A Review study on Biochar-Based Nancomposites Materials

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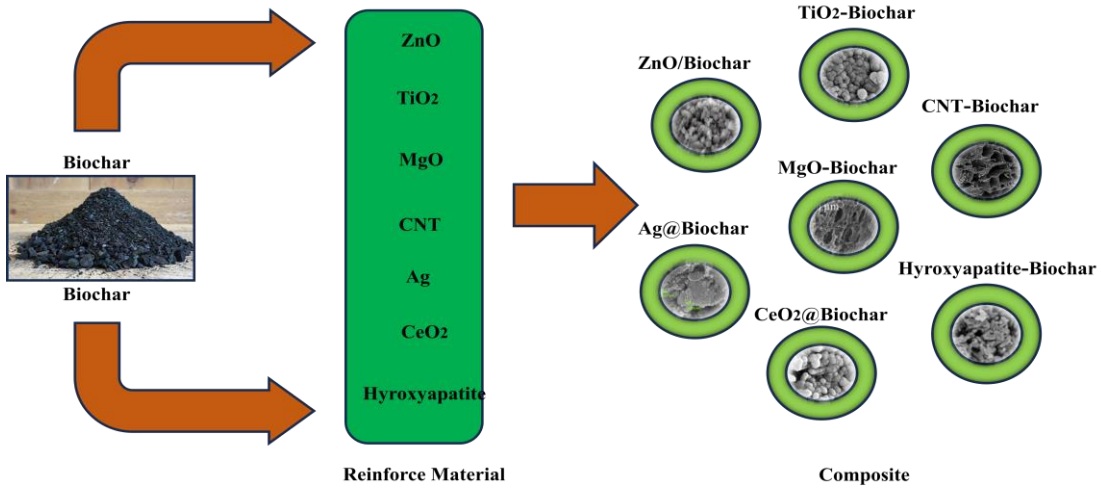
Abstract

In today's scenario, there are many problems that require sustainable modern solution. Various carbon based nano materials provide the solution of these problems. Nano material includes, nanochar-composite has the capacity to absorb various contaminant and pollutants present in the polluted water. It also has the numerous advantages such as bioremediation of contaminants and pesticides, plant disease treatment, plant growth and improvement of soil fertility, waste water treatment etc. The raw materials for biochar are easily available and low in cost so nano composite have generally low cost of production.

This review article is mainly focused on the various nanocomposite of biochar with other metals and materials. There are various biochar nanocomposite reported that include, CNT-based nanocomposite, Zn/biochar, CeO_2@biochar, Tio_2-Biochar, Ag@Biochar, Mgo-Biochar, Hydroxyapatite-biochar. Apart from this, various other biochar composite are also reported. The main purpose of these biochar nanocomposite materials are to provide easy, low cost, environmental friendly, and sustainable methods for the waste water and other adsorption related problems.

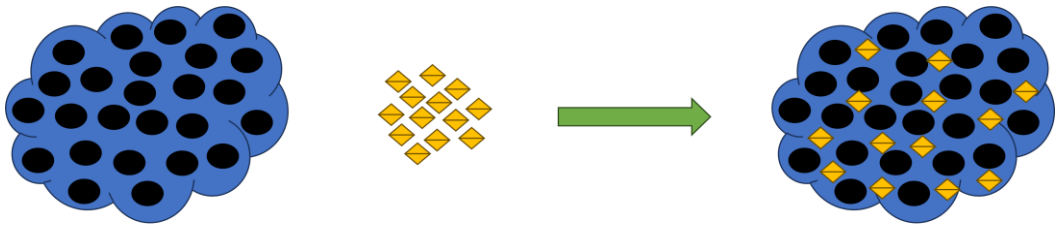


Introduction

Nano materials that contain carbon as a main component gain the attention of research community due to their vast application in various fields like environment, catalysis, agriculture, waste water treatment etc. carbon based nano materials was first discovered by Harry Kroto, a chemist from the university of Sussex and Rice university. He discovered C^{60} fullerene in 1985 [1-3]. Biochar is a solid carbonized product which is obtained by controlled process of thermal decomposition in the absence (pyrolysis) or limited environment

of oxygen of biomass feedstock like agricultural waste and other natural cellulose materials. They are also produced by thermo-chemical treatment like rapid pyrolysis, slow pyrolysis, torrefaction and carbonization [4]. On thermal treatment of biomass it produced biochar along with syn-gas and biofuel making it more economical biomass combustion [5-7]. We can enhanced the properties of biochar by combining it with other various metals and materials. By doing this the surface area, porosity, increments in functional groups and other similar properties can be increased by several times. CNT based biochar nanocomposite is reported which have the capacity to removed the organic contaminants and dyes from waste water [8-10]. But these metal based nanocomposite can easily goes into the soil and contaminate the ground water and increase the soil pollution [11-13].

The diagram below represents the general form of biochar composite materials.



This review article describes the various biochar composites that have been synthesized and have various applications in different fields.

ZnO/biochar nanocomposite

ZnO/biochar nanocomposite is reported by Fang Yu and co-workers in 2021. This nanocomposite is synthesized by ball-milling method. This method has low cost of production of biochar, environmental friendly and also gives high efficiency. Ball-Milling method also produce high rate of homogeneity in composite material. Fang Yu and co-workers use bamboo stakes and Zno as row materials for the production of composite. Composition of Zno/biochar can be controlled by using ball-mill. Morphology, elemental composition and elemental mapping of Zn/biochar is successfully investigated by Fang Yu and co-workers using SEM, XRD, TEM, and other surface analysis techniques [14-16].

Carbon nanotube-Biochar

It is a hybrid form of carbon nanotube (CNT) and biochar. It Was firstly reported by Mandu Inyang and co-workers in 2014. It is actually a coating of biochar onto the carbon nanotube. CNT-biochar nano composite have greatest thermal stability, high surface area and high pore volume. It is a great example of hybridization of existing biochar technology with emerging nano technology. Traditional method is too costly to produce this composite. So dip-coating procedure is applied to produce CNT-biochar nano composite. It has high affinity toward methylene blue(MB) so it is extremely useful for the removal of MB in waste water. Experiment shows that the 1% biochar-CNT composite has the highest sorption capacity of MB. Another benefit of these composite is that it is environmental friendly and cost effective. It is characterized by thermogravimetricmethod, elemental analysis, raman spectroscopy, Zeta potential, and surface analysis methods viz. TEM, SEM etc [17-19].

CeO_2@biochar nanocomposite

Biochar can be used as supporting materials for various nanostructure materials. There is not enough information has been confirmed about the CeO_2@biochar. A. khataee and co-worker reported about this nanocomposite in 2017. Biochar is prepare from paper waste or wheat straw and CeO2 oxide is coated by

the use of $Ce(NO_3)_3.6H_2O$. CeO_2@biochar also has sonocatalytic activity. It is characterized by XRD, FT-IR, SEM, DLS, GC-MS and Zeta Potential analysis [20, 21].

Tio_2-Biochar

This composite was firstly reported by Alireza khataee and other co-workers in 2017. Tio_2-Biochar is synthesized by sol-gel method. Other methods like precipitation, electrochemical, spin coating and thin film, dip coating, wet chemical, solvothermal, hydrothermal, sonochemical, xerogel and areogel can also we used for the preparation of Tio_2-Biochar. It has exceptional physical and chemical and non-toxically properties. Now a day's textile waste is major problems in waste water treatment. Because dyes have great toxicity and it is highly stable and visible in polluted water. It is characterized by XRF, EDX, FT-IR, BET analysis, and SEM and TEM is used for the morphology of the Tio_2-Biochar composite. It is extremely useful for the removal of organic dyes in waste water [22-24].

Ag@Biochar

Most of the biochar composite are made by physical and chemical methods, which use toxic chemical but Ag@biochar is produce by facile, ecofriendly and cost effective method. This was firstly reported by Abdelazeem S. Eltaweil and co-workers. It is a first Ag based biochar material which used Chenopodium ambrosioids leaf as a carbon source. It uses many of the green chemistry principles. It also has photoluminescent properties. Ag@biochar has high affinity to remove methylene blue from waste water. It is resistant to oxidation and has biocompatibility with optical properties. Because of this, it is widely used in the field of medical and environment. It is characterized by UV-visible spectroscopy, X-ray diffraction method, FTIR spectroscopy, XPS analysis, Thermal gravimetric analysis, BET analysis, Fluorescence spectroscopy, and the morphology is done by the SEM and TEM [25-27].

Mgo-Biochar

It is prepared by stirring modification method. Mgo-biochar is mainly useful in absorbing phosphates in polluted water. Biochar dose not have the much affinity toward the absorbing phosphates from waste water. But the composite of biochar with Magnesium have high affinity to absorb phosphates from waste water. The affinity toward phosphate is mainly due to its inner-sphere complexation ($Mg\text{-}O\text{-}PO_3H^{2-}$, $Mg\text{-}O\text{-}PO_3H^{-}$ species). It is also useful in controlling eutrophication process.

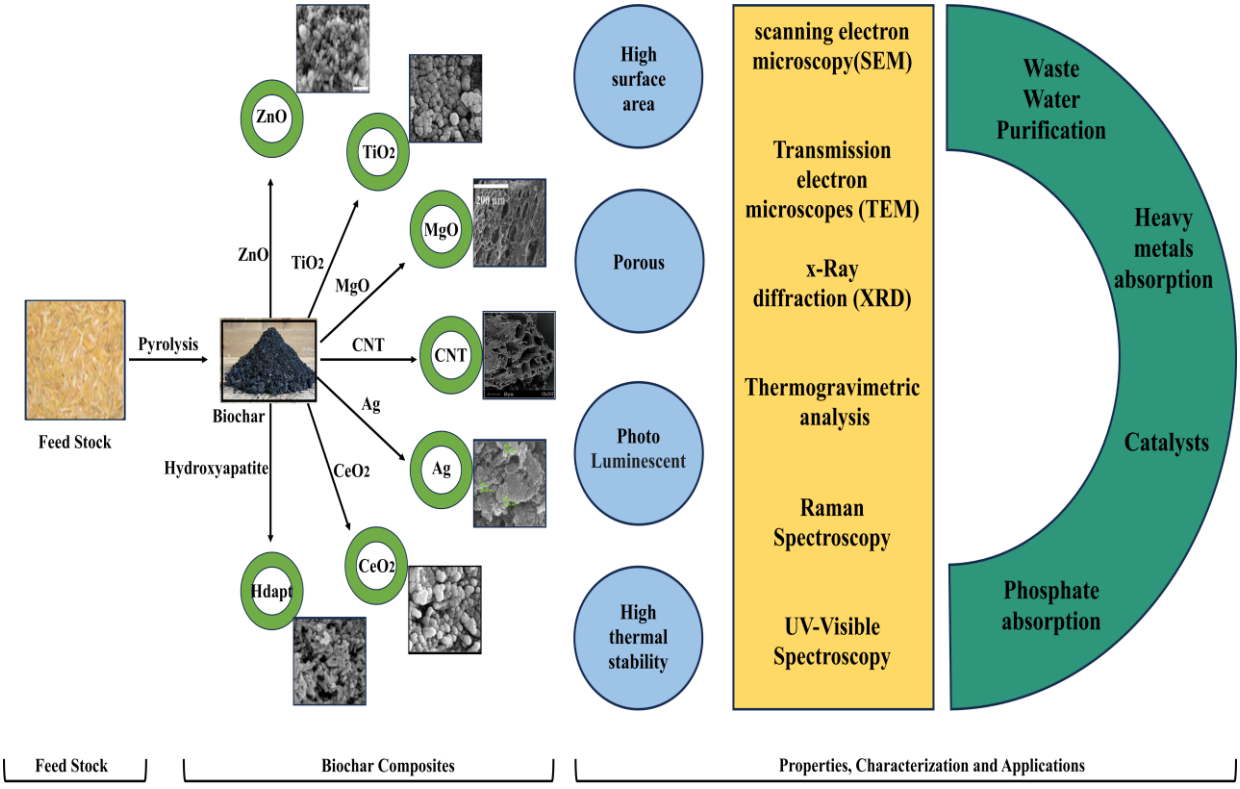
Traditional methods like nano filtration and RO filtration are very useful for removing contamination from waste water but due to very high cost and non-selectivity for ions these methods are unable to fulfill current requirements. The morphology is explain by TEM, SEM, XRD, BET analysis and FTIR techniques. The absorption data explain that there is non-monolayer and multiple adsorption sites is present on the surface of Mgo-biochar [28-30].

Hydroxyapatite-biochar

It was successfully fabricated by Yu-Ying Wang and co-workers. It has the capacity to adsorb one or more than one different metal ions. The adsorbtion of different ions is pH dependent. Most of the metals like Cd, Cu, Pb and Zn causes cancer and damage the immune system. So if we have one method or one materials that detect these metals than it is beneficial for us. Hydroxyapatite-biochar have the capacity to detect these metals with other materials or metals. Hydroxyapatite [HAP,$Ca_{10}(PO_4)_6(OH)_2$] is naturally present in the human bones and teeth. It is environmentally friendly and it get aggregated in aqueous solution and decrease their surface area. If it combine with biochar it produce high adsorption capacity for metal ions.

Yu-Ying Wang and co-workers produce this composite by rice straw by slow pyrolysis. It is characterise by SEM, TEM, EDX, FTIR, surface area analyzer, and zeta potential measurement. It successfully remove single and ternary metal ions [Pb(II), Cu(II), Zn(II)] From mixed solution [31-33].

The diagram below represents the composition and application of biochar nanocomposite.



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Conclusion

In present days many biochar composite has been prepared and all are mainly used in the purification of polluted water which is coming from various waste water resources. All the biochar composite discussed above are highly capable for the removal of various metal ions like Pb, Cu, Zn, Hg, etc. They are also capable of removing organic dyes like methyl blue. These biochar composite materials can easily prepared from various carbon rich sources and also they are economical, as well as environmental friendly. Some of the biochar composite have the potential to replaced our traditional water purification system in upcoming future technologies. There is continuous research has been carried out on the various nano composite materials and in upcoming future be are able to succeed in achieving an easy, cost economical, environmental friendly and long lasting methods for ours various purification problems.

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