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ORIGINAL ARTICLE

Investigation the advantages of some biocompatible adsorbent materials in removal of environmental pollutants in aqueous solutions

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Water Pollution resulted from environmental pollutants such as organic compounds and heavy metal ions is a serious problem due to the severe toxicity and carcinogenic nature of these compounds. Among the various methods of water purification, the adsorption mechanism with the low cost, abundance, and availability of the natural adsorbents is considered as one of the best practices. Among many natural materials, such as: coconut peel, orange peel, rice peel, corn straw, and cane bagasse, wastes resulted from oil products, fly ash, cellulose and lignocellulose compounds and rubber wastes are used in the adsorption process. In this article, the impact and efficiency of some of these waste materials in the cleaning and purification of the water systems will be discussed.
Key words: Environmental pollutants; adsorbent materials;water pollution; adsorbtion

Introduction

Water pollution sources include practices related to the agriculture, industrial, mining, and climate change. As previously mentioned, organic pollutants are highly dangerous because of their carcinogenic nature and the ability to dissolve in water systems. To this end, preserving of water resources along with some actions to improve its quality is essential and this is in line with the Millennium Development Goals for sustainable global development.Surface and underground water resources are not useable due to environmental pollution in many places. According to the global statistics in 2050, the earth's population will be reached over 9.3 billion people, and it is likely that the inhabitants of the earth will encounter with problem of famine or lack of clean water. Therefore, removing organic and toxic pollutants from aquatic environments is essential and inevitable.

In this article, a number of studies on the removal of environmental pollutants are briefly mentioned. There are many ways to remove organic compounds and heavy metals such as oxidation, reverse osmosis, ion exchange processes, Electrodialysis, electrolyte, adsorption, and so on. It is necessary to mention that due to the high operating cost of reverse osmosis methods, electrodialysis, electrolyte, the adsorption mechanism as one of the best methods due to its availability and frequency of adsorbents, and cheapness, bioavailability of natural adsorbents. Could be a more suitable option for this process (Gupta & Shukla, 1996). In the adsorption process, all compounds, both soluble and insoluble in water, can be separated. It should be mentioned that in the adsorption process, the accumulation of absorbable materials at the external surface, including the external surface and the space between surfaces occur in the adsorbent particles.

Application of natural low-cost adsorbents in removing oil compounds from sea water

One way to deal with pollution of sea water and preventing the pollution of the marine environment is the application of absorbent materials to collect and prevent the spreading of contaminants on the water surface. The adsorbent material is usually used in small oil pollution and in cases where there is a limitation on the collection of oil contaminants by skimmers. The application of adsorbent materials includes:

1. Adsorption of oil pollution in places where the amount of water depth is low or there is some kind problem to access.
2. Using adsorbents in the form of floating belts in a way that encircle the coastal lines with oil contaminated to adsorb the amount of oil released from the coast and prevent also further contamination of coastal areas.
3. Increasing the rate of adsorption of oil pollution and its containment by standard booms.
4 Protecting areas which are difficult to clean, such as rocky beaches and sandy beds.
5. Using adsorbent materials in oil pollution on the coastal areas in order to prevent the penetration of pollution into the ground.
6. Collecting contamination from areas where water is stagnant and immovable.

7. Collecting oil pollution and preventing from spreading in environments where it is difficult to collect oil from the water surface, such as canals, rivers and water inlets.

Safety procedures for the application of absorbent materials

1. When using adsorbent materials in bulk scale, which are usually used as poweder form so these could be spread and created dust particles in the environment. In this case, the individuals which are involved in the operation should be covered appropriately, such as a dust mask, protective glasses, protective suits, and gloves, in order to prevent creating stimulation and allergy.
2. When using adsorbent materials in bulk scale, it is the best that these materials be placed within a suitable cover to prevent from dispersion in the environment.
3. Adsorbent materials should not be used in conjunction with dispersant and detergents due to the loss of hydrophobicity.
4. When using adsorbent materials in chemical absorption, the following cases should be considered:
5. When using adsorbent materials, the chemical characteristics of the adsorbent substance should be correlated with the chemical structure of contamination.
6. Adsorbent materials neither should be solved by chemical substances, it is worth to mention that there is no chemical reaction should be occurred between adsorbent materials and contamination.
7. After the absorption, the chemical waste materials must be treated, and the properties of the chemical substance, such as flammability, toxicity and corrosion, should be considered.

The application of adsorbent materials according to the location of area

Sometimes to deal with contamination, regarding the environmental situation and the abundance of adsorbent materials, adsorbent materials could be used at this places. One of the cases that abundant materials can be used temporarily is the application of straw, dried ferns, bagasse (sugar waste) and other available and abundant materials in the region. In counteraction_operations of oil pollution, identifying and using of indigenous plants to the marine environment due to the lesser effects of these materials has a more priority when compared with many different industrial adsorbent materials. To use these materials, they should be placed in a wired or lattice net. Sometimes using these materials and placing them inside a cylindrical wired net,. Adsorbent should be made in small size as much as possible due to water adsorption and increasing weight.

Safty Methods for the removal of Adsorbent materials after adsorption process

1. To remove the waste materials after adsorption, it should be repulsed according to the criteria due to dangerous materials in areas which are declared by the Environmental Protection Agency.
2. Type of contamination and adsorbent material must be considered.
3. The volume of adsorbent material that should be removed after adsorption is one of the important point has to consider . .
4. The probability of existence of other materials such as minerals, sand and other materials along with adsorbent materials should be noticed.
5. When delivering waste of adsorbent materials into the waste material collection facilities, the owner of the factory must be informed by the waste material factory of the precise information about the adsorbent and the chemical structure of pollution which is adsorbed by adsorbent material. In some cases, before the adsorbent delivered to the factory, a solution of lime and soil are used to stabilize and prevent the release of oil pollution.
6. Sometimes adsorbent with a high amount of oil capacity which are used as fuel in cement factory furnaces. In all cases, accurate information must be provided about the type of material which is adsorbed by the adsorbent. The burning of adsorbent material should be carried out in special furnaces and according to the environmental regulations.
7. When using the adsorbent to adsorb the chemical materials, the chemical properties of this materials must be considered. The way of neutralizing, stabilization, and burning of chemical materials in the environment is completely different.

Categorization of adsorbent types

Household wastes

Fruit waste

Olive kernel, almond peel, peach core, etc. are raw materials for making and preparation of activated carbon as adsorbent (Rodriguez-Reinso, Lopez-Gonzalez, & Berenguer 1982). In 1982, Rodriguez et al. Use a carbonization process to modify natural adsorbents. In the following, the high quality of activated carbon with microporous porosity was prepared. The results obtained from the Langmuir model were used to determine the specific surface area of modified adsorbent in the range of 90-1550 m^2/g. At the same time, it was mentioned that olive kernel and almond peel were used to remove some industrial colors such as methylene blue, crystal violet, victoria blue from aqueous solutions (Aziz, Ouali, Elandaloussi, Menorval, & Lindheimer, 2009).

Coconut peel

Coconut peel is known as one of the raw materials because of its high quality of activated carbon. In fact, according to the results of study, about 18% of the commercial production of activated carbon is obtained from coconut peel. It should be indicated that one of its important benefits is the widespread distribution in developing countries. In 1976, Banerjee et al. conducted an investigation about the preparation of activated carbon which is made by heating crushed coconut peel Stained with $ZnCl_2$ at 700 °C. The activated carbon was obtained with a special surface area around 800 m^2/g. In another study, the removal of lead from aquatic solutions was investigated by coconut peel Surface adsorption experiments were conducted to identify the effective removal of lead in different concentrations of metal ion. The results of the experiments

indicated that the lead adsorption was highly dependent on the amount of pH medium. Therefore, the highest amount of lead ion adsorption was achieved by coconut adsorbent in the range of pH: 4.5 was 26.5 mg/g. To better understand the adsorption process, companion isotherms of Langmuir, Freundlich, and Tamkin were determined. The results revealed that the data obtained from the experiments were well suited to Langmuir isotherm models. Moreover, the results of thermodynamic reactions revealed that the lead removal process was carried out spantaneously in a stoichiometric manner and the adsorption reaction was endothermic.

Orange peel

In 2001, a study on the effectiveness and efficiency of orange peel on the removal of acid violet 17 from aqueous solutions was analyzed by Rajeshwari Sivaraj, Namasivayam and K Kadirvelu. The results indicated that experimental data were well correlated with both Langmuir and Frendlich isotherms, and the adsorption capacity was 19.88 mg/g in the range of pH: 6.3.

Rubber wastes

One of the major concerns in using rubber waste materials is their high ignition risk and there is some kind problems about their uncontrolled burning, which could be bring a large amount of poly-aromatic hydrocarbons and phenol-containing compounds into the atmosphere and result in contamination. On the other hand, these compounds contain a lot of carbon. Therefore, to use rubber tire wastes, it is necessary to use a controlled thermal mechanism to convert and repair these waste materials. Lacchi and Masiquazar,In 1993, to obtain activated carbon from waste products, they used a reactor at temperatures ranging from 400 to 700°C. The specific surface area of the modified carbon was 320 m^2/g. This adsorbent was used to remove Orange 2 and Black 24 from aqueous solutions.

Agricultural waste materials

Removal of heavy metals from aquatic solutions are important because of the persistence and resistance of these compounds in the environment. It is worth to mention that the common techniques which are used to remove these heavy metals are not cost-effective due to the high cost and also the production a large amount of dangerous chemical sludge in to the environment. Therefore, the application of biological absorption or biosorption process is considered as one of the important parameters for replacing with the other common techniques for the removal of heavy metal ions from aqueous solutions. One of the main advantages of using the biological absorption process is the low cost of operations, high efficiency, the possibility of recovery of heavy metal ions, as well as the ability of reproduction of natural adsorbent. Cellulose and lignocellulose materials due to their abundance and availability could be used to adsorb these pollutants from aquatic environments. Active agents of these adsorbents, such as acetamido, alcoholococarbonyl, phenolic, amido, amino, have the capacity to adsorb metal ions and convert them into neutral metal complexes.

Rice peel

As mentioned before, low-cost adsorbents with high adsorption efficiency are mainly used instead of other high-cost techniques. Haluk Aydin, Yasemin Bulut and Çiğdem Yerlikaya investigated The efficiency of the adsorption of Cu(Ⅱ)ion in aqueous solution by various biocompatible adsorbents such as lentil, wheat and rice peel, in different laboratory conditions,such as contact time, temperature, pH, and adsorbent dose. The results of this study revealed that the data from the experiments were correlated with Langmuir and Freundlich isotherms. The maximum amount of copper ion adsorption capacity for lentil, wheat and rice peel were 8.977, 9.510 and 9.588 mg/g, at 293 K and 7.391, 16.077, 17.422 mg/g at 313 K. The results of the experimental data indicated that, among the adsorbents used in this study, rice peel has a higher efficiency for copper ion removal, and with increasing temperature to 313 K, the efficiency of the adsorption process increases.

Industrial wastes

Waste materials resulted from petroleum products

In many studies, carbon which is produced from oil products from refineries has been used. These materials are used as the pioneer activated carbon recovery agent. For example, in 1976 Fasoli and Genon,used refined waste products for the preparation of activated carbon in granular sizes. In this study, the raw material first passes through a sand filter to remove insoluble oil residues.. The primary substance was first filtered from the sand to remove insoluble oil wastes. In order to carry out the carbonization process, the adsorbent was placed in a circled furnace and then exposed to atmospheric steam.

Fly ash

According to the global statistics, the amount of annual production of Fly ash about 67.5 million tons per year was estimated in 2010. Fly ash is an inorganic waste whose chemical composition contains 40-50% silica SiO_2, Al_2O_3 20-35% and Fe_2O_3 5-12%. Fly ash also contains 12-30% carbon. Fly ash is known as waste material which is resulted from thermal power plants, steel mills, which is found in abundance in the world. In recent years, using Fly ash as an adsorbent has gained attention in Economic actives in private distract_and industry, which consequently contributes to environmental degradation and economic benefits. In 2006, Shoabin Wang and Hongwei Wu conducted studies about using this low cost adsorbent instead of other adsorbents, such as zeolite and activated carbon, in various adsorption processes to remove environmental contaminants such as sulfur and nitrogen oxides (NOx, SOx), organic compounds and mercury in the air, as well as cathode and anode ions, colors and other organic materials in aquatic solutions. The results of these studies revealed that Fly ashes could be used as a suitable adsorbent with high adsorption efficiency to remove various pollutants. In addition, further research had shown that chemical modification of Fly ash can lead to further adsorption to clean up water and gas systems. It is important to mention that the presence of unburned carbon content in Fly ash plays an important role to increase the efficiency of this adsorbent dose. In another study, the removal of color and phenol compounds from industrial waste materials by Fly ash was studied by Boyd in 1982. The results of the study revealed that the maximum removal of acid dyes by

activated carbon in the range of pH 5-6 would be achieved. Moreover, by increasing initial amount of color, the adsorption capacity was increased, but the efficiency of oil removal was reduced.

Discussion and conclusion

Researchers have found that natural and low-cost adsorbents have many advantages in water purification and decontamination, which is due to the abundance and availability and most importantly the low cost of these adsorbents. Therefore, the application of these adsorbents in developing countries is important. It should be noted that the low cost adsorbents are widely used in the removal of colors, metal ions and organic compounds in aqueous solution , it is important to use them in industries and private distract .

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