Development of environmentally friendly sorbents based on nanotechnology for the removal of organic and inorganic pollutants

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Growing population and the intensity of anthropogenic activities have led to an increase in wastewater flows that pose a threat to the environment, wildlife and humans. Addressing the challenges posed by increasing wastewater flows requires comprehensive and integrated approaches that prioritize pollution prevention, wastewater treatment, and sustainable water management practices. Conventional techniques for cleaning harmful persistent pollutants do not meet modern requirements as they are not cost-efficient, do not ensure the required level of cleaning and use harmful synthetic chemicals. It is believed that the use of natural materials such as clay, minerals, biopolymers and adsorbents based on them could be a good alternative. In addition, modern nanotechnologies are very effective in the removal and detection of pollutants. Nanoadsorbents, nanofiltration, nanophotocatalysts, magnetic nanoparticles and nanosensors can be used to detect and remove pollutants in wastewater. The application of these green technologies ensures a healthy environment and is an effective means of achieving sustainable development.

Composites based on chitosan, natural clay of local origin, montmorillonite and zeolite were synthesised using various cross-linking agents (epichlorohydrin, sodium tripolyphosphate, glutaraldehyde) and plasticiser (glycerol). In addition, composites of muscovite-mica-clay-graphene oxide-maghemite-magnetite composite and chitosan-graphene oxide-maghemite composite with magnetic particles of 14-15 nm and < 10 nm, respectively, were synthesised. The obtained composites showed high adsorption efficiency in the removal of Cs^{+}, Co^{+2}, Eu^{3+}, Am^{3+} and Pu^{4+} from water. These adsorbents are environmentally friendly, cost-effective and do not require special disposal conditions after use. They can be used for waste disposal and for monitoring during long exposure of the adsorbent in natural waters. The harmful effects of radioactive and non-radioactive isotopes of caesium, cobalt and europium released into the environment are well known. These isotopes are components of nuclear waste. There are currently concerns about the safe disposal of already accumulated and newly produced nuclear waste. Europium isotopes are often used as analogues of trivalent actinides (Am^{3+} and Pu^{3+}), which are toxic and highly migratory in the environment. In addition, various technologies are sources of non-radioactive caesium, cobalt and europium elements in the environment, of which lithium-ion batteries for electric vehicles are the most advanced.

1. Lujanienė, G.; Novikau, R.; Karalevičiūtė, K., Pakštas, V.; Talaikis, M.; Levinskaitė, L.; Selskienė, A.; Selskis, A.; Mažeika, J.; Jokšas K. Chitosan-minerals-based composites for adsorption of caesium, cobalt and europium. Journal of Hazardous Materials 462 (2024) 132747, p. 1-17. https://doi.org/10.1016/j.jhazmat.2023.132747
2. Novikau, R.; Lujanienė, G. Adsorption behaviour of pollutants: Heavy metals, radionuclides, organic pollutants, on clays and their minerals (raw, modified and treated): A review // Journal of environmental management. 309 (2022) 114685, p. 1-23. https://10.1016/j.jenvman.2022.114685