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RESEARCH ARTICLE

STUDYING PROCESSING TECHNOLOGY OF SOLID AND LIQUID RADIOACTIVE WASTE

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ABSTRACT

Global concern for environmental protection of soild and liquid radioactive waste contaminated with alpha ,beta and gamma radiation emitter. The aim of this paper such experiments for solidifying or minimizing volume and decontamination process of polluted liquid and soil samples with radioactive nuclides. For decontamination of radioactive soils process; the following systems were used; a) water, b) HNO_3, c) $C_6H_7O_8$, d) NaOH, contact time 4 hours, temperature 80 ^{O}C. Experimental investigations were performed on 5 soil samples which have been characterized in terms of activity concentration. It was established the remediation degree for each type of soil and reagent. Results show successful remediation to U-238 of radioactive contaminated soil using the system above and the highest efficiency clearly using $C_6H_7O_8$ as extraction material than HNO_3. Experiments per formed with application of polymer (No.1) for the liquid radioactive waste immobilization in this paper. The economic effect forms the implementation of polymer liquid radioactive waste. Solidification; was defined by the weight /volume reduction of waste (about 2.5 -3 times reduction ratio). Interesting results have been obtained during the search allow using the polymer materials in the processing technology of the industrial toxic waste.

Key words: Radioactive Waste, Solid, Liquid, Polymer, Solidification.

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INTRODUCTION

Radioactive waste that generated from different nuclear activities in solid or liquid waste type in small or large volumes needs to be treated in such method to reduced activity concentratin of radioisotopes to the limited quantities or to the clearance level to be able to environment released or discharged. According to IAEA publication soil and liquid radioactive waste levels or classification has specific management and end points depend on the alpha, beta, and gamma emitters concentration in addition to other factors (IAEA, 2005; IAEA, 2011; IAEA, 2012; IAEA, 2004). Uranium natural series and isotopes heavy nuclides is a common naturally occurring and radioactive substance in solid and liquid material state. Uranium has demonstrated toxic effects on human kidneys leading kidneys inflammation and changes in urine composition (Aura *et al*., 2013). Consequently, an environmental protection goal is to develop a process for uranium rescuing of the soils and liquids. In recent years, there is an increased interest in finding new, and innovation solutions for efficient removal of contaminates in order to save ground water and soil. Many conventional techniques for soil washing are based on the principle of adsorption of pollutants on soil fine particles such as mud, clay, and hemic material. These tend to adsorb sand and gravel particles on largely grain size, (Aura *et al*., 2013). The primary purpose of soil washing is to separate theses fine comports from the bulk mass of soil ground. Several studies regarding removal of contaminants from polluted soils were collaborated. A method for soil decontamination is based on extraction with citrate (acids). Citrate is an extracting substance that does not alter the environment and is successfully used in decontaminate soil with heavy metal. The effect of washing method was established that microorganism catalyze redox processes which result metal precipitation ; the reduction of uranium from its hexavelent state (U^{6+}) which is very soluble to its tetravalent state (U^{4+}) insoluble and essentially immobile, lead finally to precipitate in the form of UO_{2}. The goal of water –chemical washing remediation process is to limit the extraction of contamination at hazardous waste soils; to prevent for their deterioration of the environment and to prevent exposure by humans and other life forms to hazardous chemical and radiation risks.

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Table 1. Experimental Properties of LRW Process

Sample(1)set	Radionuclide Activity concentration Bq/Kg	Total weight before process(g)	Total weight after process(g)	Radionuclide Activity concentration Bq/Kg after process	weight of additive polymer(g)
PH=2.5 T=28c°	U-235 (17.1) Pa-234 (1424.4) K-40 (22.4) Cs-137 (1037.1) Am-241 (66.5)	1500	500	U-135 (69.7) Pa-234 (2407.2) K-40 (350.5) Cs-137 (2159.3) Am-241 (158.8)	400 gm

Table 2. Experimental properties of LRW Process

Sample (2) set	Radionuclide Activity concentration Bq/Kg	Total weight before process(g)	Total weight after process	Radionuclide Activity concentration Bq/Kg after process	Weight of polymer (g)
PH=2.5T=28c°	U-235 (17.5) Pa-234 (1649.7) K-40 (24.9) Cs-137 (1179.7) Am-241 (64.3)	1500	500	U-235 (59) Pa-234 (3166.7) K-40 (395.5) Cs-137 (2138) Am-241(151)	400 gm

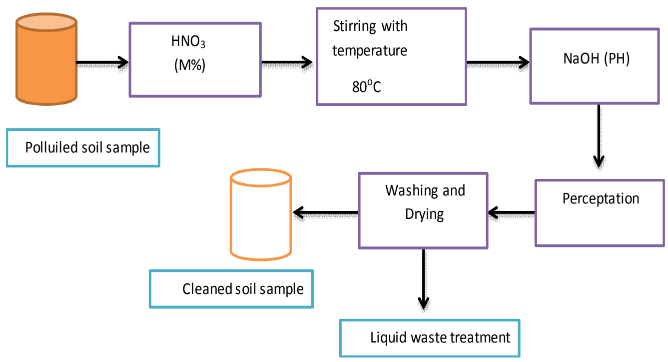
(Aura *et al.*, 2013; Popov *et al.*, 2005; Furmkawa, 2004) For liquid radioactive waste(LRW) contaminated with radioisotopes, many studies in this field concentrated on minimizing volumes with limited concentration of radioisotopes using green or clean techniques. One of the issues in (LRW) management during treatment for storage and disposal the toxic radiology of large various liquid radioactive waste. Solidification techniques using organic materials or polymers are reported. Cementation and verification are most common processes used in LRW treatment. Polymers have been used from many years in industry technology with liquid or chemical solution in so many different applications. Polymer materials could be used for immobilizing different RW types are given in references (Anderson, 1993; Environmental Engineering and Management Journal, 2009; Proceedings of the 1998 con ferrous on Hazardous Waste Research, 1998; Cerna, 1995). The second goal of this paper is using certain polymer material symbolic as (No.1) to be experimented for solidifying liquid radioactive waste polluted with radioisotopes (U, Pu, K, Am, Cs) resulted from decontamination processes. In addition to study the solidification conditions such as temperate, PH, and additives ratios. The main adhesion in this work was paid to study waste solidification process with polymer in ambient temperature (Proceedings of the 1998 con ferrous on Hazardous Waste Research, 1998; Cerna, 1995; Kroschwitz *et al.*, 1982).

Experiment Part

Laboratory tests were performed on 5 soil types characterized in terms of activity concentration to uranium radioactive contamination. The soil particle size distribution were obtained by sieve analysis method which reached (<0.5mm). Measuring soil texture was made using a validated method (simplified pipette method), thus obtaining the approached distribution of soil particles in three classes range sand (50%), silt (40%), and clay (10%). The Method to established the soil composition consists in the treatment of a soil sample dried at 80^{O}C, with 2000 ml water and, HNO_3 with molarity (5-12 %); once $C_6 H_7O_8$ (24%), and NaOH with (25%) and PH at ranged (Popov, 2005; Furmkawa, 2004; Anderson, 1993; Environmental Engineering and Management Journal, 2008). The mixture has been homogenized for 3 hours; then, the sample was filtered and the settlement time has expired, the fraction containing clay settled and the silt particles within the sediment was dried 35 ^{O}C and silt fractions were directly calculated and expressed as sample mass. Clay fraction was dispersed between the sample mass and the byproduct water waste.

Organic content of the soil is important, because uranium and a series of other pollutants have a certain affinity to bind to organic substances. The experimental results for organic matter content of the soil established by dry combustion method (Popov, 2005), and the mass difference was so rare (less than 0.00293).

Fig. (1) : operational stages of the decontamination method of soil sample from uranium pollutions.



The soil and liquid samples were regardless of their content, gamma spectrometric method analysis with multichannel analyzer with pure Ge detector for gamma radiation (0-2 MeV)–type ORTEC with 60% efficiency resolution for gamma ray energy (1333KeV) type of Co-60 gamma source was used. For liquid radioactive waste experiments we used the liquid waste of decommissioned facility where the drains from the building collected and polluted with U,Pa.K, Am and Cs radio isotopes. For the solidification process of LRW, here we used polymer called as (No.1) intend for solidifying waste containing organic compound contents. The processing for LRW followed steps cleared in figure (1).

The materials used in this study are suggested as simple and inexpensive as possible. The polymer mass ratio to the solution mass at the solidification process was justified with temperature and at atmosphere of air drying. Two set samples of LRW examined for activity concentration characterization using gamma spectroscopy before and after using (polymer material) in two ratios as in Table (1,2). The appearance of, sample before and after solidifying the solution is given is Fig. (4). liquid to solid waste Solidification process; was defined by the weight/ volume reduction of waste (about 2.5 to 3times reduction weight /volume).

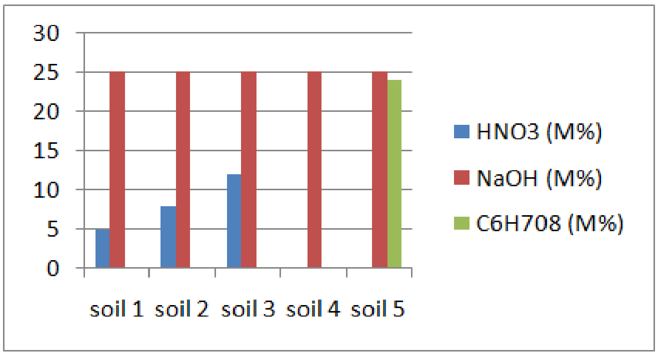


Fig. 2. Experimental Soil Tests with Washing Material molirity ratios

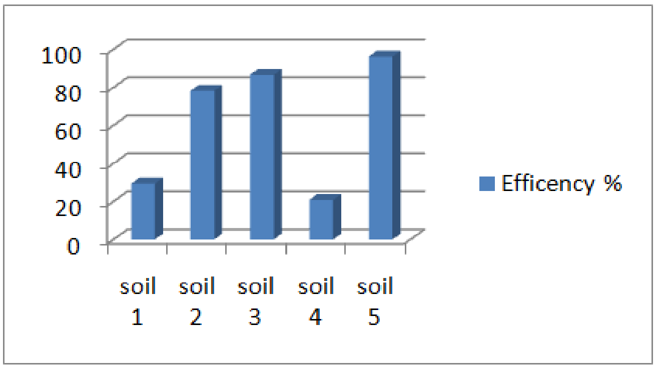


Fig. 3. Efficiency Processing Ratios Due to Soil Sample

DISCUSSION AND CONCLUSION

As can be seen from Figures (2, 3) the most efficient remediation agent for all types of soil was ($C_6H_7O_8$). The degree of remediation is different with HNO_3 where depending on the molarity and PH value of the base NaOH. Soil sample (4) show low remediation degree due to washing with water only. The high degree of remediation with $C_6H_7O_8$ solution consists in fact that uranium was retained on soil samples through adsorption and complex formation processes and minimum ratio of clay. High degree of remediation with low cost was achieved as expected ,for the samples (soil),which contain high ratio of sand and the reagents (HNO_3, $C_6H_7O_8$, NaOH) are very effective in washing method of uranium soil decontamination. The response to the extraction reagent is strongly dependent on molarity ratios and PH in addition to nature of the soil (Furmkawa, 2004; Environmental Engineering and Management Journal, 2009). The five soil samples were treated during (Popov, 2005; Furmkawa, 2004; Furmkawa, 1993) working hours with synthetic solutions which has the following chemical composition and molarity percent shown in Fig. (2,3). In Figure (4) one can clearly see that the process of water removes occurred uniformly without destruction of the sample. The density of the obtained tiny pellet depend on activity concentration of radioisotope. The polymer mass (400 g) to the mass of the liquid rational (1500 g) near to (0.266) mass ratio. The weight reduction ratio from 1500 g to 500 g is about 3:1 which is good result and could be improved in more research and experimental work. It shows the high activity concentration of the LRW solid samples in tables 1 and 2 related to volume reduction of liquid state and turned to low volume sample easy to conditioned for long term storage or disposed. During experiments on solidifying waste dewatering process is of interest in one main notes which at the ambient temperature (28-27)^{o}C for 5-6 hr. in light day.

Fig. 4. The appearance LRW Sample after solidifying Process

In the experiments on solidifying LRW; the variation of the solidified sample mass during hold-up in the atmosphere of air was monitored. The (polymerization) of the aqueous solution in rather (big or small) quantity was observed. After the water was changed to solid the next move is the packaging of the sample in smaller package or container. Experiments were conducted in polyethylene cups of 100ml in volume. A change (mass) of polymer in amount of 400g; was placed into the cap and after that 500ml of liquid radioactive waste solution were poured there. Solidified compositions obtained after solution mixing with polymer were subjected to air caring at a room temperature .Partial evaporation of water and volatile organic compositions took place in the course of solidifying. The degree of evaporation was determined by periodic weighting. When evaporation was completed, solid pellets include in polymer matrix RW was ready to be packed. Solidification; was defined by the volume reduction of waste (about2.5 could be 3times reduction volume) coming onto the repository, transportation and of repository construction on account of cutting down the construction volume.

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