Progress and Prospects of the biosorption process for wastewater treatment

Ajay Kumar

Department of Bioengineering and Biosciences, Lovely Professional University, Phagwara, Punjab, India.

Abstract: Polluted water is a treat to the human community. One of the biological methods used to treat polluted water is the use of biosorbent. To enhance the efficiency of the wastewater treatment process, the use of biosorbents (microbial and plant origin based biomaterials)is promoted by several investigators. Hydrothermal carbonization of biomass is one of the promising techniques for the formation of activated carbon which can be used as bio sorbent for the removal of the pollutant from the wastewater. A wide variety of bio sorbents such as bacteria (microbial polysaccharide-based nanoadsorbents), fungi (*Rhizopus arrhizus*), yeast, algae (red and green macroalgae), biochar, pyrochar, hydrochar has been investigated.Biosorbent hasthe potential for wastewater treatment which can be scaled up in the coming days.

Keywords: Bio sorbent, Hydrothermal carbonization, models, Biochar, Hydrochar, pollutants.

Introduction: Several livings and non-living biomass can be used as biosorbent for wastewater treatment**.**The carbonization of the biomass resulted in solid material termed as biochar by the International Biochar Initiative (IBI). Biomass conversion technology is based on pyrolysis(slow and fast pyrolysis), gasification, torrefaction, and hydrothermal carbonization (HTC). Pollutants present wastewater such as heavy metals, toxic dyes, several kinds of antibiotics, pesticides and polynuclear aromatic compounds are reported to be removed by the biochar. Classification of biochar as graded by IBI, based on carbon content as Class I biochar (whichcontain 60% ofcarbon or more), Class II biochar (the carbon content has been reported between 30 to 60 %) and Class III biochar (contains the carbon content between 10 to 30 %) (Meyer et al.,2017). Electrostatic interaction, π-π interaction and intermolecular hydrogen bonding pay a role in the biochar adsorption mechanism. Biochar modified with an amorphous metal oxide (AMO Char) is used for the removal of metalloids (Pb, As, Cd). The desorption of biosorbent can be achieved through NaOH or HCl for the regeneration of the column (Jiang et al.,2017). The high surface area and pore volume make the biochar asfavorable adsorbent. Biochar is characterized based on surface area and porosity, pH,functional groups and mineral composition. Kinetic adsorption of chromium onto biochar follow pseudo-second-order kinetics. Hydrochar is produced by hydrothermal carbonization of biomass at high temperatures and pressure in the presence of water. Hydrocharis less stable than biochar because hydrocharis dominated by alkyl moieties whereas biochar is dominated by aromatic moieties. European biochar certificate (EBC) standardization does not include hydrochar due to their different chemical properties (Kambo, & Dutta, 2015). Many fungal species have been reported by the researcher for the removal of heavy metals. But their studies have been restricted to shake flask culture using Sabouraud Dextrose Broth which is more expensive as compared to PDB (Bano et al.,2018; Muthukrishnan, et al.,2018). Many macroalgal (red, brown and green) biomass has been shown by the researcher as sequestrants for the removal of cationic heavy metals (Demey et al., 2018). Several bacteria have been investigated as biosorbents for the removal of heavy metals (Pugazhendhi et al., 2018). Table1 shows different kinds of biosorbents.

Table1: Biomass as biosorbents

Biomass	Metal ions	Q_{max} (mg/g)	References
Aerobic granular sludge-derived biochar	Cu(II)	18.5	Wei et al.,2018
Magnetic biochar	Pb(II)	180.7	Ho et al.,2018
Pinewood sawdust derived magnetic hydrochar	Pb(II)	167.22	Wang et al.,2018
Lagenariasiceraria peel biomass	Cu(II)	7.34	Ahmed et al.,2018
Immobilized *Bacillus licheniformis*	Pb(II)	113.84	Wen et al.,2018

Characterization of Bio sorbent:

Several tools are used for the characterization of bio sorbent which are shown in figure1 which is based on chemical and physical-based characterization such as SEM (Scanning electron microscopy), TEM (Transmission electron microscopy), NMR (Nuclear magnetic resonance), Zeta potential, EDX (Energydispersive *X*-ray spectroscopy), BET (Brunauer–Emmett–Teller),Particle size distribution, FTIR (Fourier-transform infrared spectroscopy), ash content, bulk density, pore-volume, etc.

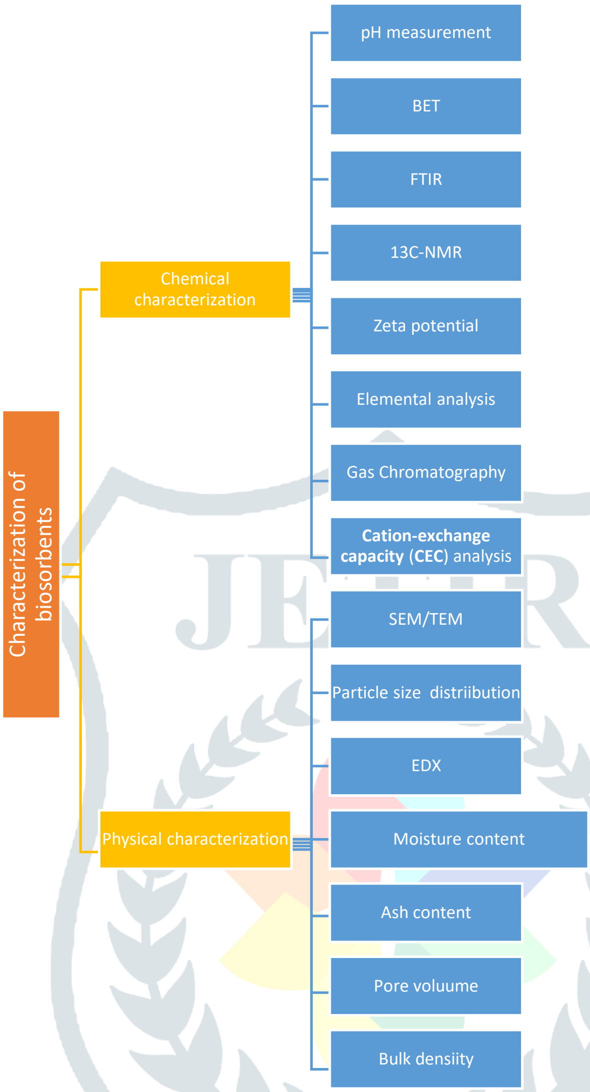

Figure 1: Overview of the proposed characterization of Biochar (Nartey & Zhao, 2014).

Factors affecting Biosorption: Several factors like temperature, pH, initial concentration, contact time, bio sorbent dose, etc have been reported by the researcher which can affect the process of biosorption (Arief et al., 2008; Bankar&Nagaraja, 2018).

Mechanism of biosorption: Different kinds of processes have been shown by the researches to show the phenomenon of biosorption like ion-exchange mechanism, affinity mechanism, chelation mechanism, etc (Anastopoulos&Kyzas, 2015; Wang & Chen, 2014; Gavrilescu, 2004; Gupta, & Diwan, 2016). The probable mechanism of biosorption has been shown in figure 2.

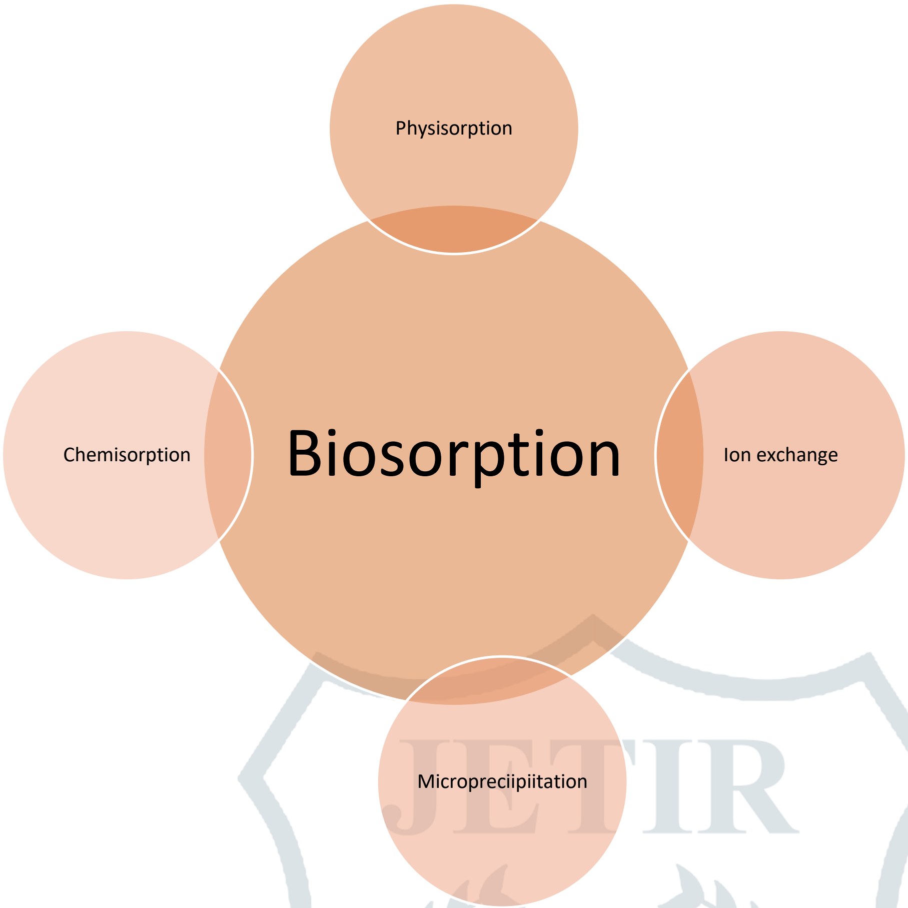

Figure2:Different mechanisms of biosorption.

Bioreactor for wastewater treatment: Membrane bioreactor (MBR) can be used efficiently for the removal of antibiotics from the wastewater (Shi et al., 2018). The wastewater heavy metals are removed by the use of afixed bed and fluidized bed bioreactors (Shakya & Ghosh, 2018;Alvarino et al., 2018). Packed bed bioreactors are used for petroleum-based wastewater treatment (Ismail, &Khudhair, 2018).

Conclusions and Future direction: This review draw the attention of the researcher towards the use of the biologically active or derived product for the removal of heavy metals, toxic dyes, pharmaceutical waste present in water. Biosorption characteristics of biomass are often described by thermodynamics, kinetics and equilibrium parameters. The process of biosorption is affected by several factors like temperature, pH, ionic strength and biosorbent dose etc Packed bed column is highly recommended to do the filtration on the heavy metals.

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