the following future recommendations can be made:

Although many publications and patents regarding biosorption technology are available, Biosorption technology is still on the laboratory scale. Thus, there is a necessity for commercializing this technology at the industrial level. To promote the use of AFW as biosorbents on a large scale, a detailed investigation is essential to develop the novel AFW biosorbents, and also economic analysis of the overall process is required.

Future research should concentrate on a detailed understanding of biosorption mechanism, sorption efficiency, characteristics of functional group, and various cost-effective pretreatment techniques and their influence for effectively functionalizing AFW as biosorbents. The need to develop computer-based models on the pilot-scale provides detailed data and application to avoid the field test and attract consultants, investors, and clients.

Conclusion

Heavy metal contamination and agricultural waste disposal are major global issues due to their toxic nature, impacting the environment and health concerns. In this review, the mechanism of biosorption, pretreatment methods for agricultural and food industry waste (AFW) for the biosorption process, suitability of AFW as an adsorbent and selection of efficient biosorption operation modes have been discussed. This study reveals that the AFW has the potential to use in the biosorption process due to its availability, renewable nature and minor disposal problem with good heavy metal removal capacity. Further, this study also reveals the presence of functional groups such as hydroxyl, carbonyl, and amines, which shows an affinity for heavy metal ions to form metal complexes either in their natural form or pretreated form, making AFW's suitability to be an adsorbent. Research findings showed that chemical modification opened more popularity because it directly targets the surface material and increases the adsorption capacity of target pollutants. However, chemical toxicity and modifying cost could be a vital drawback of this method. Although the AFW has been reported as a suitable replacement for the existing conventional system, there is still a need to extend the studies on the usage of AFW as a heavy metal adsorbent on an industrial scale for the betterment of effective utilization of agricultural and food industry waste. Further studies on the production and commercialization of low-cost adsorbents to successfully utilize the AFW effectively are needed.

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Declarations

Conflict of interest The corresponding author states that there is no conflict of interest on behalf of all authors whatsoever.

Data Availability All data generated and presented in the study are included in the article.

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