Young Scientists' Circle

Value Addition of Food Waste for Treatment of Contaminated Water

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With the advancement of technology, the problems associated with the ecosystems are also increasing. As a result, the components of the ecosystem; water, land, and air are contaminated with pollutants. Water is used for domestic, commercial, industrial, and agricultural activities. Wastewater released from such activities usually contains many hazardous substances that could be harmful to both the environment and humans. Oil, dyes, heavy metals and their derivative compounds, and pesticides are some examples of hazardous substances that could lead to health issues. Industrial processes release large quantities of heavy metals and dyes containing water. If the wastewater released from such processes is not treated properly, these contaminants end up in nearby water streams polluting the environment.

Generally, the heavy metals are defined as the metals with density of at least 5.0 g cm^{-3}. Among the heavy metals, Cd, Cr, Cu, Ni, As, Pb and Zn are considered as the most hazardous heavy metals used in chemical-intensive industries. Many industries, especially the garment industries, release dyes and wastewater containing dyes to the environment, which are usually considered difficult to treat. Some examples of hazardous dyes used in industries are malachite green, rhodamine B, methylene blue, methyl violet and methyl violet 2B. Moreover, toxic anionic and cationic surfactants are added to detergents, cleaning agents, and agrochemicals in order to enhance the surface characteristics. When mixed with water bodies, these surfactants result in harmful health problems to living beings. Anions such as sulfate, nitrate, and phosphates are another group of environmental hazards which are released into the environment during some industrial processes, whereas these ions usually cause eutrophication of the water bodies.

Many contaminants mixed with water can be removed using the biosorption techniques, which use biomaterials for the adsorption process. Different types of food wastes have been investigated as effective biosorbents for the removal of water contaminants in the recent past. Biosorbents possess many advantages as absorbent materials, given they are less toxic, environmentally friendly and low-cost material. Some examples of biosorbent materials investigated in the recent past are jackfruit peel and core, breadfruit peel and core, rice husk, wild breadfruit peel, orange peel, potato peel, coconut waste, maize cob/husk, tea waste, eggshells, fish scales, and chitosan. An attractive feature of such biosorbents is that they possess functional groups, such as hydroxyl, amine, ester, and carboxyl, which attract positively charged metal ions, thereby removing metallic contaminants in water [1].

Some drawbacks of using food waste as biosorbents are their limited capacity and lack of selectivity. These issues can be resolved to some extent through chemical modification. Once the surface of the material is chemically modified, it usually behaves as a different material having similar characteristics to the modifier. As such, chemically modified biosorbents have received a great deal attention among the research communities in this field. Method development through optimization of process parameters and solution parameters are some of the critical steps in optimizing the most desirable conditions for the contaminant removal process. Some reports on surface modifications provide the evidence for closer to 100% biosorption capacity. Ethylenediamine tetraacetic acid (EDTA), sodium dodecyl sulfate, strong bases (e.g. sodium hydroxide, potassium hydroxide) and acids (e.g. nitric acid, citric acid, acetic acid) are some examples of the modifying agents used for chemical modification processes. Selection of a suitable modifying agent depends on the intended application. Depending on the agent, different chemical processes, such as complexation, ion exchange, hydrolysis of surface functional groups, and protonation take place during the biosorption process [1,2,3]. In addition to chemical modification of adsorbents, thermal treatment methods have also provided positive results for adsorption. The enhancement of adsorption results from the increase of the porosity of the adsorbent surface. Moreover, conversion of food waste into biochar or activated carbon also leads to enhanced contaminant removal. However, these processes are not considered a cost-effective strategy due to the high energy requirement. Furthermore, treatment of food waste at high temperatures would also destroy functional groups present and therefore, chemical attractions of certain contaminants would not be possible.

Today, researchers are investigating the biosorption behaviors of food wastes, in raw or modified forms, and under static and dynamic conditions. In static conditions, optimization parameters such as biosorbent dosage, particle size, contact time, and solution pH are considered as critical parameters, while the flow rate and biosorbent column height are considered under dynamic conditions. Out of all these parameters, pH of the system is very important for biosorption processes, given that both the kinetic and equilibrium processes are directly influenced by pH. Investigation of kinetics is important as the mechanism of biosorption can be explained using the kinetics of the contaminant removal. When analyzing the kinetics behavior, the data is interpreted in terms of the curve fitting to pseudo-first-order, pseudo-second-order, etc. and diffusion models. The equilibrium studies are performed to check the validity of adsorption isotherms. Two-parameter models such as Langmuir, Freundlich, Temkin and Dubinin Raduskevich, and three-parameter models, such as Sips, are the most common isotherms used for the purpose [2]. Adsorption equilibrium data can be fitted to both linear and non-linear forms of isotherms. In the analysis of adsorption isotherms, the maximum biosorption capacity is a critical pentameter, which is a measure of the efficiency of the removal. This is important when expanding to large-scale applications [3,4]. Detailed studies of biosorption processes, such as thermodynamics, desorption and interference characteristics, are performed for better understanding of the biosorption process.

In large-scale industries, ion-exchange membrane filtration, chemical precipitation and oxidation, and electrochemical methods are used for the treatment processes. These methods are highly capital intensive and require trained personnel to operate. Biosorption is an alternative for such methods because of its efficiency, being able to handle large volumes, and the possibility of extending toward static and dynamic conditions through prototype treatment systems.

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