Original Article
ISSN (Online): 2454-1907

International Journal of Engineering Technologies and Management Research
October 2022 9(10), 43–49

TREATMENT OF RADIOACTIVE LIQUID WASTE USING SUN HEAT

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Received 26 August 2022
Accepted 27 September 2022
Published 13 October 2022

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DOI

10.29121/ijetmr.v9.i10.2022.1225

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ABSTRACT

This research aims to study the benefits of using the renewable energy in the field of treatment of liquid radioactive waste which is contaminated with a mixture of radionuclides such as Cesium Cs-137, Uranium U-238, Radium Ra-226,etc. which their evaporation degree is too high (more than 600C0) . The sun energy as example for renewable energy is used in the process of evaporation of liquid radioactive waste which formed from the decontamination by washing metallic pipes and washing a contaminated soil to convert liquid radioactive waste to more stable and less size radioactive waste in a form of sediment which treated later using cement and then to disposal. The effect of evaporation using sun energy on the human and environment is studied in the laboratory using chemical and radioactive measurement devices. A very good results had been gotten because no level of a radioactive contamination had appeared on the filter which had used in the evaporation process. An electric heater also had used for evaporation process and the results were the same which refers that radioactive nuclides weren't evaporate because of using low temperature. Liquid radioactive waste had distillated, the distillated liquid was measured, and it was clear from any contamination, and this shows that there is no diffusion of radionuclides during evaporation process, and in this process the Decontamination Factor (DF) is very high.

Keywords: Renewable Energy, Liquid Radioactive Waste, Evaporation, Distillation

1. INTRODUCTION

Radioactive waste (RW) is hazardous to most forms of life and the environment and is regulated by government agencies in order to protect human health and the environment International Atomic Energy Agency (2009). The large quantities of radioactive in Iraq are of different origins. The legacy RW which was produced in the former Iraqi Atomic Energy Commission IAEC – Nuclear Research Centre (NRC) laboratories in the fields of (physics, chemistry, agricultural and other nuclear activities) are certainly produce radioactive waste Shamsaldin et al. (2014).

Three techniques are most commonly used to treat water wastes, namely chemical deposition, ion exchange and evaporation. At present, membrane processes such as reverse osmosis, fine filtration, super filtration, and filtration are used and have shown good performance. In each case, the process constraints resulting from corrosion, shrinkage, foam, and the risk of fire or explosion in the presence of organic matter, particularly with regard to safety impacts on operations and maintenance, should be carefully considered. If wastes contain fissile material, the possibility of inevitability must be assessed and eliminated to the extent practicable by design and administrative features. International Atomic Energy Agency (2017)

Radioactive waste is generated due to Decontamination works from the contaminated material, soil washing, industrial applications, Scientific research, all facilities which used nuclear fuel, and it's generated also as a result from Natural and human accident or from wars, etc. This waste contains many types of Radionuclides. Liquid Radioactive waste is considered as chemical compounds with Radiation Activity because it contains Radionuclides such as Cesium, Strontium, Cobalt, Uranium, etc. according to their source. The responsible authorities at each country usually put the standard limits and levels of radiation activity and contamination which must be decided before this waste allowed to be Discharged to the environment International Atomic Energy Agency (2003), Haas (2006). Radioactive liquid waste is classified according to its volume and level of activity to three levels:

1) Low volume aqueous liquid: It's radioactive waste which include soluble or not soluble, single or mix of radionuclides with small quantity, non-chemical complex and with low radiation activity, generally for treatment of this type of waste direct solidification with cement used.
2) High volume aqueous liquid: It's radioactive waste which include soluble or not soluble, single or mix of radionuclides with high quantity, non-chemical complex and with low radiation activity, and there are many methods for treatment of this type of waste such as (chemical precipitation, Ion exchange, filtration, reverses osmosis, flow filtration, etc,).
3) Organic liquid waste: It's the waste which have low level activity of radiation and have an organic radioactive material; single or double; and insoluble in the water, this waste is treated by mixing it with cement for solidification.

At the current time there are several classifications for the radioactive waste depending on the physical and chemical characteristics and also according to its origin International Atomic Energy Agency (1994), International Atomic Energy Agency (1994),International Atomic Energy Agency (2014).

This variety of radionuclides and their sources requires finding appropriate methods to deal with and reduce the risks of these nuclides .The renewable energy is considered to be significant source which shouldn't be ignored for its ability to treat liquid radioactive waste which containing a mixture of radionuclide that can't be treated using the ordinary methods which are used for treatment of radioactive waste that containing only one type of radionuclide, for example using chemical precipitation method for Cesium can't be used for other types of nuclides because each radionuclide has its method and procedure for treatment which differs from other nuclides; this is because of the differences between characteristics of the elements. Using evaporation method is considered one of the effective ways which is used in the treatment of liquid radioactive waste where a reduction to the volume of waste is carried out as least as possible using this method and converting liquid radioactive waste to the solid state with very small size where it will be treated as a solid waste, then other process will carry out such as cementation International

Atomic Energy Agency (2001). Energy of sun is one of the most important sources which is used in the evaporation processes for the liquid radioactive waste because its available and cheap, especially in Iraq, where it can be used and gotten good result from it using some simple techniques International Renewable Energy Agency (2016).

2. MATERIALS AND METHODS

It is important to requisite for a accumulation of essential data for commonly used radionuclides, for both practice and training, has become increasingly apparent.

Evaporation is one of the methods used to treat liquid radioactive waste, which provides good pollution removal and good concentration. Water evaporation follows non-volatile components, such as salts and radionuclides. In some cases, the volume of waste is fairly high, there is a small amount of salts, but the level of activity is high, l; In this event evaporation is used to reduce the volume of waste to the concentration and also to get a high decontamination agent (for a few thousand). However, the process is energy intensive and limited by the presence of volatile radionuclides International Atomic Energy Agency (2017).

Two kinds of radiation measurements were carried out in this project:

- Measurements for the characterization of the RW in tank which includes the identification of the radiation nuclides, the approximate quantities of the identified nuclides and the radiation dose rates from the RW.

Measurements of radiation dose rates for radiation protection purposes to enable radiation protection officers to draw the dose rate map of the working site to allocate the hot spots of the radiation doses and eventually designing the radiation protection procedure which includes the manipulation of time, distance, or the usage of shielding, if necessary, in addition to the personal protection equipment's and clothing. While for the achievement of.

- Gamma spectrometry for any sample or for the RW in this work means that samples of the waste must be taken from the tank and must be processed to ensure the following requirements:
- Outer surfaces of the samples are clean (not contaminated) to eliminate the risk of contaminating the laboratory or the detector or it, s shield.

1) Samples must be homogeneous.
2) Samples could be enclosed in a Marinelli beaker that fits to the detector head.

2.1. QUALITY ASSURANCE

The management of radioactive wastes aims to develop a set of procedures that allow for the handling, transportation, treatment storage or safe disposal of radioactive wastes in order to ensure safety, these measures shall be in accordance with the standards and criteria for the acceptance of radioactive wastes established by international organizations and internal regulatory bodies in order to protect human health and the environment from the risks associated with radioactive wastes.

Quality assurance processes include the examination and selection of specific items, services and processes that are carried out using acceptance criteria and standards for the proper application of procedures. The QA also provides a systematic approach to verifying the quality of processes and products.

2.2. SAFETY ASSESSMENT

The safety assessments include analyses of potential radiation impacts from treatment and storage of low and intermediate radioactive waste (LILW) on the workforce and the public as a consequence of normal operation, operational transients, and accident situations. The analyses included in the Preliminary Safety Analysis Report aim at demonstrating by experience, design basis considerations or by simplistic calculations that the planned waste management practices meet the safety goals.

3. RESULTS AND DISCUSSIONS

In this research two methods were used in the evaporation, energy sun and electrical energy. Experiments were carried out on the Contaminated liquid radioactive waste which exists in a tank inside Radioactive Waste Treatment Station (RWTS).

3.1. MEASUREMENTS OF SPECIFIC ACTIVITY

The activity of the liquid was determined for one hour using High Purity Germanium detector (HPGe) with efficiency 40% for the nuclide (Co-60) and with resolution energy 1.3kev at 1332.6

Kev Canberra (N.A.). a software program called Gamma vision- 6.8 was used to accumulate and analyse the data see Figure 1

The analyses were carried out using a gamma library that includes over 300 radionuclides and 1900 gamma lines. Directed measurement of RW liquid sample were carried out, the radioisotopes (the contamination) were identified by utilizing the HPGe detector as shown in Figure 2. The work was performed by highly qualified personnel and equipped with suitable protective clothing and equipment.

Figure 1

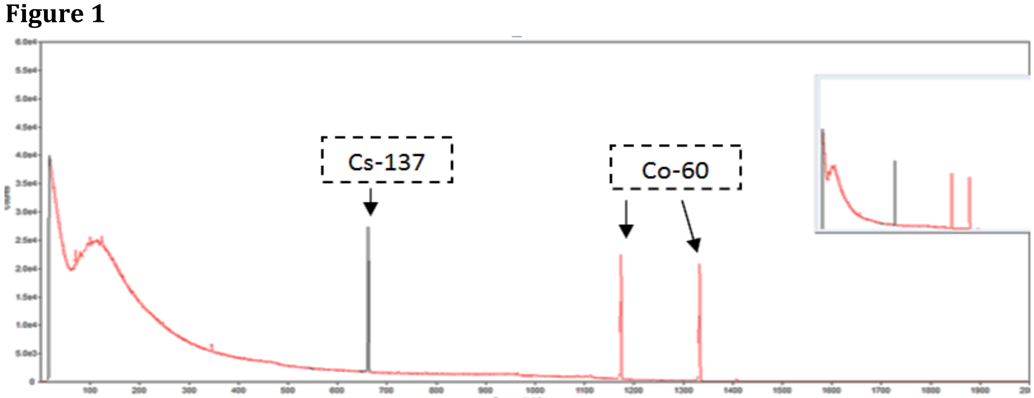

Figure 1 Spectrum Gamma Decay of Cobalt-60, and the Corresponding Energies of 1.1732 and 1.3325 MeV with Cs-137 Energies 661.6keV

Figure 2

Figure 2 Micro-Detective-HX Handheld HPGe Radionuclide Identifier

3.2. EXPERIMENTAL WORK (EVAPORATION PROCESS)

The following steps were followed for the evaporation process scheme(below).

Figure 3

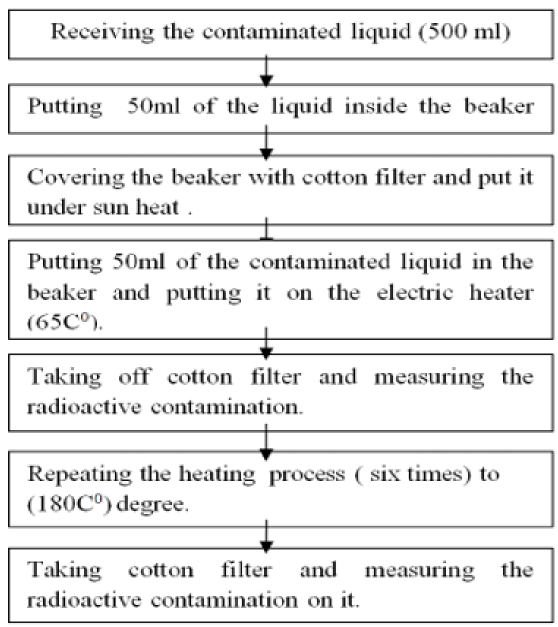

Figure 3 Scheme of the Steps Were Followed for the Evaporation Process

A (500ml)of the radioactive liquid waste ,with a mixture of radionuclides ,was taken and then put (50ml) of liquid waste in the glass beaker (volume =500ml) and covered with cotton filter and left under the sun heat in Summer (July) , and within four hours all liquid waste was evaporated because the heat of the sun was so high and the temperature was above 50 C0 ,then the filter was removed in order to take measurements, after that the process was repeated using the electric heater then (50ml) was put in a glass beaker covered with cotton filter and temperature was setted at 65C0 and after two hours the liquid was evaporated and the filter was lifted in order to take measurements using (Rad eye) device which is used for measuring surface contamination in (Bq/cm2) units, see Figure 4. The detector efficiency is:

1) 36% for (α) Am-241.
2) 23% for(β) Co-60.

3) 49% for(β) Sr-90.

Figure 4

Figure 4 Show the Rad Eye Detectors

As shown in Table 1 Concentration of radionuclides before evaporation, one can find that the activity concentration of Cs-137 and Pa-234 is higher. The results shown in Table 2 show that evaporation efficiency does not evaporate Temperatures below 600 ° C. Table 3

shows that the distillation fluid does not contain any radiation activity. The decontamination factor (DF) resulting from pre-treatment concentration was very high for the total concentration table

(DF) = 896.844 (Bq / l) / 2.4 (Bq / l) = 213.

Table1

Table 1 The Concentration of Radionuclides Before Evaporation

Radionuclide	Cs137	Pb-212	Ac-228	Pb-214	Ra-226	Pa-234	K40	Bi-214
Concentration Bq/L	297.74	13.67	10.36	6.65	26.04	343.03	185	14.09

Table 2

Table 2 Show the Comparative of Surface Contamination Bq/Cm2 Between Standard Value (Background) and Practical Value at Different Temperatures

Filter NO	**Background**	**Surface contamination**	**Temperature**
1	Bq/cm2	Bq/cm2	C0
2	0.16	0.16	Sun temperature
3	0.16	0.17	65
4	0.16	0.16	80
5	0.16	0.16	100
6	0.16	0.16	120
7	0.16	0.17	140
8	0.16	0.16	160

Table 3

Table 3 The Values of Radionuclide Before and After Distillation Process

Sample	Cs137	Pb-212	Ac-228	Pb-214	Ra-226	Pa-234	K40	Bi-214
Before distillation Bq/l	297.74	13.67	10.36	6.65	26.04	343.03	185	14.09
After distillation Bq/L	-	-	4.2	-	-	-	-	-

4. CONCLUSIONS AND RECOMMENDATIONS

The results of this study indicate that the use of evaporation process, either generated by solar or through the use of electrical energy, does not cause any pollution to the environment and human, therefore, evaporation is the best method For the treatment of liquid radioactive wastes, which have a low level of activity; in order to minimize their size compared to other methods; this is in conformity with the regulations of the International Atomic Energy Agency (IAEA) and International Commission on Radiological Protection.

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

None.

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