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Agricultural wastes use as a magnetic biosorbent for removal of contaminants from wastewater- A review

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ABSTRACT - Agricultural wastes present all over the world constitute suitable substrate for various applications due to their abundance, degradability and low cost. This waste is commonly utilized for magnetic biosorbent production through various methods. Biosorbent materials when doped with magnetic medium get converted into magnetic biosorbent, which possess numerous applications in the field of environmental technology. Due to their high porosity they are being utilized for adsorption of heavy metals, organic and inorganic chemicals like tetracycline, phenols, etc. The various substrate and methods used for production of magnetic biosorbent, with their suitable application will be collectively reviewed in this paper.

Keywords: Agricultural waste, Magnetic biosorbent, contaminant.

I. INTRODUCTION

Natural wastes (Biomass) derived from food industry after the processing of crops are abundantly generated by-products requiring proper utilization. [1] studied that activated carbon synthesized from agricultural and food industry waste can adsorb various bio-resistant organic pollutants from the aqueous system. Production of activated carbon is not only costly but also generates environmental concerns like pollution. Therefore researchers have carried out extensive studies to develop a low cost material, which is not only eco-friendly but also has high surface area with high adsorption properties [2]. As a result, biochar materials are doped with magnetic medium to convert into magnetic biosorbent, which enhances surface property which can be used for removal of heavy metals, organic pollutants and inorganic toxic elements. Several technologies like ion exchange, membrane separation, solvent extraction, coagulation flocculation, electrolysis are commonly used techniques for treatment of waste water. However, these techniques possess greatest disadvantage of being time consuming and uneconomical. Magnetic biosorbent are attached with various metal ions on their surface in order to enhance its magnetic effect and their application in various field. Common methods such as co-precipitation[3], conventional heating in an electrical furnace [4] and calcinations [5,6] were being employed for the production at laboratory scale. Studies have shown that magnetic biosorbent are used for removal of contaminants such as cadmium [7], Lead [8], phosphate [9], methylene blue [10,11], Arsenic [12,13].

II. SYNTHESIS OF BIOSORBENT AND MAGNETIC BIOSORBENT

Agriculture wastes produced from food processing industry are used for making adsorbents. The collected material was washed with distilled water for several times to remove the dirt particles. It was cut to small pieces and dry with tray dryer. Now the dried materials were then crushed and sieve and stored in a bottle. Three most common methods used to produce magnetic biosorbent include **co-precipitation, calcinations and pyrolysis** as shown in fig.1. These methods result in high quality biosorbent with high yield of magnetic biosorbent material. Biosorbent was magnetized using a chemical precipitation method. Briefly, biosorbent was suspended in distilled water for one hour followed by mixing of ferric chloride and ferrous sulphate solutions and magnetically stirred for an hour. Addition the biosorbent in mixed solution and slowly stirred. Now add 10M-NaOH drop wise into suspension until the pH raised to 10-11 and stirred for 60 minutes, the suspension was aged at room temp for 24 hours followed by washing with DW and ethanol and after that several time washed with DW followed by ethanol. The filtrated was dried overnight in hot air oven and stored in container.

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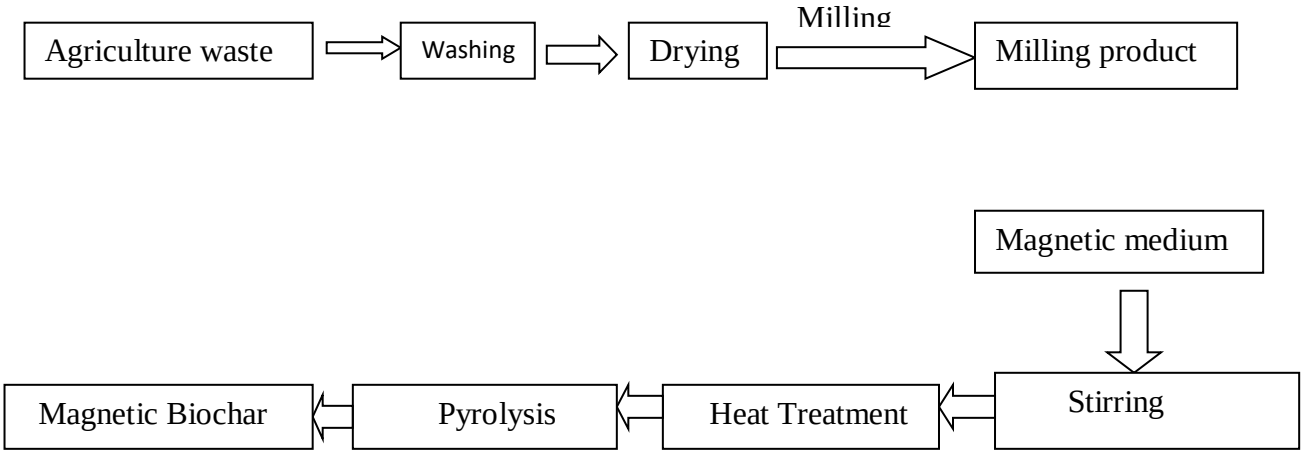

Fig-1. Synthesis of Magnetic biosorbent by pyrolysis from agricultural waste

III. APPLICATION OF MAGNETIC BIOSORBENT

Magnetic biosorbent was found to be widely used as an absorbent in the water treatment industries. The need for clean water is high concern in each and every part of the world, due to water scarcity. Contamination of water only due to discharge of hazardous effluent such as dye and organic substance from textile industries, heavy metals from industries such as battery, metal plating, mining and paper industries etc. [14]. Many technique such as ion exchange, membrane filtration, biological treatment and adsorption [15] are employed for cleaning up of the waste water. However, every method of wastewater treatment have its own set of advantage and disadvantages.

Arsenic is a toxic carcinogen present in water as a As(v) (H_2AsO_4, $H_2AsO_4^-$ and $HAsO^{3-}$) and As(III) (H_2AsO_4, $H_2AsO_4^-$ and $HAsO_3^{2-}$)[16]. It is very difficult to destroy these oxides and can be transformed into insoluble compounds. Many investigations have been performed on the study of magnetically modified biosorbents and capability to remove arsenic from waste water. [17] used biosorbent as an ultrafine Fe_2O_3 particle for removal of arsenic from wastewater. When the pH was in acidic range, all As(v) was removed. [13] using red mud for synthesis of magnetic Fe_3O_4 nanoparticles and studied the effect of modified magnetic biosorbent for As(v) removal. Chromium used in various industries like leather, tanning, battery, dye etc. due to this, water pollution is increasing due to chromium. Rhizopuscohnialginate is use as a magnetic biosorbent were able to remove Cr(VI) from wastewater [18]. Adsorption capacity is increased with increase the temperature.[19] studies on magnetic modified biosorbent (PS-EDTA resin) for removal of chromium from wastewater, adsorption were adsorbed in the pH range 3-4. A study was carried out on fabricated a nitrogen doped porous carbon containing magnetic biosorbent and absorbed their capability for removal of chromium from wastewater [20]. [21] studied on zircomium ferrite and used for removal of phosphorous from wastewater.

As Nano particles may also increase the surface of biosorbent [8], it promotes the adsorption properties. Several researcher reported that the increased adsorption of different heavy metals is attributed to the formation of surface complexes with nano metal oxide/ hydroxide and magnetic iron oxide [22,23]. In contrast several studies reported that nano particles could heavily block and fill the pore, reduce the surface area and pore volume of biosorbent [22,24,25]. Chitosan modified biosorbent was successfully prepared by combining the superiority of chitosan, biosorbent and Fe_2O_3, which has low operating cost, easily available biomass resource, with magnetic, and abundant functional groups possessing four times higher Cr(VI) adsorption capacity than unmodified biochar [26].

Groundwater can be easily contaminated due to the highly toxic heavy metal such as arsenic which is naturally available in the earth's crust. Consumption of arsenic contaminated water bring a serious threat to the public health and has already affected millions of people around the world [27]. Magnetic biosorbent developed from pinewood [25], hickory chip [22],cottonwood [28] and corn straw[29] has the capability to remove the arsenic from groundwater by acting as a adsorbent with high adsorption capacity value. Application of magnetic biosorbent as adsorbents for many heavy metal such as chromium[30], copper, cadmium (Noraini et al.2011; Reddy and Lee 2014), tin [32] was studied. The textile industries are a continuously growing due to demand of fashion in present generation. They consume more amount of water and generates high volume of effluent that contains different types of colors. So, magnetic bisorbent also acts as adsorbent for removal of these synthetic dye colors such as methylene blue [33,34], malachite green [35], crystal violet [36], Congo red [37] found in wastewater. On other hand, Eutrophication anion such as nitrogen and phosphate and hydrophobic organic compounds can also be removed. These entire positive outcome boost the production of magnetic biosorbent from different biomass in larger scale for its application in waste water treatment.

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IV. FUTURE CHALLENGES

As the demand of magnetic biosorbent is increasing, due to their excellent adsorption properties, they also face some major pullbacks too. Since the substrate used for biosorbent production is agricultural waste materials, handling must be given special care. These waste materials may contain hazardous substances, toxic compounds and pathogenic microorganisms which needs to be handled with care. The complete study on physical, chemical and sorptive characterization of each biosorbent from different agricultural waste needs to be done. As the scope of nanotechnology is in wide horizon, nanomaterials for enhancing the surface properties of biosorbent should be focused in-depth in future. In case of fruits and vegetables processing, the by-products like peel, pulp residue, etc. can be utilized for primary extraction of valuable compounds like bio actives, flavors, colors. No studies were carried out on the residue left out after this primary extraction as a substrate for biosorbent manufacture. Moreover, the scaling up of production process should be focused more because, the success in utilization of agricultural waste lies in their beneficial end application. The industrialist must be convinced that natural compound is more efficient than chemical substances for waste water treatment. Other innovative techniques which is time consuming and cost effective needs to be further analyzed to make the production simple.

V. CONCLUSION

The management of agricultural waste has been highlighted as one of the concerned sustainability issues which have huge impact on the surrounding health of habitants. Therefore, many techniques for producing magnetic biosorbent has excellent functionality due to its high porosity and significant morphology. Agri-waste derived biosorbents developed from the natural waste will provide a sustainable solution to mitigate water pollution which is a challenge and potential threat to aquatic flora, fauna and will ultimately reduce the impact of polluted waterbodies on the human health.Thus, Magnetic biosorbent from biomass has high characteristic adsorption power to remove heavy metals, organic pollutants and various toxic substances from wastewater aiding wastewater treatment.

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