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Highly Efficient Removal of Oil from Wastewater by Bio-nanoadsorbents

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Abstract
In our research, we used pomegranate peels and hazelnut shells as plant of origin to clean oil-contaminated water. The main objective of the work was to determine the optimal conditions for oil absorption by pomegranate and hazelnut shell bio-adsorbents, pomegranate peels and hazelnut shells, and Fe_3O_4 bio-nanoadsorbents. The effects of bioadsorbent and bio-nanoadsorbents, nanoparticles, and oil concentration, temperature, and pH on oil adsorption were studied to find the optimal conditions.

Key words: pomegranate peels, hazelnut shells, plant of origin, bio-nanoadsorbents, absorption

Introduction
Oil pollution in the environment is considered toxic and dangerous to the human body. Many methods are used to clean water from oil and oil product spills in the environment (Ferrero, 2007). Removing oil from oil-contaminated waters without harming the environment is considered a significant challenge for the oil industry. Plant-based adsorbents, which are considered environmentally friendly products, were used to clean up the oil from water (Nenkova, *et al*., 2004). The transformation of plant of origin into a valuable adsorbent with high adsorption capacity is presented as a new method for cleaning agricultural waste from the environment.
A new type of adsorbent (bio-nanoadsorbent) with nanoparticles has been synthesized to increase the effectiveness of plant of origin for oil removal from water. To increase the absorbency of pomegranate peel and hazelnut shell, magnetite nanoparticles were impregnated onto the surface of the plant waste we used. Fe_3O_4 nanoparticles, a magnetite nanoparticle, were used due to their high surface-to-volume ratio and their ability to absorb and react. Fe_3O_4 magnetite nanoparticles were used during the synthesis of the bio-nanosorbent (Bhatnagar and Sillanpää, 2010).

The oil sorption capacity of hazelnut shells, a plant-based biosorbent, was determined to be 61.25%, and the oil sorption capacity of pomegranate shells was determined to be 71.5%.

The new bio-nanoadsorbent synthesized based on hazelnut shell + Fe_3O_4 nanoparticles has an oil absorption capacity of approximately 92.5%, while the pomegranate shell + Fe_3O_4 bio-nansorbent has an oil absorption capacity of approximately 100%, depending on time.

Materials and Methods

Firstly, pomegranate peels and hazelnut shells are dried in a muffle furnace at 60^0C for 24 hours, then crushed.

Then, Fe_3O_4 nanoparticles are synthesized to increase sorption. Fe_3O_4magnetic nanoparticles were synthesized by co-precipitation of Fe^{3+} and Fe^{2+} ions in the ratio of (3:2) with ammonium solution in the presence of polyethylene glycol (Ravikumar, *et al*., 2017).

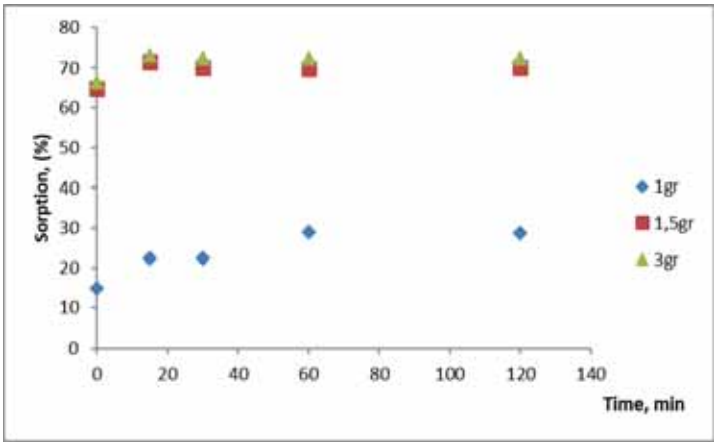

Figure 1. Time dependence of oil sorption of pomegranate peel biosorbent

The synthesized superparamagnetic Fe_3O_4 nanoparticles are then mixed with 1 ml of NH_4OH solution and impregnated onto pomegranate peels and hazelnut shells for 1 hour, thereby synthesizing a new type of bio-nanoadsorbents (Yang, *et al*., 2020).

After synthesis of biosorbent and bio-nanosorbent, oil purification process was carried out.

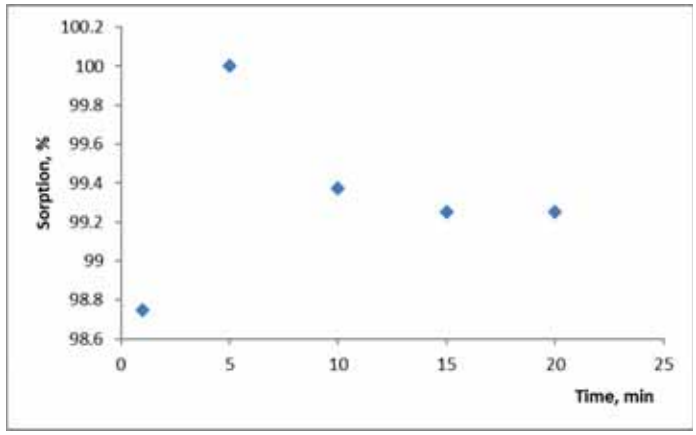

Figure 2. Time dependence of the amount of pomegranate peel+Fe_3O_4 bionanosorbent in oil sorption

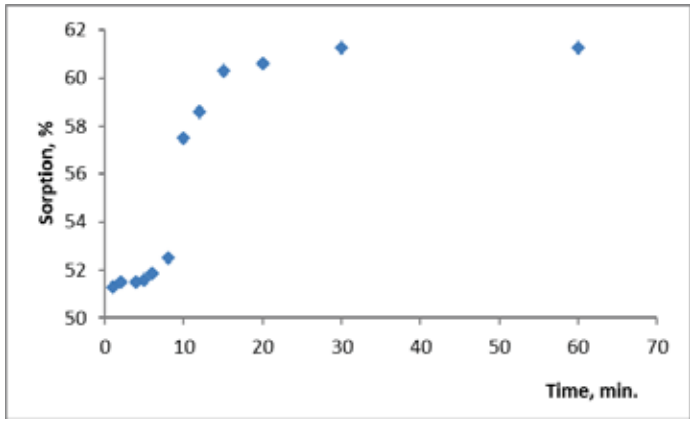

Figure 3. Time dependence of oil sorption of po hazelnut shell biosorbent

Oil-contaminated water was obtained by mixing 10 ml of oil in 100 ml of water (Ajji and Al-Ghouti, 2021). Bio-nanoadsorbent synthesized based on pomegranate peel, hazelnut peel, pomegranate peel+Fe_3O_4 nanoparticles, and bio-nanoadsorbent synthesized based on hazelnut peel+Fe_3O_4 nanoparticles were added to the obtained oil-contaminated water, respectively, and the sorption process was carried out. In the sorption process, the time dependence experiment was initially carried out (Shartooh, *et al*., 2018). The time dependence experiment was carried out in 1, 2, 4, 6, 10, 12, 15, 20, 30, 60 minutes According to the time-dependent experiment of the sorption process for biosorbent and bio-nanoadsorbent, pomegranate peel adsorbs 71.5% of oil in 15 minutes, bio-nanoadsorbent synthesized

based on pomegranate peel + Fe_3O_4 nanoparticles adsorbs approximately 100% in 1 minute, hazelnut peel adsorbs 61.25% of oil in 30 minutes, and bio-nanoadsorbent synthesized based on hazelnut peel + Fe_3O_4 nanoparticles adsorbs 92.5% of oil in 12 minutes. Based on the dependence graph of the time dependence of pomegranate peel and hazelnut peel, as well as the nano-composite of each, it can be clearly determined that the bio-nanoadsorbent synthesized on the basis of pomegranate peel + Fe_3O_4 nanoparticles has a greater oil absorption capacity than other biosorbents and bionanosorbents (Feumba *et al*., 2016; Bhatnagar, *et al*. 2010) .

Figure 1 shows that the absorption of oil based on pomegranate peel was determined by the plant-based adsorbent, with 29% of the oil absorbed by 1 gram of pomegranate peel in 1 hour, 71.5% in 1.5 grams of pomegranate peel in 15 minutes, and 73.25% in 3 grams of pomegranate peel in 15 minutes.

Figure 2 shows that the pomegranate peel bio-nanoadsorbent has the ability to absorb approximately 100% of the oil within 5 minutes.

If we look at the time dependence graph of the oil adsorption of the hazelnut shell, it is determined that the pure vegetable hazelnut shell has the ability to absorb 61.25% oil in 30 minutes (Fig.3.).

Figure 1 shows that the based on the experimental results, it is determined that the bio-nanoadsorbent synthesized based on hazelnut shell + Fe_3O_4 nanoparticles has the ability to adsorb 92.5% of oil within 12 minutes.

Result

A new plant-based sorbent and bio-nanoadsorbent were synthesized for the purification of water contaminated with oil and oil products. The time of oil adsorption of the biosorbent and bio-nanoadsorbent was determined. It is possible to prevent oil pollution from water using pomegranate peels and hazelnut shells, which are plant-based waste. In our research, it was determined that pomegranate peels and hazelnut shells have the ability to adsorb oil from the aquatic environment by reusing them. Our research is based on the principle of low-waste and waste-free technology.

As a result, the oil sorption capacity of hazelnut shells is 61.25%, the oil sorption capacity of pomegranate shells is 71.5%, the new bio-nanoadsorbent synthesized on the basis of hazelnut shell + Fe_3O_4 nanoparticles has an oil absorption capacity of approximately 92.5%, and the pomegranate shell + Fe_3O_4 bionansorbent has an oil absorption capacity of approximately 100%, depending on time.

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