

On-Site Decontamination System for Liquid Low Level Radioactive Waste – 13010

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This study is based on an evaluation of purification methods for liquid low-level radioactive waste (LLLW) by using natural zeolite. Generally the volume of liquid low-level waste is relatively large and the specific activity is rather low when compared to other radioactive waste types. In this study, a pilot scale column was used with natural zeolite as an ion exchange media. Decontamination and minimization of LLLW especially at the generation site decrease operational cost in waste management operations. Portable pilot scale column was constructed for decontamination of LLW on site. Effect of temperature on the radionuclide adsorption of the zeolite was determined to optimize the waste solution temperature for the plant scale operations. In addition, effect of pH on the radionuclide uptake of the zeolite column was determined to optimize the waste solution pH for the plant scale operations. The advantages of this method used for the processing of LLLW are discussed in this paper.

INTRODUCTION

Ion exchange technology has been applied for many years in nuclear fuel cycle operations and other activities involving the treatment of radioactive liquids. In nuclear power plants ion exchange materials have applications in: Primary coolant (water) purification, treatment of primary effluents, treatment of fuel storage pond water, steam generator blow-down demineralization, Liquid waste and drainage water treatments, Boric acid purification for recycling, Condensate polishing (for nuclear power plants with boiling water reactors).

Liquid low-level radioactive waste is generated primarily by nuclear power plants during purification of cooling water or other examples of liquid low-level waste. Liquid low-level radioactive waste must be solidified for transportation and disposal. Usually, as much water as possible is removed from the liquid waste, and the remaining material is immobilized.

A wide range of ion exchange media is now available, from low cost naturally occurring inorganic (such as clay and natural zeolite) materials to expensive synthetic organics and inorganics engineered to remove specific ions. The chemistry of most ion exchange media has been extensively studied for the nuclear industry and for other applications [1,2,3]. The selection of an appropriate medium depends on the needs of the system. If low cost general ion exchange media are used, large volumes may be required, leading to larger volumes of waste to treat and dispose of. Most of the systems and operating methods described will work with many different types of ion exchange media. The selection of an appropriate ion exchange medium is best done using information provided by the media manufacturer together with trials on the actual liquid to be treated. A wide range of materials are available for the ion exchange treatment of radioactive liquids. These materials are available in a variety of forms, have widely differing chemical and physical properties and can be naturally occurring or synthetic. To minimize disposal costs, in

any process for the removal of radionuclides from a liquid waste it is important to minimize the volume of the secondary waste to be conditioned and disposed of in a final repository [4,5].

DESCRIPTION

Materials

The zeolite consists of clinoptilolite and k-feldspar. The cation exchange capacity OF zeolites was determined about between 70 - 100 meq/100 g.

Zeolites work over a limited pH range (4–9) since they are soluble both in acidic and alkaline media. In general, a single ion exchange material is unlikely to be able take up a particular radionuclide over the whole pH range. Radionuclides, especially those of transition metals, can be found in several hydrolysed and complexed forms at different pH values and in different media. The effect of pH levels on the distribution coefficient (Kd) of the zeolites was determined to optimize the waste solution pH for the plant scale operations. Distribution coefficients at different pH levels are shown in Figure 2.

Methods

Ion exchangers were prepared by using natural zeolite exchanger beads of size –16 + 25 ASTM mesh in column. The pilot plant scale column system was constructed with a 5 liter capacity. 0,5 kg of exchanger powder was equilibrated with 5 liters of radioactive LLW. The most common uses of ion exchange media is in vessels or columns. In this study, the ion exchange medium zeolite is contained inside a steel pressure vessel, with an engineered inlet, outlet and flow distribution system to allow liquid to percolate through the bed of the medium at a specified flow rate. Retention screens on the inlet and outlet prevent the medium from escaping into the process loop. A secondary circuit with unscreened drain and fill lines is used to remove the spent medium and fill the vessel with a new medium. Columns with bead type zeolite ion exchange media in size –16 + 25 ASTM mesh were used to meet the requirements of the system.

If interruptions in the process to replace ion exchange media are not desirable, multiple columns can be connected in parallel. While one set is in operation the other is filled with a fresh medium or, after refilling, is on standby. The frequency of such changeovers is governed by the capacity of the medium relative to the ionic strength and flow rate of the liquid being treated. The capacity of the system is frequently measured in bed volumes, which is the ratio of the volume of liquid treated to the volume of the bed of the exchanger. A wide range of materials are available for the ion exchange treatment of radioactive liquids [7,8]. These materials are available in a variety of forms, have widely differing chemical and physical properties and can be naturally occurring material like zeolites. Ion exchange materials can be categorized according to their suitability for different applications. The type of material to be used is selected based on its ability to remove impurities and undesirable ions and to control pH.

Liquid Radioactive Waste Composition

Gross radioactivity values and specific radioactivities of radionuclides in liquid radioactive waste are presented in Table 1. The pH level of liquid waste ranges between 8 and 10.

Ion exchange is generally suited only for the treatment of aqueous liquid satisfying several criteria: in columns with a downward flow of liquid the concentration of total suspended solids in the waste should be less than 4 mg/L. The liquid radioactive waste should have less than 1 to 2 g/L total dissolved salts content. Radionuclides should be present in a suitable ionic form. Suitable conditions were maintained by controlling the pH level of the liquid. Waste should only contain very small amounts of organic contaminants. According to test results, passed radioactivities from the column during the operation time are presented in Figure 3.

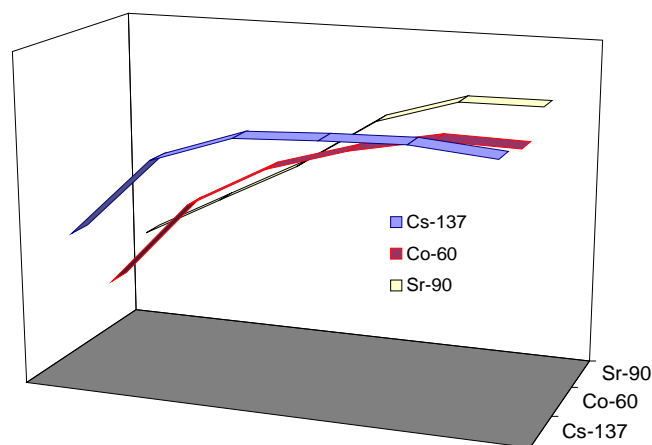


Figure 3. Radioactivity versus time.

DISCUSSION

To minimize operational waste treatment and disposal costs, in any process for the removal of radionuclides from a liquid waste it is important to minimize the volume of the secondary waste to be conditioned and disposed of in a final repository. An intermediate goal in the treatment process is that the main waste stream after treatment can be discharged or recycled in a technically less demanding and less costly manner. Environmental aspects are also very important, since the regulations on discharges are becoming increasingly more stringent. Even if an inorganic ion exchanger is highly selective for a certain radionuclide, it needs to meet several other requirements to become a product that can be used in industrial scale separation

processes. Results show that the natural zeolite is convenient when used as preliminary on site decontamination system for LLW. As ion exchanger, low-cost natural zeolite is acceptable for on site decontamination applications for LLW.

REFERENCES

1. IAEA, *Combined Methods for Liquid Radioactive Waste Treatment*. IAEA-TECDOC-1336 (2003).
2. D.O. Campbell and D.D. Lee, "Low-Level Liquid Waste Decontamination by Ion Exchange" *Proc. Waste Management Symposium*, Vol.1, Tucson, Az.(1990).
3. A.M. Yasmen and J.Z. Maysoon, "Treatment of radioactive liquid waste (Co-60) by sorption on Zeolite Na-A prepared from Iraqi kaolin" *Journal of Hazardous Materials*, 196, 228-233 (2011).
4. A.M. El-Kamash, "Evaluation of Zeolite A for the sorptive removal of Cs and Sr ions from aqueous solutions using batch and fixed bed column operations", *Journal of Hazardous Materials*, 151, 432-445 (2008).
5. B. Calvo et al., "Continuous elimination of Pb, Cu, Zn, H and NH₄ from acidic waters by ionic exchange on natural zeolites", *Journal of Hazardous Materials*, 166, 619-627 (2009).
6. T.P. Valsala et al., "Removal of radioactive caesium from low level radioactive waste (LLW) streams using cobalt ferrocyanide impregnated organic anion exchanger", *Journal of Hazardous Materials*, 166, 1148-1153 (2009).
7. A.E. Osmanlioglu, "Treatment of radioactive liquid waste by sorption on natural zeolite in Turkey", *Journal of Hazardous Materials*, Volume 137, Issue 1, 1 September 2006, Pages 332-335
8. A.E. Osmanlioglu, "Natural diatomite process for removal of radioactivity from liquid waste", *Applied Radiation and Isotopes*, Volume 65, Issue 1, January 2007, Pages 17-20