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INVESTIGATION OF PALMYRAH (*Borassus flabellifer* L.) NUTSHELL DERIVED ACTIVATED CARBON FOR REMOVAL OF NITRATES FROM GROUNDWATER

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Nitrate is one of the most worldwide contaminants due to its tendency to leach from soil to water, polluting drinking water resources, especially groundwater. The effect of nitrate on human health is described as primary toxicity, causing methemoglobinemia (blue baby syndrome), tumours and gastrointestinal cancers. The WHO has set the maximum contaminant level of 50 mgL^{-1} nitrates in drinking water. Therefore, this research was conducted to remove nitrate ions from groundwater using citric acid-activated carbon developed from palmyrah nutshells. The advantage of using this activated carbon made from palmyrah nutshell is that it can act as an absorbent like coconut shell and is available as waste material in South Asian countries. The palmyrah nutshells were cleaned, dried in the sun, and carbonized in a muffle furnace at 500 °C for 2 h. The chemical activation of carbon of the carbonized product was performed using citric acid with the impregnation ratio of carbon: citric acid at 1:2 at 30 °C for 24 h. The resulting slurry was washed with deionized water to neutral pH, dried at 110 °C for 8 h, and the activated carbon was obtained. This activated carbon was characterized for different physical and chemical parameters using standard Association of Official Analytical Chemists methods. Moisture, ash, fixed carbon, pH and bulk density were determined, and the values obtained were 4.0%, 3.5%, 75.2%, 6.83 and 0.64 g cm^{-3}, respectively. The nitrate removal efficiency was estimated at different pH values of 2, 4, 6, 8 and 10 by varying adsorbent dosages of 2, 4, 6, 8 and 10 gL^{-1} at the equilibrium contact time of 1, 2, 3, 4 and 5 h based on the concentration of adsorbed nitrate ion by palmyrah nutshell activated carbon. The results revealed that the maximum nitrate adsorption of 82.8% was found to be at the pH of 6 with the adsorbent dosage of 6 gL^{-1} and with a contact time of 3 h. At the pH of 6, the maximum amount of nitrate ions was adsorbed by the electrostatic interaction between the positive charge of the adsorbent and nitrate anion. In the pH range from 4 to 10, the maximum percentage of nitrate removal was achieved, while this percentage slightly decreased at pH 2. Nitrate removal showed an increasing trend from pH 2 to 6, and it decreased afterwards. This may be due to the presence of positive adsorption sites that favours nitrate adsorption and then OH^- ions that compete for the same adsorption sites. The results revealed that the activated carbon effectively reduced the nitrate content in groundwater below the permissible limits; hence, the activated carbon derived from palmyrah nutshells can be successfully applied in water treatment technologies to control the nitrate content.

Keywords: Adsorption, Citric acid activated carbon, Groundwater pollution, Nitrate removal efficiency, Palmyrah nut shells.