Natural Sorbents for Remediation of ^{137}Cs-Polluted Aquatic Environments

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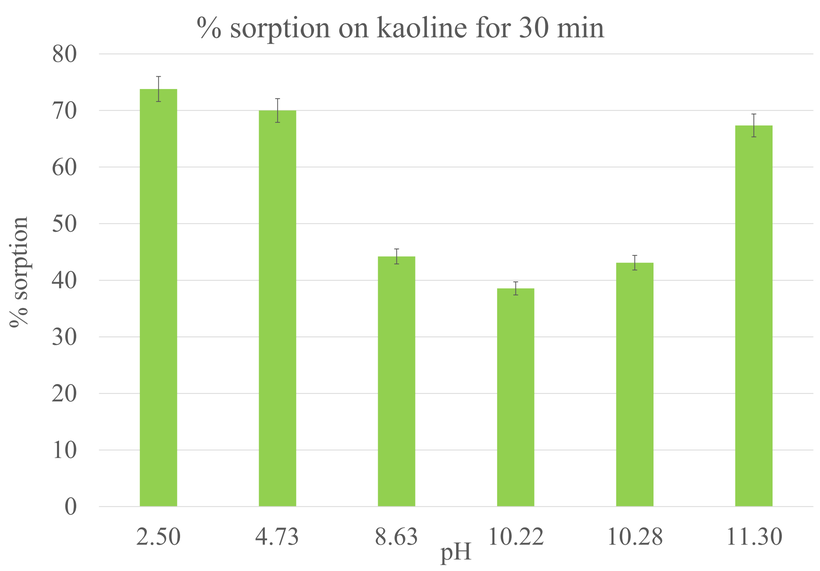
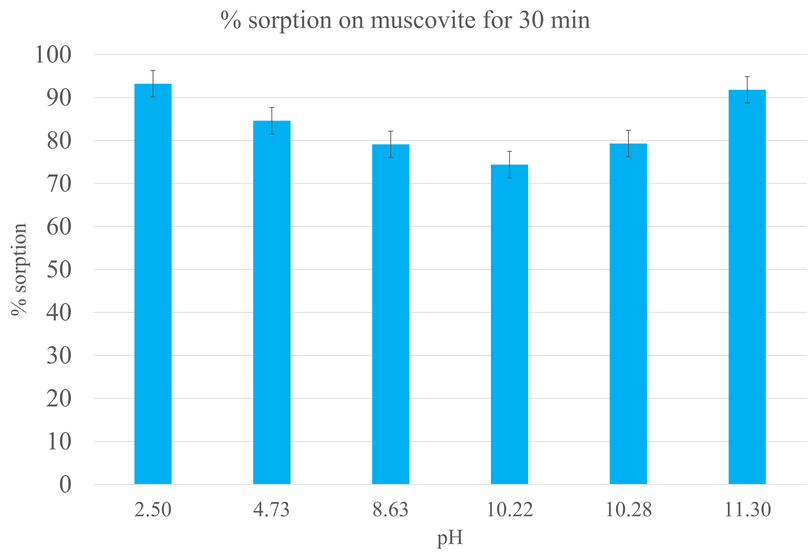
SUMMARY

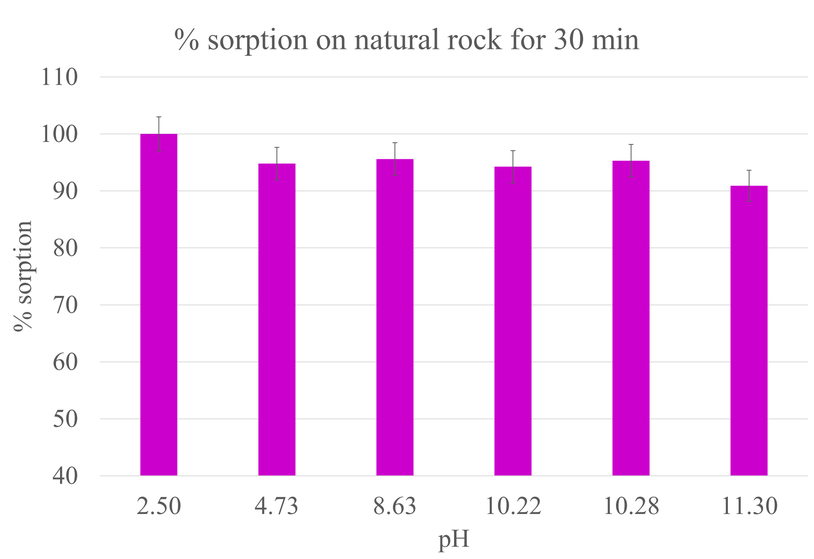
This study is dedicated to the ability to use natural mineral sorbents for remediation of waters, contaminated with ^{137}Cs. ^{137}Cs is an anthropogenic radionuclide ($T_{1/2}$ = 30.17 years) and is synthesized as a fission-product in nuclear reactors and aboveground nuclear weapons explosions. It is released into the environment through nuclear accidents or improper management of radioactive waste. As an alkali metal, it displays high aqueous mobility due to its negligible hydrolysis, persisting predominantly as free Cs^+ ions (>95%) that mimic K^+ ions. Radiocesium demonstrates weak sorption onto inorganic phases (Fe/Mn oxides, $CaCO_3$) which facilitates its rapid dispersion and bioaccumulation risks via trophic transfer. Micaceous minerals are known to have high affinity to retain Cs at the frayed edge sites, which provides an ability for effective remediation of contaminated waters. The efficiency of kaolinite as a Cs sorbent is worth to be considered due to its wide distribution in soils and sediments, offering cost-effective abundance for large-scale applications. In our work we present the sorption degree of ^{137}Cs from waters in wide pH interval, using muscovite, kaolinite and rock, consisted of mineral mixture of muscovite, chlorite, quartz and albite. The sorption of ^{137}Cs was measured by its daughter product ^{137m}Ba at 661.5 keV, by means of gamma-spectrometry. HPGe detector Canberra 7221 coupled to a 16000-channel analyzer DSA-1000 was used. The effects of the mechanochemical activation on the sorption ability of kaolinite was examined. The mineral composition of the studied rock was determined by a Siemens D500 powder X-ray diffractometer, using CuKα radiation filtered by a secondary monochromator (40 kV, 30 mA, 0.05° 2θ / 2 s) for the 2θ interval 3–60°. Quantitative processing of the diffractograms and identification of the mineral phases were carried out using the X'Pert HighScore Plus software.

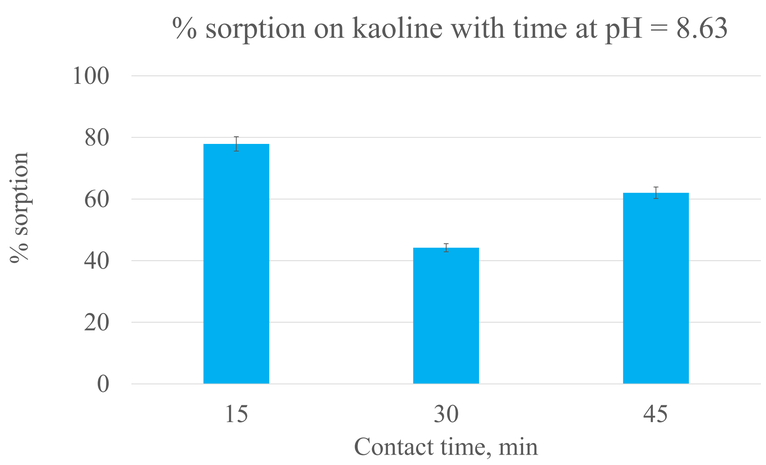
RESULTS AND DISCUSSION

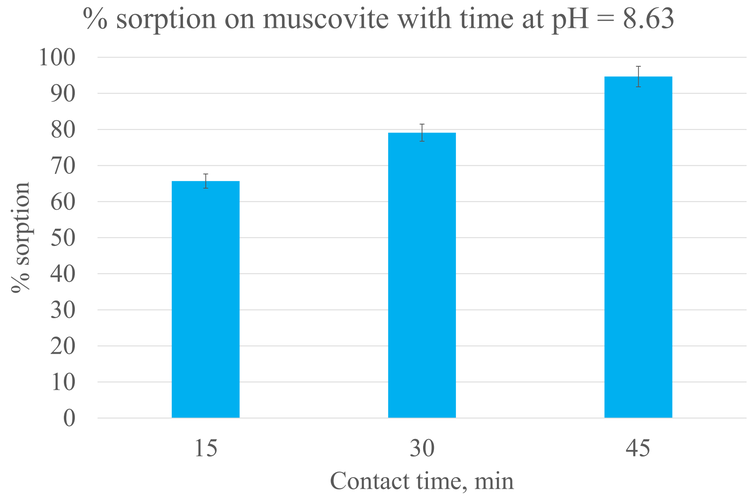
The natural rock is composed of: muscovite chromian (79.2%), with significant amounts of chlorite (10.2%), quartz (11.1%), and albite (9.5%), as determined by XRD.

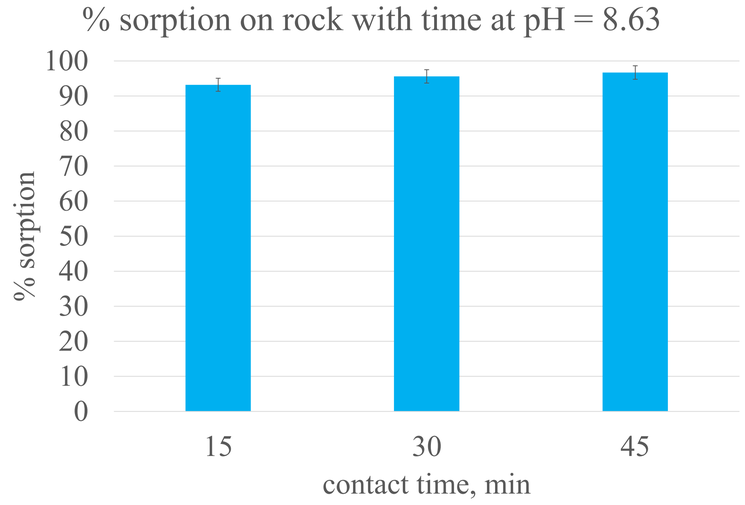


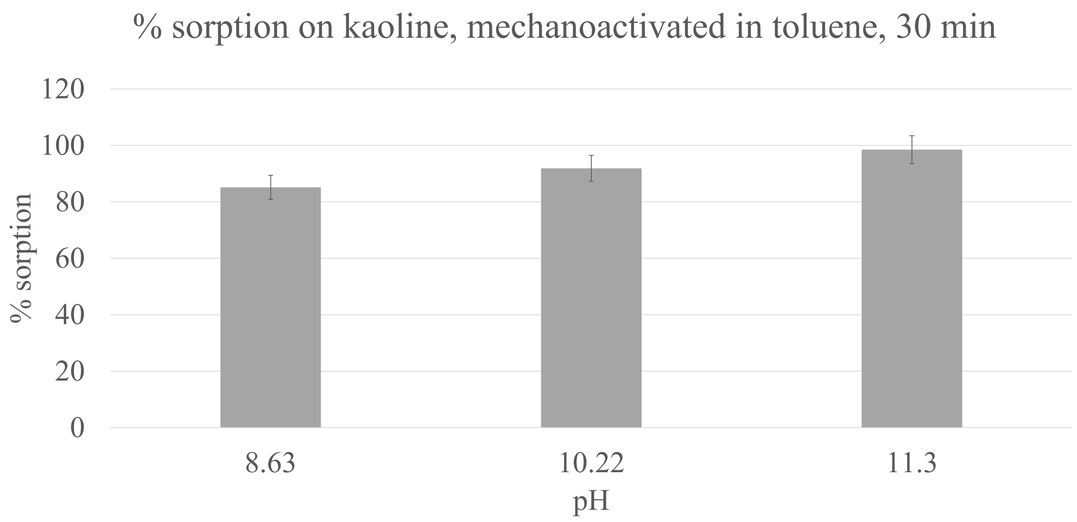


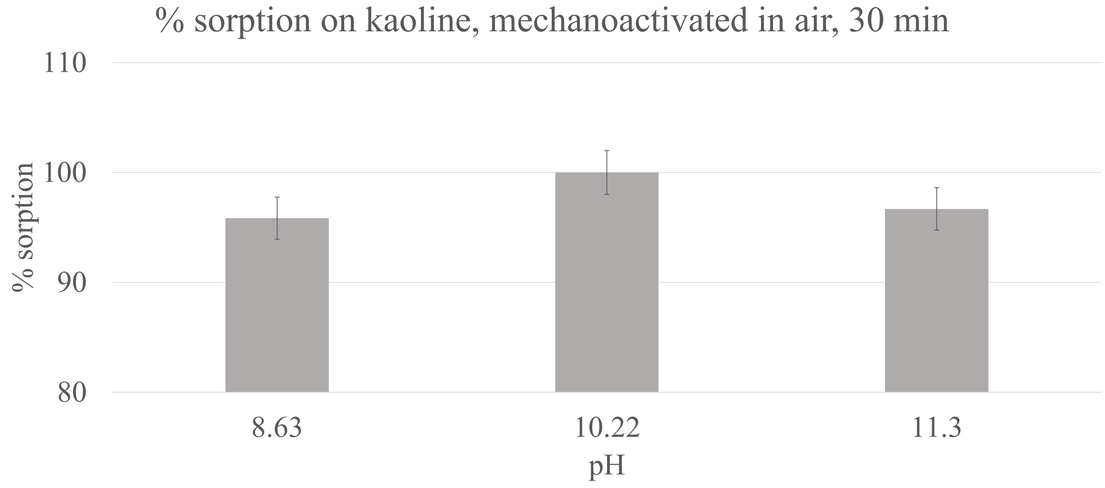












CONCLUSION: The results showed that the natural rock and muscovite provide better and faster retention of radiocesium, while kaolinite demonstrated the least efficient and most time-dependent uptake. The mechanochemical activation, particularly in organic media, was found to transform kaolinite into a highly effective sorbent for ^{137}Cs retention in a wide pH range.

Acknowledgements: *This research was funded by the Sofia University Fund, Contract 80-10-23/01.04.2026, entitled: Ecologically compatible natural and modified minerals and mineral mixtures for water purification and remediation of soils contaminated with Am-241 and Cs-137.*