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Review

Prospects of banana waste utilization in wastewater treatment: A review

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ABSTRACT

This review article explores utilization of banana waste (fruit peels, pseudo-stem, trunks, and leaves) as precursor materials to produce an adsorbent, and its application against environmental pollutants such as heavy metals, dyes, organic pollutants, pesticides, and various other gaseous pollutants. In recent past, quite a good number of research articles have been published on the utilization of low-cost adsorbents derived from biomass wastes. The literature survey on banana waste derived adsorbents shown that due to the abundance of banana waste worldwide, it also considered as low-cost adsorbents with promising future application against various environmental pollutants. Furthermore, raw banana biomass can be chemically modified to prepare efficient adsorbent as per requirement; chemical surface functional group modification may enhance the multiple uses of the adsorbent with industrial standard. It was evident from a literature survey that banana waste derived adsorbents have significant removal efficiency against various pollutants. Most of the published articles on banana waste derived adsorbents have been discussed critically, and the conclusion is drawn based on the results reported. Some results with poorly performed experiments were also discussed and pointed out their lacking in reporting. Based on literature survey, the future research prospect on banana wastes has a significant impact on upcoming research strategy.

Contents

1. Introduction

Pristine water is an essential solvent for all living being growing

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on planet earth, although bottom billions population on earth are struggling to get fresh potable water. The scarcity of water is the major concern of contemporary world. For last few decades, demand for potable water has increased exponentially due to rapid population growth, the burgeoning of industrial growth and el niño and la niña effect on regular rainfall. With the modernization of civilization, many industrial products are entered into our lifestyle like plastics, phenolic products, petrol operated cars, industrial level food processing units. These industries and their products effectively degraded the existing pristine water source and polluted the soil, air, and water bodies to such an extent that it has an affecting human life. Presently, its effect showing through some specific diseases that occur across the world like arsenic contamination in many parts of West Bengal jute growing farmers in India, mercury contamination in Minamata Bay fish in Japan, due to the use of DDT contamination in water many birds became endangered species. In many countries, groundwater is the primary source of potable water for their local inhabitants in villages, small and medium cities. However, the ground and surface water quality are deteriorating due to the use of fertilizers and pesticides in agricultural activities, antibiotics, dyes, and heavy metals in industrial activities. The various industrial effluents continuously discharging into the river and ponds contain a wide variety of pollutants that are slowly entered into the natural ecosystem, it has a significant toxic impact on human health, aquatic habitats, and plant species. Recently, some highly toxic chemicals have been detected at alarming levels in drinking water at different parts of developing nations, posing a serious threat to human and aquatic life. Initially, when the chemical load was less, the soil function as an adsorbent to separate the toxicants from water and clean water pass to an underground aquifer, but with the rise of population and concentration of toxicants the soil adsorption capacity exhausted and now toxicants percolating to groundwater. The serious health problems like cancer, kidney failure, liver disorder, etc., arise owing to the high concentration of chemical pollutants. There is an urgent need of environmentally friendly and cheaper adsorbent material to eliminate chemical toxicants from potable water to improve the water quality.

A wide range of scientific methods is accessible to a researcher with varying degree of success to minimize the water contamination. Some of reported techniques are reverse osmosis, solvent extraction, flocculation, membrane separation, filtration, chemical precipitation, oxidation, reduction, coagulation, ion exchange, evaporation, electrolysis (Ali and Jain, 2005; Gupta and Ali, 2003; Wojnarovits et al., 2010), photochemical reactions (Fox and Dulay, 1993), activated sludge (Bromley-Challenor et al., 2000), anaerobic and aerobic treatment (dos Santos et al., 2007), microbial reduction (Shen and Wang, 1994), bacterial treatment (LaPara et al., 2000), irradiation by nuclear radiation (Basfar and Abdel Rehim, 2002), electrodialysis (Ali et al., 2011), ultrasonic treatment (Suzuki et al., 2000), magnetic separation (Karapinar, 2003), and adsorption (Gupta and Ali, 2008; Danish et al., 2011a, 2011b, 2016a, 2016b; Li et al., 2016; Hashem and Amin, 2016) used to remove and/or separate toxic contaminants from aqueous solutions. However, some of the techniques mentioned above have high operational cost, need highly skilled labor, and generates sludge at the end of the operation. Compared to other techniques adsorption methods have an advantage. The adsorption techniques through cost-effective adsorbents offer some benefits such as easy to operate, so not required any high-skilled labor, environmentally safe, no health risk for the operator, and the process is non-destructive so that contaminants can be separated and recycled (Ahmad et al., 2011). The macropores, mesopores, and micropores in adsorbents can serve as a molecular sieve. Hence, it can be used for the adsorption of soluble and insoluble pollutants with large adsorption capacity. Undoubtedly, large surface area activated carbons are considered as a highly efficient adsorbent against various toxicants (Bansal and Goyal, 2005). Nevertheless, its extensive use in effluent treatment is sometimes restricted owing to the scarcity of cheaper activated carbons.

The unconventional adsorbents from biomass waste and other carbon-rich sources have been tested against water-soluble contaminants; the reported research works have been reviewed extensively (Ahmad et al., 2011, 2010, 2012; Patel, 2012; Rafatullah et al., 2013; Nor et al., 2013; Abdolali et al., 2014; Mohan et al., 2014; Anastopoulos and Kyzas, 2014; Yahya et al., 2015; Bhatnagar et al., 2015; Jain et al., 2016; Gupta et al., 2015; Adegoke and Bello, 2015; Bhatnagar et al., 2010). It has been reported that under ordinary conditions, the activated carbon produced from various low-cost raw materials have little or poor adsorption capacity against various pollutants as compared to commercial coal-based activated carbon (Bhatnagar et al., 2015; DeMessie et al., 2015). Therefore, search for the low-cost raw material as well as the production method of activated carbon is going on.

Many agricultural wastes were tried as an adsorbent, among them, banana waste has been of significant importance because it has various parts that can be utilized such as banana fruit peels, trunks, pseudo-stems, leaves, and piths. These parts of banana wastes have been extensively studied as an adsorbent against a wide range of pollutants. Banana wastes have attracted researcher's attention as an effective raw material for adsorbents owing to abundantly available, post fruit harvesting no proper utilization of the banana waste by the farmers, and a significant amount of carbon compounds present in it. Moreover, banana tree waste can cause serious environmental threat if its waste not properly managed, it can produce greenhouse gas if dumped in wet conditions. Usually, farmers threw the banana tree waste in rivers and ponds where it degraded slowly and formed methane, and other gases spread putricible smell and affect the nearby ecosystem. Therefore the selection of banana tree and fruit waste as an effective adsorbent material is a smart choice for sustainable future.

Banana plants belong to the family Musaceae. The banana species suitable for consumption, belong to *Australimusa* and *Eumusa* series that has the different origin of the same genus. The commonly available human consumable banana is a member of *Musa accuminata* species. The worldwide growing species of Musa are *M. cavendishii*, *M. paradisiaca,* and *M. sapientum* (Mohapatra et al., 2010). Banana tree can bear fruit (nearly 20 fruits of banana grow to a hand (tier) and 3–20 hands can grow in a cluster) once in a lifetime, so lots of biomass waste generated from the tree. The banana plant has been initially grown in India, and Southeast Asian region (Malaysia and Japan). Whereas, some banana species are considered to be genetically linked with some African banana species (Anwar et al., 2010; De Langhe et al., 2009). Banana fruit is one of the most popular and highly nutritional fruit crops cultivated in more than 130 countries; the largest banana producing countries are located in tropical and sub-tropical regions. India, China, Philippines, Brazil, and Ecuador are the top 5 bananas growing countries according to 2016 data. The production of banana has considerable economic importance. In India, the banana production in 2016 was about 27.6 million metric ton, while the total world production of banana during 2016 was about 144 million metric ton (Vezina and den Bergh, 2016; Ali and Saeed, 2015).

Among several wastes generated due to banana tree and fruit, the banana peel is one of the important waste generated in large quantities due to banana fruit consumption. Banana peel contributes about 40% of total weight of the fresh banana fruit (Anhwange et al., 2008). According to banana production data mentioned in above paragraph, it is evident that the banana industry produces banana peels more than 57.6 million metric tons annually. Banana