Chapter 5
Adsorption Applications of Different Clay Types for Removal of the Radioactive Wastes

Murat Kiranşan
https://orcid.org/0000-0002-8520-6563
Gümüşhane University, Turkey

ABSTRACT

The nuclear fuel cycle started from the mining of uranium ore. Nuclear technology is used from medicine to agriculture, from energy to industry but it is not preferred today. Radioactive substances are used in the nuclear technology studies. Radioactive wastes emerges in different activity, physical and chemical conditions in different application field such as medicine, industry and research. Radioactive waste must be management in a safe, economical and environmentally acceptable behavior. In order to facilitate waste management, radioactive wastes are classified according to different criteria. Many different countries have developed different waste classification systems depending on the characteristics required by the waste management to be application. Wastes are processed and removal of as required by their class. Radioactive wastes are generally classified according to the level of radiation and their active time.

INTRODUCTION

Nuclear technology in our world in recent years, it is encountered in almost every field of life such as medicine, agriculture, energy and weapon industry and many radioactive materials are produced and used in these areas, (Dai *et al.,* 2019). Substances containing radionuclides in activity above the legal limit values determined by the competent authorities or contaminated by these radionuclides are considered as radioactive waste, (Li *et al.*, 2018) (Mishra *et al.*, 2006). Wastes during the purification, enrichment, fueling and combustion of uranium radioactive material in nuclear power reactors and reprocessing are the main sources of the radioactive waste, (Kademani *et al.*, 2013) (Li *et al.*, 2021). Fission products are formed as a result of reactions in nuclear reactors, (Gunathilake *et al.*, 2015). An estimated 600 fission products are formed and the vast majority of these fission products are radionuclides with short half

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lives. According to the IAEA classification, Cs-137 and Sr-90 are short-lived radionuclides, (Krishna *et al.*, 2004) (Wen *et al.*, 2021). Radioactive wastes are substances formed as a result of physical and chemical processes in different application areas such as medicine, industry and research, (Valsala *et al.*, 2009). Radioactive waste must be management in a safety and environmentally sound manner. In order to facilitate waste management, radioactive wastes are classified by applying different criteria, (Mansy *et al.*, 2017) (Sayed *et al.*, 2016). Many different countries have developed different waste classification systems depending on the characteristics required by the waste management to be applied. Radioactive waste is handled and disposal of properly, (Osmanlioglu, 2002). In the nuclear fuel cycle, uranium mining, uranium enrichment, nuclear fuel making, reprocessing of spent fuel materials and storage of radioactive products, decommissioning of nuclear fuel cycle facilities are the waste sources of nuclear power facilitys, (Liu *et al.*, 2019) (Song *et al.*, 2019). Radioactive wastes are formed as a result of the fuel cycle during the operation of nuclear reactors. More than about 95% is in liquid form. Then 99% of this liquid waste is converted into solid waste and stored, (Sun *et al.*, 2021) (Duan *et al.*, 2020). Removal of radioactive materials is an unsolved problem and the most preferred method in this respect is to cover and to store radioactive materials with low permeability materials, (Yang *et al.*, 2020). Montmorillonite clay is a highly preferred clay type in adsorption processes due to its large surface area, swelling properties of its layers and the dispersion of clay aggregates in another phase in a single layer under suitable preparation conditions, (Kıranşan *et al.*, 2014) (Karaca *et al.*, 2013) (Hassani *et al.*, 2015). Montmorillonite clay is used as an adsorbent in different processes, (Gürses *et al.*, 2014) (Hassani *et al.*, 2016). Especially montmorillonite clay modified with metal oxides is a special type of clay preferred in advanced oxidation processes such as photocatalytic, sonocatalytic and photocatalytic-ozonation, (Kıranşan *et al.*, 2015a) (Kıranşan *et al.*, 2015b) (Khataee *et al.*, 2016) (Karaca *et al.*, 2016).

CRYSTAL STRUCTURE OF CLAY MINERALS WITH DIFFERENT PROPERTIES

Clay minerals have a layered structure. Each of the clay layers consists of two, three or four tetrahedral and octahedral, (De Paiva, Morales, & Diaz, 2008). Tetrahedrals occur of four oxygen anions arranged around a silicon cation. Octahedrals occur of six oxygen anions located around an aluminum cation, (Xu *et al.*, 2007) (Hassani *et al.*, 2015). A layered structure is formed as a result of tetrahedrals and octahedrals being overlapped and connected to each other by oxygen bridges between them. Clay minerals are formed by the overlapping of layers, (Huang, Liu, & Wang, 2008).

Clay Minerals of Allophane Group

The general chemical composition of allophane group clay minerals is xAl_2O_3. $ySiO_2$. zH_2O. SiO_2/Al_2O_3 ratio varies between 0.5-1.8. This ratio is smaller than other clay minerals, (Pan *et al.*, 2006). While it is transparent and colorless when pure, it becomes blue, green, yellow and brown when mixed with foreign matter. In addition, alkali and alkaline earth content of allophane group clay minerals is much less than other clays, (Sarkar *et al.*, 2011) (Rahnemaie, Hiemstra, & Van Riemsdijk, 2007).

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