7th Workshop

SPECIFIC METHODS FOR FOOD SAFETY AND QUALITY

September 22nd 2021, Vinča Institute of Nuclear Sciences - National Institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia

PROCEEDINGS

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7th WORKSHOP: SPECIFIC METHODS FOR FOOD SAFETY AND QUALITY

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BELGRADE, SERBIA 2021

BIOWASTE-BASED CARBON MATERIAL FOR MALATHION REMOVAL FROM WATER

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ABSTRACT

The extensive application of a pesticide, such as malathion, is a potential risk to human health as it can easily enter the food chain. An efficient and economical method for pesticide removal from the environment is necessary. In this work, we prepared a carbon material derived from biowaste (rabbit litter) for the removal of malathion from water. The adsorption capacity of carbon material derived from used litter (UL) is higher than that made from not-used litter. The maximum adsorption capacity of UL is 1.16 x10^{-5} mol/g for malathion.

INTRODUCTION

Organophosphorus pesticides (OPs) are the widely used compound to improve agricultural production by controlling pests and preventing crop diseases. Extensive application of OPPs leads to contamination of water environment and results in pesticide enter into the food chain, representing health hazard to humans and animals [1].

Malathion (Figure 1) is a wide-spectrum organophosphorus insecticide and acaricide, which is abundantly used for pest control in agriculture, industry, and public health. Similar to other organophosphorus pesticides, malathion toxicity is related to inhibition of acetylcholinesterase enzyme, which is vital for normal nerve function in insects, but also in humans and animals. Malathion can enter into the human body by ingestion of contaminated food or water as well as inhalation, and dermal absorption. Malathion belongs to a class of moderately toxic pesticide; however, the main insecticidal effects and acute toxicity of malathion are attributed to its metabolite malaoxon, which is considerably more toxic [2].

Therefore, it is important to develop an efficient removal method of malathion from natural water. Although several methods of water purification have been proposed, adsorption stands out as a suitable technique due to its efficiency, low cost, ease of application, and eco-friendly nature [1,3]. Carbon-based adsorbents, such as activated carbon and graphene, have shown a high adsorption capacity for OPs [1,3,4]. An important role in the adsorption process plays interactions of pesticides with carbon materials, primarily interactions with π conjugate system and interactions with surface functional groups of adsorbent [1].

Biowaste appears as an attractive carbon materials precursor due to its high carbon content as well as the presence of various elements (nitrogen, potassium, phosphorous, etc.) which can be doped as heteroatoms and enhance adsorption properties. Additionally, biowaste is abundant, available, and low-cost and its utilization as a resource material makes adsorbent production sustainable and renewable [5].

Bearing in mind the fact that the features of the carbon material depend on the used precursor, we cared out experiments to investigate the adsorptive properties of carbon material derived from both used and not-used rabbit litter for the removal of the malathion from water.

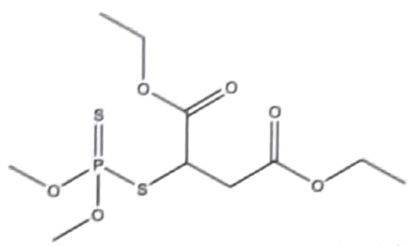

Figure 1. Structure of malathion.

EXPERIMENTAL

The used and not-used rabbit litter were converted into carbon material in a chamber furnace under a nitrogen atmosphere with a heating rate of 5.0 °C/min and held isothermal for 60 min at 900 °C. The products were washed with 0.1 M HCl, then with 0.1 M NaOH and rinsed with 50% ethanol solution. The adsorbents were dispersed in 50% ethanol solution (2 mg/mL), and the desired amount of malathion stock solution was added to provide the targeted concentration of adsorbent and OP. Then, the vessel containing the adsorbent and OP mixture was placed on a laboratory shaker and left for 60 min at 25 °C to ensure that equilibrium was reached. After equilibration, the mixture was filtered through a nylon filter membrane. The concentration of OP was determined using UPLC analysis [2]. Control experiments were performed identically but without adsorbent. The adsorption capacity, q_e (mol/g) is calculated by using the following equation:

$$q_e = \frac{C_0 - Ce}{m} \times V \qquad (1)$$

where C_0 is the initial adsorbate concentration and C_e is the residual adsorbate concentration (mol/L), V is the volume of solution (L) and m is the mass of the carbon material (g). The adsorbate removal percentage is calculated as follows:

$$R\% = \frac{C_0 - Ce}{C_0} \times 100 \qquad (2)$$

For convenience, the carbon material based on used litter and not-used litter is referred to hereafter as UL and NUL, respectively.

RESULTS AND DISCUSSION

Adsorption of malathion onto two bio-derived carbon materials (NUL and UL) was investigated over the initial concentration range from $1x10^{-5}$ M to $5x10^{-4}$ M at pH 6, carbon material dose of 1.0 mg/ml, reaction temperature 25°C and contact time 60 min. The results are presented in Figure 2.

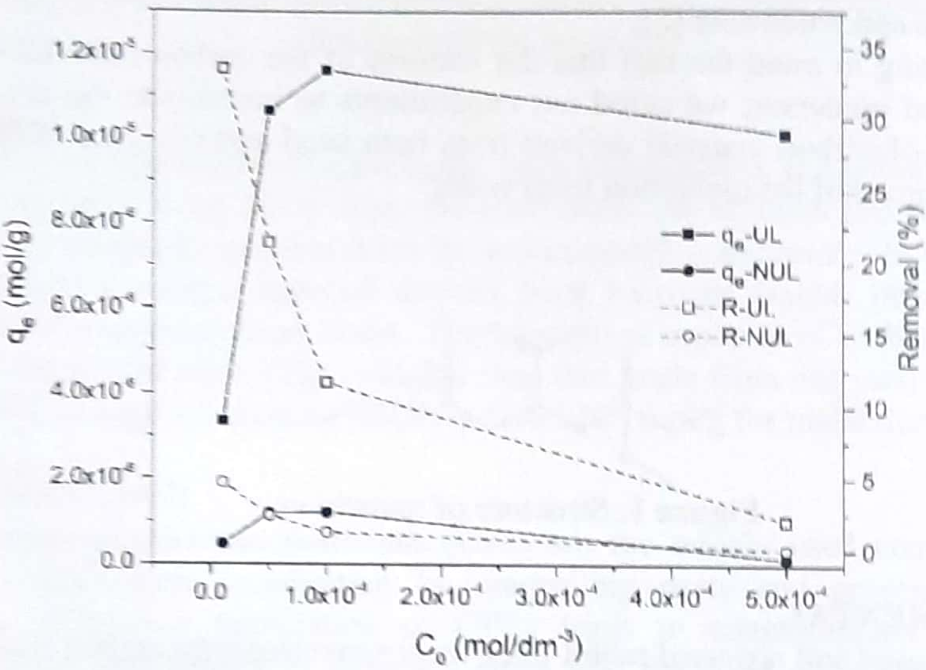

Figure 2. Dependence of the adsorption capacity (qe) and removal efficiency of malathion on its initial concentration after the incubation with 1 mg/mL adsorbent (UL or NUL) for 60 min at 25 °C.

The results show that malathion adsorbs on UL with the removal efficiency above 30% for initial concentration of $1x10^{-5}$ M. It is clear that the removal efficiency decreases when the initial concentration of malathion in the solutions increases, which indicates that adsorption sites got saturated with increasing concentration of pesticide, and less adsorption surface was available for adsorbate resulting in lower efficiency. The highest removal efficiency is at the initial concentration of malathion of $1x10^{-5}$ M, and the lowest at the initial concentration of $5x10^{-4}$ M for both materials. On the other hand, the actual amount of malathion adsorbed per unit mass of adsorbent increases with increase in malathion concentration. The adsorption maximum of $1.16x10^{-5}$ mol/g and $1.20x10^{-6}$ mol/g for UL, and NUL, respectively, are reached at an initial concentration of $1x10^{-4}$ M. From the results, it is clear that UL has a significantly higher adsorption capacity comparing to NUL, probably this is due to various compounds present in a used litter which improved morphology and/or surface chemistry of adsorbent.

CONCLUSION

Carbon material derived from used and not-used rabbit litter was applied for malathion removal from water. It was shown that material produced from used litter is capable to adsorb malathion, with an adsorption maximum of 1.16 $x10^{-5}$ mol/g at initial concentration of $1x10^{-4}$ M. There is potential for utilizing rabbit litter as a precursor to the production of carbon materials for OPs removal, however, further optimization of the synthesis process is needed to obtain better adsorption features.

Acknowledgement

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REFERENCES

[1] T. Lazarević-Pašti, V. Anićijević, M. Baljozović, D. Vasic Anićijević, S.Gutić, V. Vasić, N. Skorodumova, I. Pašti, Environmental Science: Nano, 2018, 5 (6), 1482-1494.

[2] M. Mirković, T. Lazarević-Pašti, A. Došen, M. Čebela, A. Rosić, B. Matović, B. Babić, RSC Advances, 2016, 6 (15), 12219-12225.

[3] T.D. Lazarević-Pašti, I.A. Pašti, B. Jokić, B.M. Babić, V.M. Vasić, RSC Advances, 2016, 6, 62128–62139.

[4] P. Kumar, H. Singh, M. Kapur, M.K. Mondal, Journal of Water Process Engineering, 2014, 3, 67–73.

[5] S. Wong, N. Ngadi, I.M. Inuwa, O. Hassan, Journal of Cleaner Production, 2018, 175, 361–375.