The Abdus Salam
International Centre
for Theoretical Physics

Joint ICTP-IAEA International School on Radioactive Waste Cementation | (SMR 3484)

16 Oct 2020 - 25 Nov 2020
Virtual, Virtual, Italy

P01 - ADIAHA Monday Sunday

MEETING TODAY'S FOOD NEED: IMPACT OF HUMAN-URINE-RADIOACTIVE SILVER MIXTURE AS A PHOSPHORUS SOURCE ON MAIZE (ZEA MAYS L.) PRODUCTION FOR SOIL SUSTAINABILITY AND FOOD SECURITY

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CERUS: Ceramization of radioactive elements in sintered uranium

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Radioactive Waste Management option for Cameroon: Current Practices towards an optimized management strategy in the future

P06 - GUPTA Merry

Radioactive waste management practices in India

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Cementation of radioactive liquid wastes

P08 - NAQVI Syed Mansoor

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P09 - SAKR Ahmed Khairy Ali Mohammed

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P01

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Joint ICTP-IAEA International School on Radioactive Waste Cementation

Lecture: Meeting Today's Food Need: Impact of Human-Urine-Radioactive Silver Mixture As A Phosphorus Source On Maize (Zea Mays L.) Production For Soil Sustainability And Food Security

Monday S. ADIAHA
Nigeria Institute of Soil Science
Academic Researcher/Scientist (https://scholar.google.com/citations?user=4BIIXPIAAAAJ&hl=en)

2. Introduction

It is a wide known fact that increasing human hunger is one key factor responsible for malnutrition, poor human health, death and increasing societal unrest. All around the globe humans have been reported hungry (FAO, 2015) Maize has thus grown to be local ‘cash crop’ most especially in the southwest part of Nigeria where at least 30% of the crop land has been devoted to maize production under various cropping systems (Ayeni, 1991).

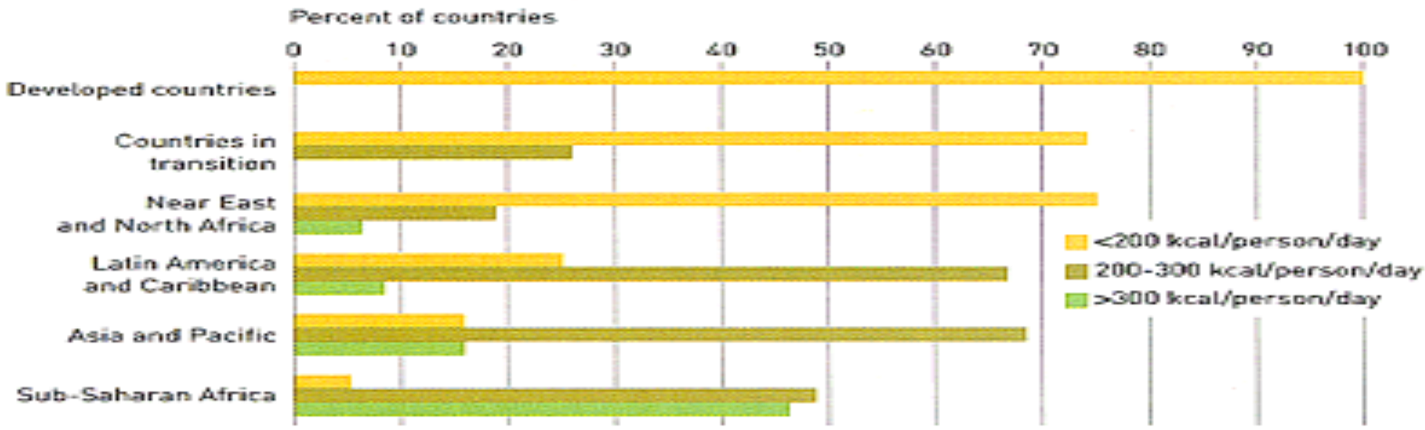

Figure 1: Estimate of world undernourished people, Source: (FAO, 2015).

3. Aim/goal/background

Against the rapid increase in food shortages, food insecurity, increased malnutrition, poor human health, and as adaptive approach to the negative impact of climate change on soil sustainability the need for this work arises, with the following objectives:

1. To access the impact of human urine-radioactive silver mixture as a nutrient source for crop production.

2. To test the efficiency of human urine-Radioactive silver mixture (HURSM) as a carrier material for Integrated fertilizer formulation.

Location of Geographical the Study Area

Gwagwalada has *Global Positioning System* coordinates of 8° 57' 2.9988'' N and 7° 4' 36.2532'' E, with elevation of 205 meters height, that is equal to 673 feet. The University of Abuja is located in Gwagwalada. The Latitude of university of Abuja is 8°.95' 43'' and Longitude is 7°.07'47'' respectively

4. Equipment/procedures

Laboratory Preparation

2 liters of urine and 10 kg of radioactive silver was distilled together (through heating at temperature of about 150°C). The end product was a white-waxy substance.

Product Analysis

The white-waxy substance produced was analyzed to contain Phosphorus (P) using standard method for proximate analysis, and method described by AHT (2015) for radioactive Nano-Silver formulations

Figure 3: Laboratory distillation image

5. Equipment/procedures/Result

The experiment was layout in a Completely Randomized Design (CRD) approach. Human urine-Radioactive silver mixture was treated to maize at five different levels- (3.1 t ha−1, 3.2 t ha−1 , 3.3t ha−1 and 3.4t ha−1) replicated three times.

Parameter	Value
Clay (g/kg)	11.2
Silt (g/kg)	12.1
Sand (g/kg)	76.7
pH (H_2O)	5.93
pH (KCL)	4.95
Organic matter (g/kg)	1.31
Total N (g/kg)	0.072
Available P (mg/kg)	2.74
Exchangeable K (cmol/kg)	0.23
Exchangeable Mg (cmol/kg)	1.49
Exchangeable Ca (cmol/kg)	3.14
Exchangeable Na (cmol/kg)	0.59
CEC (cmol/kg)	5.80

Soil properties was Influenced towards cementation by Human-urine-Radioactive-silver mixture

6. Results

***Grain Yield of Maize was Influenced by* Human urine Radioactive-silver mixture**

Result of grain yield and weight of 100 grains of maize as influenced by human urine-Radioactive silver mixture is presented in Table 1.

Table 2: Effect of Different Levels of human urine-silver mixture on Grain Yield per plot and Grain Weight of *Zea mays* L

Treatment	Weight of 100 grains (g)	Grain Yield/ plot (kg)
Control	25.00	0.425
3.1tha^{-1}	25.00	1.133
3.2 tha^{-1}	50.00	1.250
3.3 tha^{-1}	50.00	1.50
3.4 tha^{-1}	83.00	1.491
LSD (p<0.05)	12.16	0.27

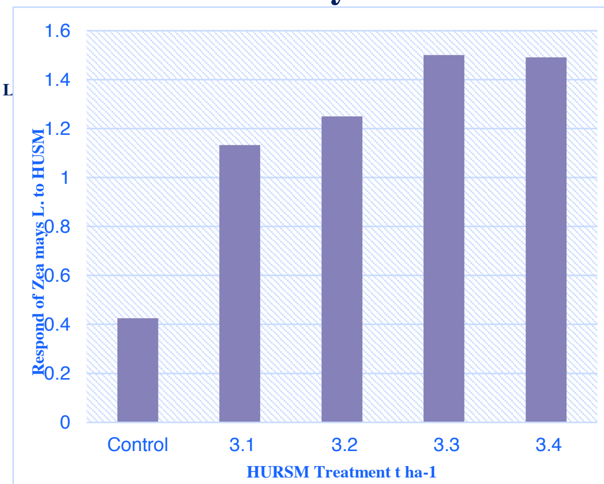

Figure 8: Influence of Human urine R-silver mixture on *Zea mays* L grain yield.

7. conclusions

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Results of this investigation has shown that application of human urine-silver mixture at different levels- (3.1 t ha^{-1}, 3.2 t ha^{-1} , 3.3t ha^{-1} and 3.4t ha^{-1}) increased crop yield over the control. Application of 3.4 t ha^{-1} of human urine-silver mixture significantly ($p<0.05$) increased yield and yield component of *Zea mays* L. Human urine-silver mixture could be used as organic amendments and can be well substituted for expensive and scarce mineral fertilizer in improving crop production, and as a mitigation strategy for increase crop production in the face of ever increasing human population and severe negative climatic impact.

Thank you for listening!

Question: Why is cementation data useful in Agricultural production

P03

IAEA International Atomic Energy Agency

ICTP The Abdus Salam International Centre for Theoretical Physics

CNEA Comisión Nacional de Energía Atómica

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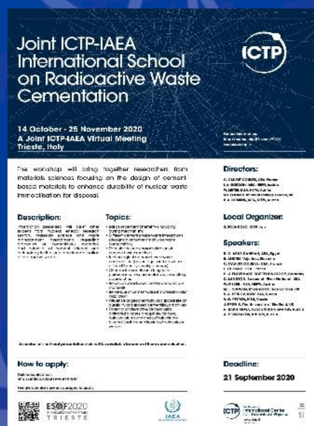
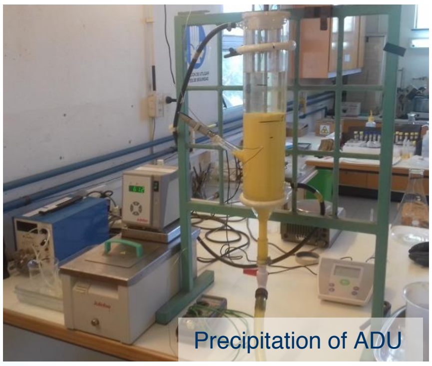
CERUS: Ceramization of radioactive elements in sintered uranium

Ariel Alejandro Chavez
Comisión Nacional de Energía Atómica. Argentina



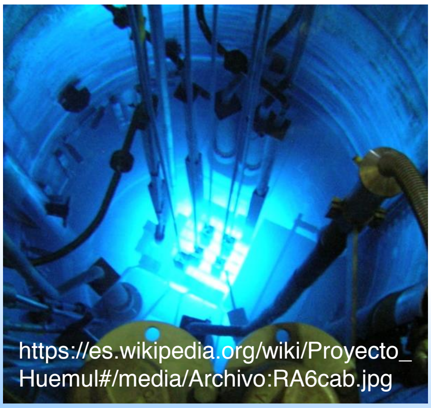
Background

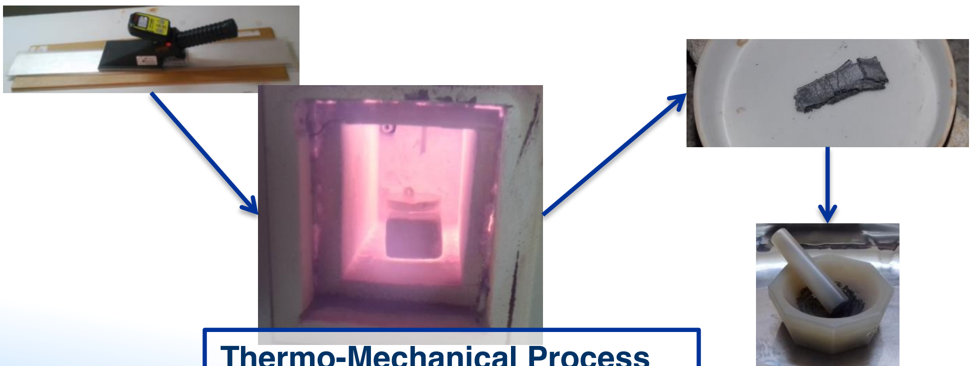
- Personal: Materials engineer, Sabato Institute (CNEA. UNSAM), Buenos Aires, Argentina. Previous experience in metal-mechanic industries, aluminum alloys, mechanical behavior.
- Context:
  - Bariloche Atomic Centre.
  - Uranium Laboratory, Nuclear fuel and waste Division, Nuclear Materials Department
  - National Radioactive Waste Management Program



CERUS: Ceramization of radioactive elements in sintered uranium

- Method proposed for contინioning spent fuel (SF) elements of Research Reactors (MTR)
  - Spent fuel enrichment ≈11%
  - Thermo-mechanical treatment
  - Isotopic dilution of U235 (Natural or depleted Uranium) → Achieve enrichment of ≈ 1%
  - Argentina´s definition of Nuclear fuel Cycle
- Study of U3O8 as immobilization matrix for treated SF



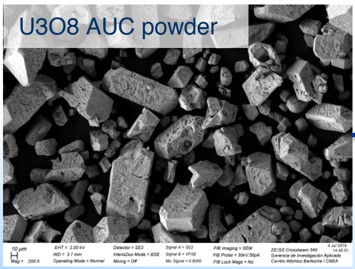


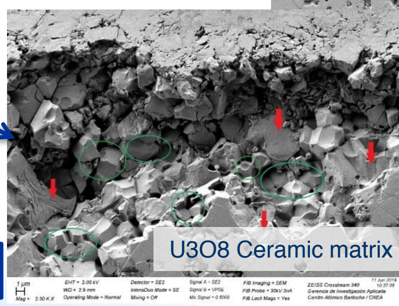
Thermo-Mechanical Process

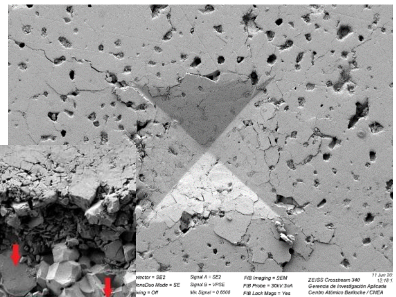
CERUS: Ceramization of radioactive elements in sintered uranium

Materials studies:

- Powder precursors for ceramic matrix: U_3O_8 from Amonium Di-Uranate (ADU), Amonium Uranyl Carbonate (AUC), Uranium nitrate, UO_2 scrap (fuel element production)
- Cold pressing, Sintering, Porosity by immersion and ceramography → Pellets samples
- Optical microscopy, electronic microscopy, Micro-Hardness, X ray diffraction, Energy Disperse Spectrometry, Micro-Tomography







Ceramic Matrix studies

CERUS: Ceramization of radioactive elements in sintered uranium

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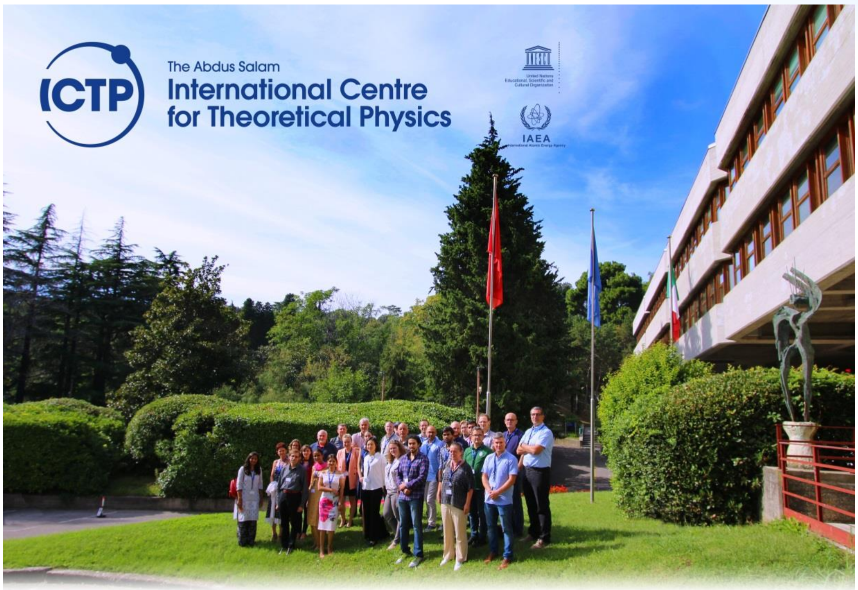
- Future activities:
  - Mixing treated SF plate (non-active) and U_3O_8 powder. Obtain composites ceramics (encapsulation, immobilization).
  - Mechanical characterization, leaching behavior.
  - Evaluation of the addition of glass frit to reduce sintering temperatures(liquid phase sintering), and possibly improve mechanical properties.
  - Evaluation of Hot Pressing and Hot Isostatic Pressing
- Long term activities:
  - Start studies with irradiated plates and materials, in hot cells or glove box.

ICTP-IAEA experience



Joint ICTP-IAEA International School on Nuclear Waste Actinide Immobilization
10 - 14 September 2018, Miramare - Trieste, Italy

Thank you!

Ariel.chavez@cab.cnea.gov.ar

P04

Joint ICTP-IAEA International School on Radioactive Waste Cementation

14 October - 25 November 2020
A Joint ICTP-IAEA Virtual Meeting
Trieste, Italy

The ENEA CETRA facility in the context of the nuclear waste management

Fabio Girardi and Giuseppe Augusto Marzo

ENEA - Nuclear Material Characterization Laboratory and Nuclear Waste Management

Italian Radioactive waste storage major locations

ENEA

ENEA is the Italian National Agency for New Technologies, Energy and Sustainable Economic Development, a public body aimed at research, technological innovation and the provision of advanced services to enterprises, public administration and citizens in the sectors of energy, the environment and sustainable economic development

Since its very foundation, ENEA performs R&D on nuclear fission. At present, activities are mainly focused on research and development of advanced nuclear systems for innovative production plants and for medium-, long-term problem solving related to both the availability of fuel resources and reducing long-life radioactive wastes.

- Still within nuclear fission, ENEA plays an important role for: qualification of nuclear components and systems; ionizing radiation metrology; radiation protection.
- ENEA hosts the National Contact Point for the transport of radioactive materials and the Integrated Service for the management of non-electro-nuclear radioactive waste.
- ENEA is a member of ARIUS and ERDO - Working Group

NUCLEAR MATERIAL CHARACTERIZATION LABORATORY AND NUCLEAR WASTE MANAGEMENT: ROLE AND TASKS

- Planning and execution of radiological characterization measurements for nuclear materials and radioactive waste.
- Study, development, and application of innovative radiological characterization techniques for radioactive materials.
- Qualification and characterization of conditioning matrices for radwaste management.
- Provision of technical-scientific and operational Public Administration Offices for issues related to radiological characterization.
- National Contact Point for the fight against illegal radioactive material trafficking.
- Integrated Service (Italian national service for the management and disposal of nuclear waste not coming from NPPs) and the Additional Protocol to the Nuclear Non Proliferation Treaty

SRWGA – Sea Radioactive Waste Gamma Analyzer

Mobile Laboratory

ISOCS – In Situ Object Counting System

CETRA

The CETRA is the facility of the Nuclear Material Characterization Laboratory and Nuclear Waste Management dedicated to the researches on encapsulation technologies for nuclear wastes.

The CETRA was the Italian national reference laboratory for the qualification and characterization of cement matrices for the encapsulation of nuclear waste according to the Italian Technical Guide n° 26 ENEA DISP (G.T. 26).

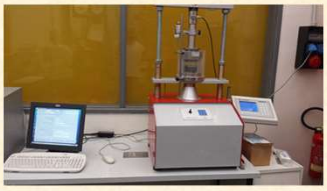
Mechanical, physical and chemical test performed in CETRA lab:

- Compressive strength test (compressive strength up to 500 N/cm^2)
- Resistance to thermal cycling freeze-thaw (i.e. 30 thermal cycles of 24 hours from -40 °C to + 40 ° C)
- Resistance to radiation (i.e. compressive strength up to 500 N/cm^2 following exposition 106 Gy)
- Fire resistant (ASTM D 635-81)
- Leaching in water
- No free liquids (ANSI/ANS 55-1)
- Biodegradation resistance
- Immersion resistance (90 days in fresh water without swelling)

In addition to the tests prescribed by G.T. 26 for the elaboration of a detailed characterization campaign, tests are carried out to determine some structural, physical, chemical and mechanical properties of particular interest:

- Heat of hydration of the cement
- Setting time
- Resistance to aggressive environments
- Permeability to water under pressure
- Blaine's fineness and porosity
- Leaching test
- Elemental analyses with an innovative instrument (MP-AES)

Climatic test chambers



Micro-press

Compressive test apparatus

Waste Category	Italian radioactive waste classification limits*
Exempt Waste	Waste that can be free-released according to the Italian regulation (T/2<75 d; < 1 Bq/g)
Very Short Lived	Waste containing very short half-life radionuclides (T½ < 100 days) that, within 5 years, can be free-released according to the Italian regulation.
Very Low Activity	Waste with a total radioactivity concentration ≤ 100 Bq/g of which alpha-emitters ≤ 10 Bq/g.
Low Activity	Waste with a radioactivity concentration as follows: - Short half-life radionuclides (T½ < 31 years) ≤ 5 MBq/g - Long half-life radionuclides ≤ 400 Bq/g - 59Ni and 63Ni ≤ 40 kBq/g
Medium Activity	Waste with a radioactivity concentration exceeding the LLW limits and without heat generation
High Activity	Waste with a high concentration of long half-life radionuclides and/or heat generation

*Source: A. Paratore – NEA Workshop on the Management of Non-Nuclear Radioactive Waste – Legnaro, 2 May 2017

MP-AES Elemental analyzer

VICAT apparatus

P05

Joint ICTP-IAEA International School on Radioactive Waste Cementation| (smr 3484) 16 Oct - 25 Nov 2020

Poster: Radioactive Waste Management option for Cameroon: Current Practices towards an optimized management strategy in the future

Cebastien Joel GUEMBOU SHOUOP, Junior Researcher
National Radiation Protection Agency (NRPA) of Cameroon
PO Box: 33732 Email: sebastianguembou@gmail.com

POLICIES AND LAWS - RWM IN CAMEROON

i. The **law No 95/08** of the 30th January 1995 on RADIATION PROTECTION;

ii. **Decree No 2002/250** of the 31 October 2002 that creates, organizes, and defines the functioning of NRPA;

iii. **Law No 89/02** of the 29th December 1989 on Toxic and dangerous waste;

iv. The **BAMAKO Convention (in January, 1991, and came into force in 1998)** that ban the importation of dangerous waste in Africa, is on control of transboundary movements and on the management of waste in Africa.

v. The **law No. 2019/012 of July 19th, 2019**, lay down the general framework for radiological and Nuclear safety, nuclear security, civil liability and safeguards enforcement. The law is divided into 12 chapters, including **the management of radioactive waste (Chapter 7)**

CURRENT PRACTICES OF RWM

I. The IAEA Fact Finding Mission (4-6 September 2014) has permitted to find the characteristics and origin of the Yaounde I University orphan source

II. **Waste producers have the first responsibility for the management of their waste and this management is done under the control of NRPA (Users in the Cameroon Territory should return the sources to their manufacturers)**

III. With the IAEA assistance, Cameroon drafted in 2013 the national waste management policy and strategy. These documents have being discussed with other ministries like Mines and Environment prior to their adoption.

IV. Adoption of temporary waste storage, a centralized spent sealed sources storage facility (LABOGENIE)

The following topic are **to be considered for the future** of Nuclear Waste in Cameroon: Nuclear Waste Safety; Classification of nuclear waste; Important radionuclides; Regulations and Standards for Nuclear Waste Safety; Multiple-barrier concept, Site-selection guidelines; Groundwater Hydrology; Subsurface Transport of Radionuclides; Waste Package/Waste Forms; Social Issues… .

- ***Scientific research and development***: Importance of developing research on whether deep geological holes can be a permanent solution for the country or not. Where could a borehole be implemented and with which level of confidence, assurance, and public trust.

ACTIVITIES DONE

- Radioactive waste localization (through physical searches using radiation monitors), identification and collection
- Strategic areas of investigation: Scrap yards, municipal waste storages, suspected locations, former users of sealed radioactive sources, … etc.
- Existence and availability of the centralized storage facility to deal with spent radioactive sources: technical skill development needed.

Fig. 1: Detection of Cs-137 orphan radioactive source covered by concrete in the Department of Physics of the University of Yaounde 1; Its identification processing after concrete removal and the screen display of the radiation monitor after identification.

FACILITY FOR THE MANAGEMENT OF DSRS

- Management of the low activity disused sealed radioactive sources is conducted within the newly constructed Cameroon interim storage facility
- 08 moisture gauges containing 08 137Cs and 08 241Am-Be sources stored in the public area in Labogenie which is national civil engineering laboratory
- Alternative Disposal of Radioactive waste in very deep holes, surface, near-surface, and geological disposal should be considered for the next 30 years

- Growth of the use of sealed radioactive sources in developing countries for Non-Destructive Testing (NDT) and other practices.
- Sources available on the national territory prior to the creation of the National Radiation Protection Agency (NRPA) of Cameroon, and thereafter being used, remain useless in the owner's factory. → Issue to deal with these spent and disused sources in addition to other recovered or found.
- Great need to manage recovered legacy and orphan radioactive sources in Cameroon: Construction of a **Centralized Waste Storage Facility**

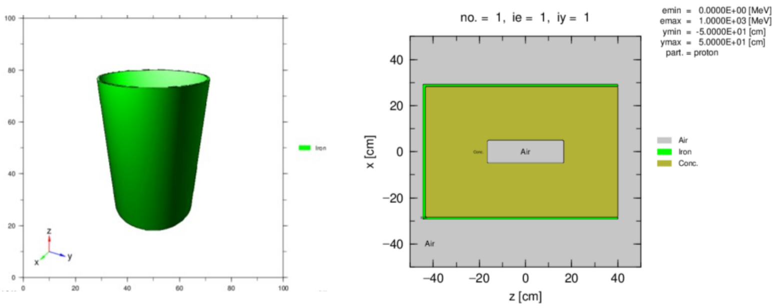
Fig. 3: Inside view of the processing container

Fig. 4: Inside view of the Cameroon Interim Storage Facility

Fig. 2: External view of the Cameroon Interim Storage Facility

MONTE CARLO CODE FOR DSRS CEMENTATION

❖ FUTURE MANAGEMENT OPTION



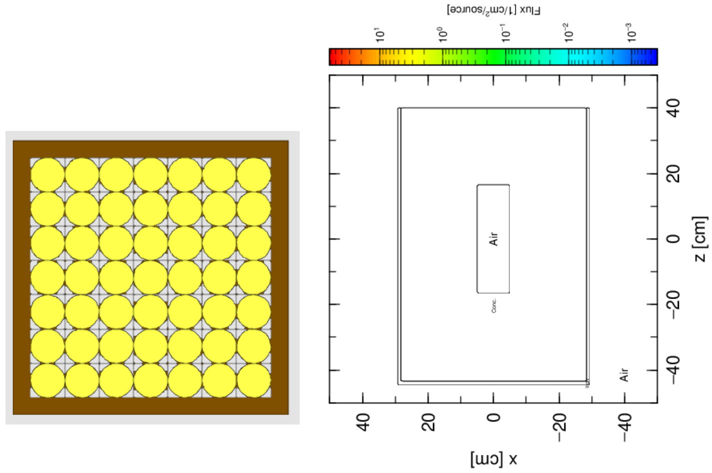
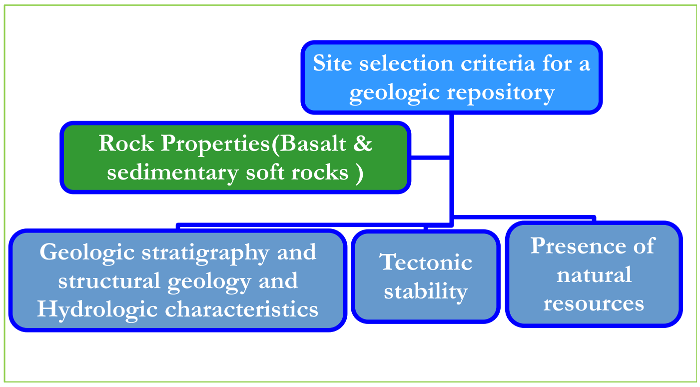


Fig. 5: Tank/drumps for waste conditioning using concrete
Different cross section views for PHITS Calculations

- The country has not high level radioactive waste or spent nuclear fuel from nuclear reactor operation: High technology for waste management to be implemented gradually.
- Implementation of the defense in depth for the protection of current and future generation from the harmful effects of radioactive waste: → Trainings needed.



MONTE CARLO CALCULATION RESULT

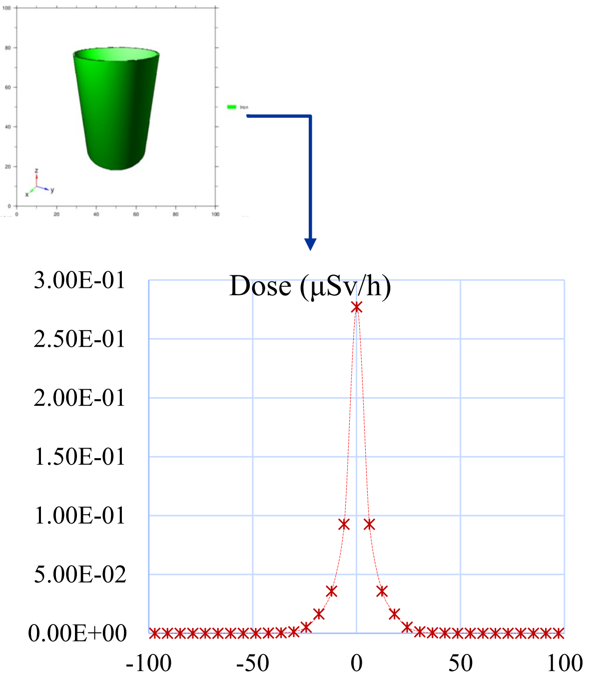


Fig. 6: Dose rate in the drum cross-section, filled with concrete and three Cs-137 disused sources.

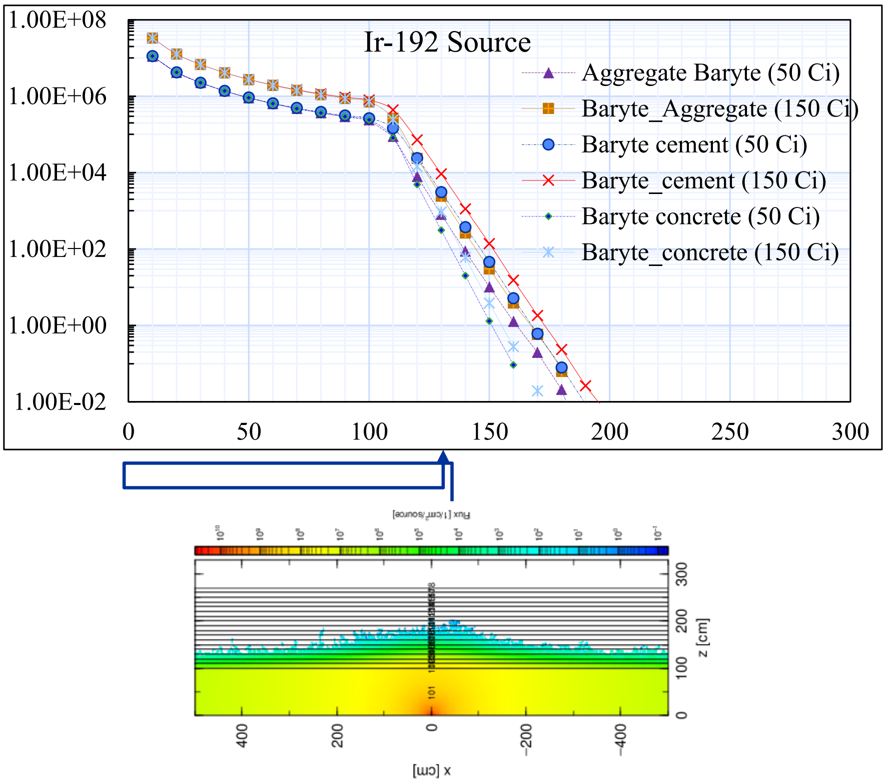


Fig. 6: Barite material for Ir-192 shielding

IMPROVEMENT OF RWM SYSTEM OF CAMEROON

PROBLEMS

- National system of waste management not established
- Insufficient trained staff
- Lack of legislation on waste management
- Lack of sounded national strategy for Radioactive waste Management

NEEDS

- Trainings in WM of all facility technician
- Support for the equipment of a temporary waste disposal facility and development of a national permanent strategy and solution for radioactive waste management (boreholes, deep geological disposal, …)
- Need of a radioactive waste classification system
- Drafting the legislation on waste management
- Adoption of the waste management policy and strategy

ACKNOWLEDGEMENTS

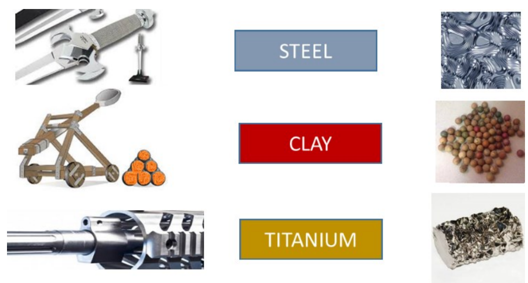
SMR3494; PHITS Collaboration; KAIST NQE Department; KINS; NRPA (A. Simo, M. Moyo, E.J. Nguelem, et al.)

PROJECTED RESEARCH STUDY

- Establishment of the National system of waste management
- Development of the regulation and legislation on waste management
- Development of the national policy and strategy regarding radioactive waste management

❖ **Implementation of MONTE CARLO Code in managing disused radioactive sources in Cameroon (skill transfer to young scientists)**

  ❖ **PHITS / GEANT4**



P07

sck cen
Belgian Nuclear Research Centre

Eduardo Ferreira - 22/10/2020

Cementation of radioactive liquid wastes

Prepared by Ferreira Eduardo by courtesy of SCK CEN

Eduardo Ferreira

Past

- PhD – Nuclear Technology at IPEN – Brazil
- Thesis – Durability of cement paste as backfill material in a borehole repository

ipen

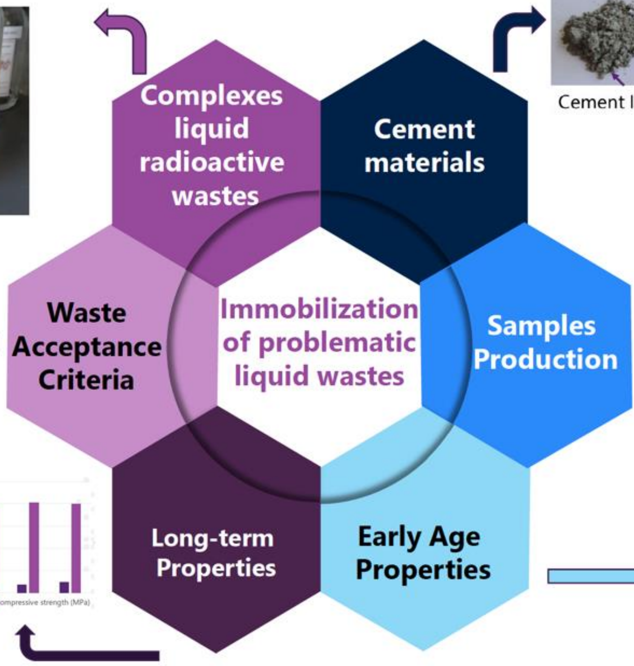
Now

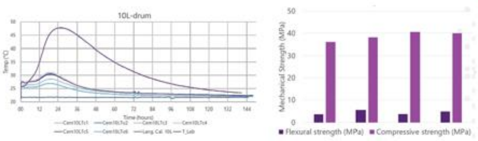
- Researcher – Radioactive Waste and Disposal group – SCK CEN
- Immobilization of liquid radioactive waste in cementitious forms.

sck cen
Exploring
a better tomorrow

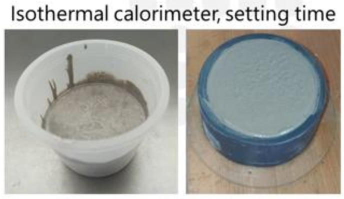
Immobilization of liquid radioactive waste in cementitious forms.

WAC	
Mechanical Strength	Compr > 10 Mpa Flex. > 1 MPa
Setting Time	Initial < 24h Final < 48h
Long-term stability	Mech. Strength + dimensional stab.





Isothermal calorimeter, setting time



also: viscosity, µstructure
semi-adiabatic calorimeter;

Comprehensive testing programme

1st order factorial experiments

- Investigation of main factors: e.g. water/cement ratio, waste loading.
- Screening the main factors on cement recipe.

2nd order factorial experiments

- Non-linear investigation on the main factors
- Optimization of cement recipe.

Robustness Tests

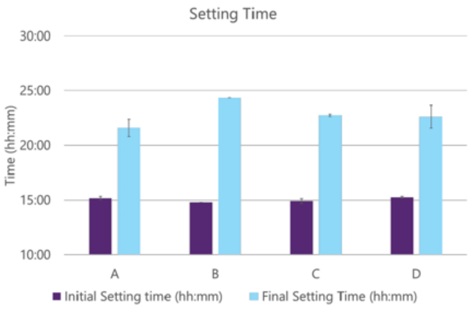
- Optimal cement recipe based on results of 2nd order experiments.
- Varying the waste chemical composition.
- Predictive Modelling
  - Calorimetry data used to predict the temperature in a real scale drum.

Industrial Scale Tests

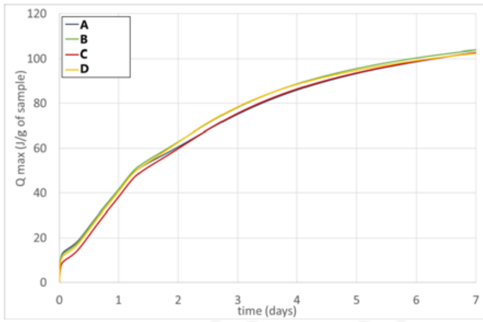
- Assess the performance of the selected recipe in industrial scale

Some results

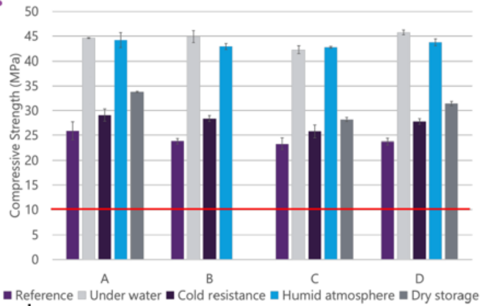
Setting Time



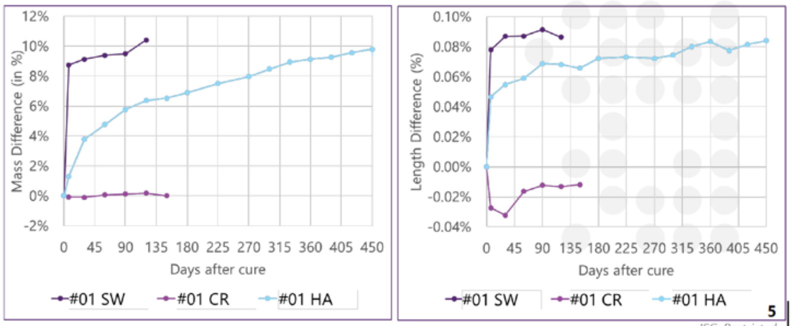
Isothermal Calorimeter



Mechanical Strength



Long Term Stability



Concluding remarks

- SCK CEN cementation programme shows promising results in immobilizing different problematic liquid radioactive waste streams
- Standard tests are being used to assess the long-term performance of our cemented waste forms.
- More studies are being done on durability of these waste forms to guarantee the stability of the conditioned matrix in the long-term.

SCK CEN
Belgian Nuclear Research Centre

Foundation of Public Utility

Registered Office: Avenue Herrmann-Debrouxlaan 40 – BE-1160 BRUSSELS
Operational Office: Boeretang 200 – BE-2400 MOL

P08

Introduction & Radioactive Waste Management at Aga Khan University Hospital, Karachi, Pakistan

Syed Mansoor Naqvi, PhD
Assistant Professor (Medical Physicist)
Department of Radiology &
Radiation Protection Officer
Aga Khan University, Karachi, Pakistan

Pakistan:

Lake Saiful Muluk, located at the northern end of the Kaghan Valley, near the town of Naran in the Saiful Muluk National Park.

Badshahi Mosque was commissioned by the Mughals in 1671. It is listed as a World Heritage Site.

The 7,788 metres (25,551 ft) tall Rakaposhi mountain towers over Hunza

Shangrila Lake with adjoining Shangrila Resort, Skardu, Gilgit-Baltistan

Fairy Meadows and the view of Nanga Parbat

Attabad Lake, Hunza Valley

The Deosai Plains are the world's second highest alpine plain.

Hawke's Bay Beach, Karachi

Minar-e-Pakistan, Lahore

K2, the second-highest mountain on Earth

Aga Khan University Hospital, Karachi, Pakistan (AKUH)

- AKUH, K (www.aku.edu) is a tertiary care hospital established in 1985 to provide compassionate care and treatment to patients with a full range and severity of specialty diseases and conditions.
- A full fledge medical center with diagnostic radiology, radiation therapy and nuclear medicine facilities including:
  - Diagnostic Radiology
  - Intervention Radiology
  - CT scanning
  - MRI
  - Dexa Scan
  - Nuclear Medicine
  - Isotope Production facility: the Cyclotron
  - PET/CT
  - Radiation therapy: LINACS & Brachytherapy

Radioactive Waste Management at Aga Khan University Hospital

- Regulations: Pakistan Nuclear Regulatory Authority Reg. PAK-915
  - www.pnra.org
- Collection and Segregation of Biomedical Radioactive Wastes
- The solid radioactive waste is categorized into following two groups;
  - Compactable and Combustible waste
  - Non- compactable and non-combustible waste
- The solid radioactive waste is managed in the following way;
  - Delay and Decay:
  - Ground Disposal: at the designated sites of Pakistan Atomic Energy Commission
- The liquid radioactive waste is managed through Delay and Decay

Radioisotopes and Radioactive Waste Details at AKUH

Sr. No.	Location	Isotope	Half Life	Typical Activity of Waste	Storage	Disposal	Type
1	Nuclear Medicine	Tc-99m	6.02 hours	6 GBq (<150 mCi) (2 generator per week)	Hot Store in Nuclear Medicine	Twice a year (Generators are stored for six months and then disposed)	Non-radioactive waste
2		I-131	8.04 days	< 74 MBq (2 mCi)		Disposed after ten half-lives of the radioisotope, exposure rate is measured before disposal which should be equal to the background level.	
3		Radioactive contaminated vials & syringes with Tc-99m & I-131		< 74 MBq (2 mCi)			

Sr. No.	Location	Isotope	Half Life	Typical Activity of Waste	Storage	Disposal	Type
6	Brachytherapy	Iridium 192	73.8 days	< 2 Ci	Hot Store, Nuclear Medicine Section of Radiology	Used sources are disposed yearly, returned to the Manufacturer	Disused radioactive source
7	Cyclotron	F-18 Tc-96 Nb-95 Mn-52 Co-57 Co-56 K-40	110 min 4.6 days 3.61 day 5.6 days 272 days 77 days $1.28x10^9$ days	Bombardment activation products from Havar or stainless steel in Cyclotron	Radioactive waste Container in Cyclotron	Disposed after ten half-lives of the radioisotope, exposure rate is measured before disposal which should be equal to the background level.	Non-radioactive waste
8	PET-CT	F-18	110 min	< 1 mCi	Hot store	Same as above	

Thank you

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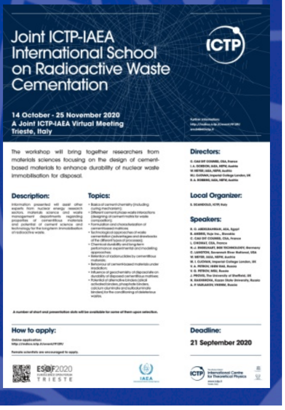
Joint ICTP-IAEA International School on Radioactive Waste Cementation

Adsorption of U(VI) from acid solution on a low-cost sorbent: equilibrium, kinetic, and thermodynamic assessments

Ahmed Sakr, PhD
Nuclear Materials Authority
akhchemist@gmail.com



Introduction

^{235}U is used as a fuel in nuclear power plants.

The pre-concentration and separation of uranium on different adsorbents are effective alternative methods for its recovery from liquid waste solutions.

Many sophisticated synthetic adsorbent materials have recently been developed for the adsorption of uranium from aqueous solutions.

In recent times, clay has become a vital mineral to be considered in uranium recovery due to the proposed utilization of bentonite or clay minerals as adsorbent materials in wastewater.

Ain of Work

The aim of this study to investigate sorption of U(VI) ions from wastewater using Spent activated clay after modification by gallic acid. Ethyl acetate was utilized to reduce the oil residues in the pent activated clay.

Experiment

Materials

uranyl acetate (BDH Chem., England)

Spent activated clay

(SAC) is obtained from Oils and Soap Company which engages in the production of oil and detergents. Mainly, it consists of montmorillonites (expanding 2:1 layer structure) activated with sulfuric acid. The main constituents of this clay are SiO_2 (65–75%) and Al_2O_3 (15–20%). It considered as an acidic adsorbent with pH 3.5.

Gallic acid

Adsorption experiments

Instrumeentation

UV-Vis Spectrophotometer at λmax of 655 nm
2- Inductively Coupled Plasma-Atomic Emission Spectrometry
3- X-Ray Diffraction Technique (XRD)
4- X-Ray Fluorescence Technique (XRF)
5- Scanning Electron Microscope (SEM)

Results

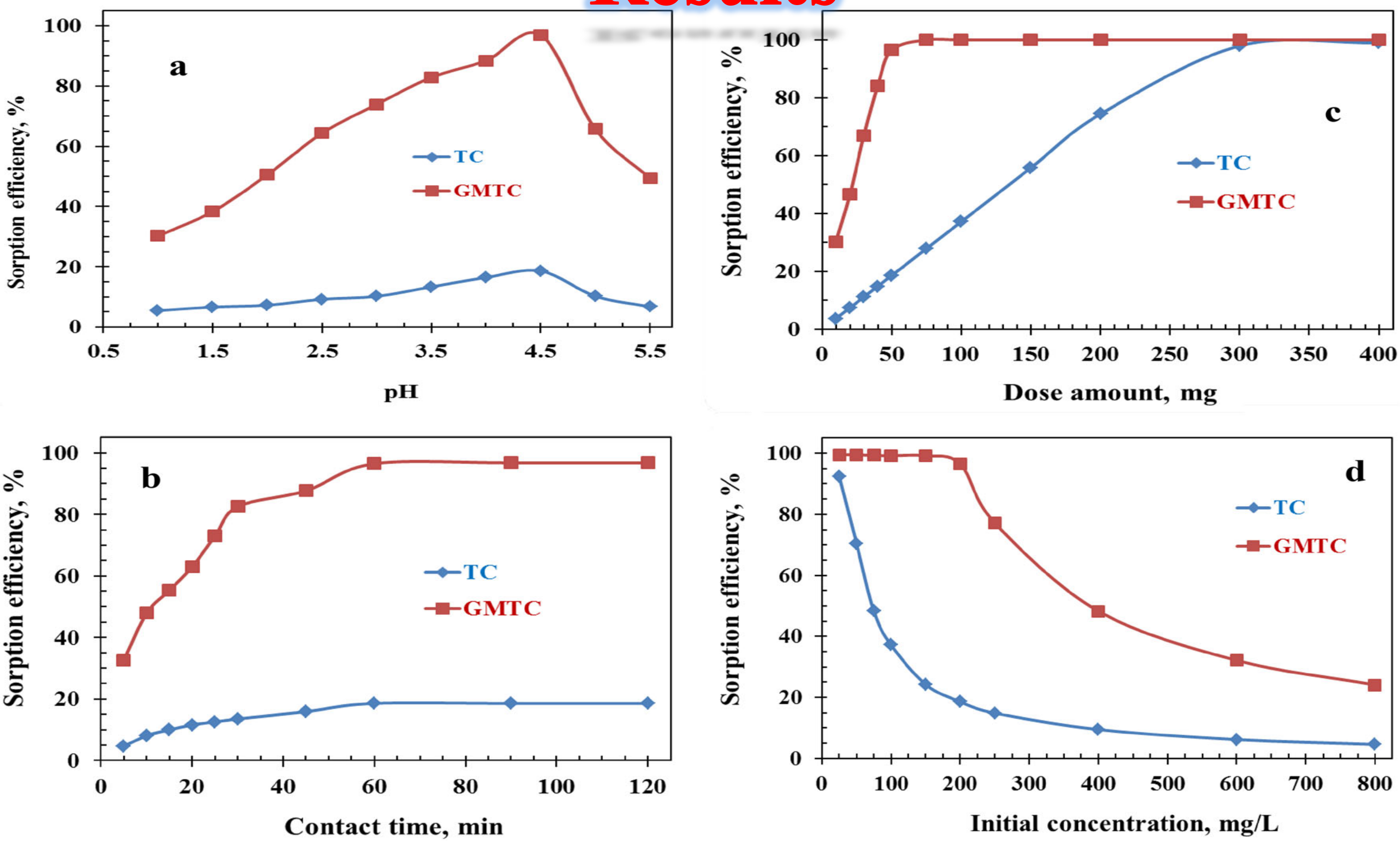


Fig 1: a) Effect of the a pH, b) contact time, c) adsorbent dose, and d) initial uranium concentration on the uranium adsorption efficiencies using TC and GMTC as adsorbents.

Effect of temperature

Table 1: Effect of temperature on uranium adsorption efficiency and uptake using TC and GMTC adsorbents

Temperature, °C	Adsorption efficiency, %		q_e (mg/g)	
	TC	GITC	TC	GITC
25	18.60	96.50	37.2	193
30	17.52	95.68	35.04	191.36
35	16.23	94.85	32.46	189.7
40	15.44	94.11	30.88	188.22
45	14.63	93.45	29.26	186.9
50	14.05	92.92	28.08	185.84
55	13.48	92.21	26.96	184.42

Physical parameters of U(VI) adsorption

Table 2: The optimum conditions of the uranium adsorption on TC and GMTC adsorbents

Parameters	Range	Optimum condition
Kinetic models	Pseudo-first-order, Pseudo-second-order, Elovich, and Morris intra-particle diffusion kinetic models in adsorption	Pseudo-second-order is fitted for the two adsorbents
Isotherm models	Langmuir, Freundlich, Dubinin–Radushkevich (D–R), and Temkin isotherm models	Langmuir isotherm model is fitted for the two adsorbents
Thermodynamic parameters	ΔG, ΔH, and ΔS	+ΔG for TC (**non-spontaneous**) -ΔG for GITC and NITC (**Spontaneous**). -ΔH (exothermic for the two adsorbents). -ΔS (feasibility of adsorption and the decreased randomness for the two adsorbents).

Conclusions

- The optimised adsorption conditions were pH 4.5, a contact time of 60 min, and ambient temperature. The maximum uranium adsorption capacities on TC and GMTC were 37.20 and 193.0 mg/g, respectively.

- The mode of uranium ion adsorption onto TC and GMTC followed the pseudo-second-order kinetic and Langmuir models well.

- The thermodynamic study revealed that the adsorption of the uranium ion on TC was nonspontaneous, while the adsorption process on GMTC was spontaneous.

- M. F. Cheira, H. I. Mira, A. K. Sakr, S. A. Mohamed, Nucl Sci Tech. (2019) 30:156
  DOI:10.1007/s41365-019-0674-3

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Joint ICTP-IAEA International School on Radioactive Waste Cementation

Lecture: A Survey on Radioactive Waste Management in Iran

Mahsa Sanaei / Environmental Engineering – solid waste management and soil pollution
PhD Erasmus Exchange student of Politecnico di Milano & University of Tehran

IRAN

Iran is a country located in west Asia. Iran is the 17th-largest country in the world. Iran's population is about 82 million. Tehran is capital of Iran with about 10 million population.

Iran Nuclear Waste Management Company (INWM Co.)

Iran Nuclear Waste Management Company (INWM Co.) is the only authorized company for radioactive waste management in the country which acts under the framework of Iran nuclear regulatory authority (INRA) and IAEA standards.

National Waste Management Policy (NWMP) :

- 1.Protection of human health
- 2.Protection of environment
- 3.Protection beyond national borders
- 4.Protection of future generations

National Waste Management Strategy (NWMS) :

- 1- The safe management of Radioactive Waste (RW)
- 2- Representing a basic system framework for the decision making of related authorities, and organizations responsible for RW.
- 3- Related Regulations in Iran

Status of Laws and Regulations :

— Atomic Energy Organization of Iran Act (1974)

— Radiation Protection Act of Iran (1989)

— The act of National five year Development Program (2011-2015)

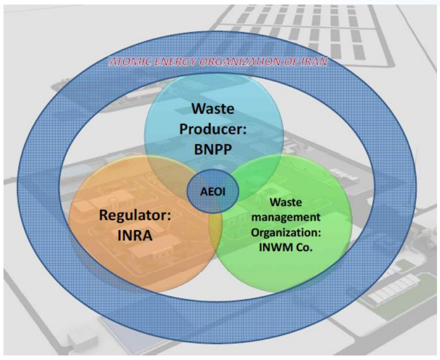
— Radiation Protection Decree (1990, 2005)

— Basic Radiation Safety Standards (2005)

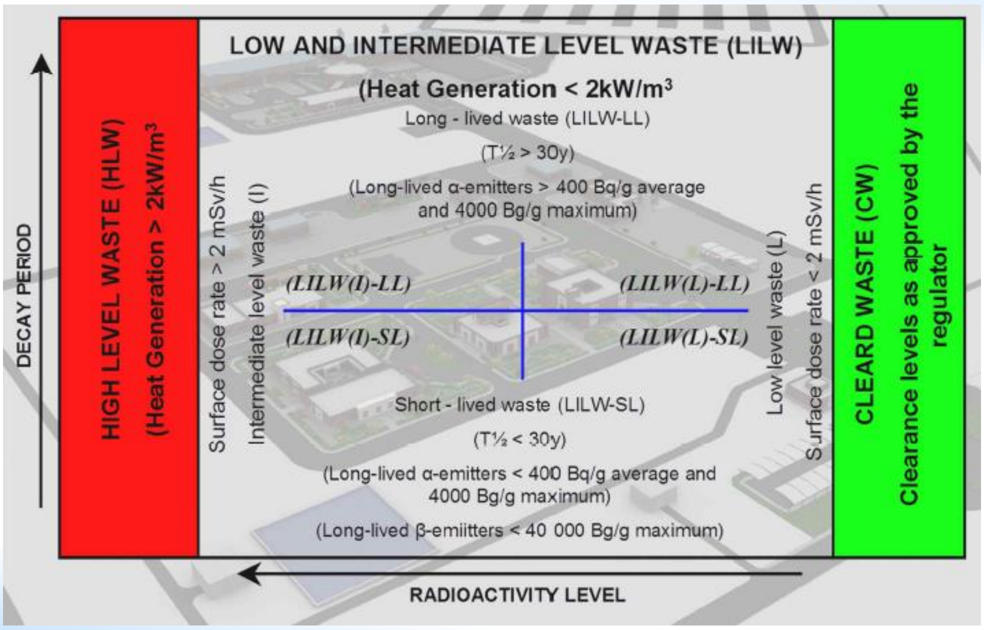
Document No.

INRA-MA-RE-200-50/01-0-Jun.2010
Regulations on Radioactive Waste Management

Responsibilities related to RWM in Iran



RADIOACTIVE WASTE CLASSIFICATION



Radwaste Disposal Classification in Iran

Iran Nuclear Waste Management company's main current activities :

- ✓ Liquid waste treatment,
- ✓ conditioning of disused sealed sources,
- ✓ transportation of institutional and interim storage,
- ✓ NORM and TENORM waste management
- ✓ Design and construction of near surface disposal facility
- ✓ Prepare supplementary documents such as safety & licensing

NORM/TENORM waste management

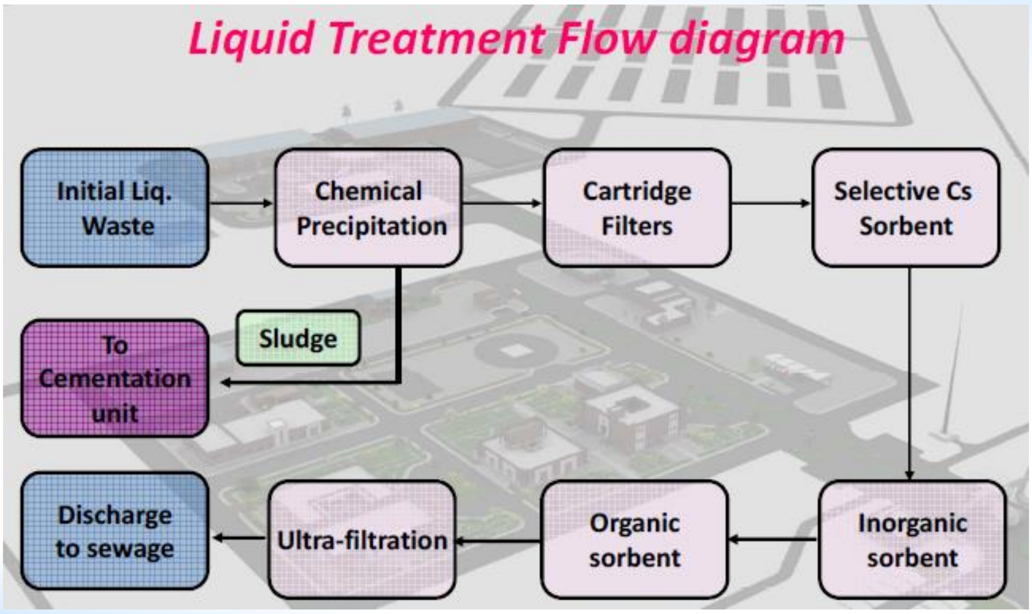
Industries with NORM Radiation in Iran

- ✓ Mining and mineral Processing;
- ✓ Oil and Gas Production;
- ✓ Phosphate industry, including phosphoric acid and phosphate fertilizers production ;
- ✓ Ceramics and building materials;
- ✓ Metal Recycling;
- ✓ Water Treatment Facilities;
- ✓ Tunneling and Underground Workings;

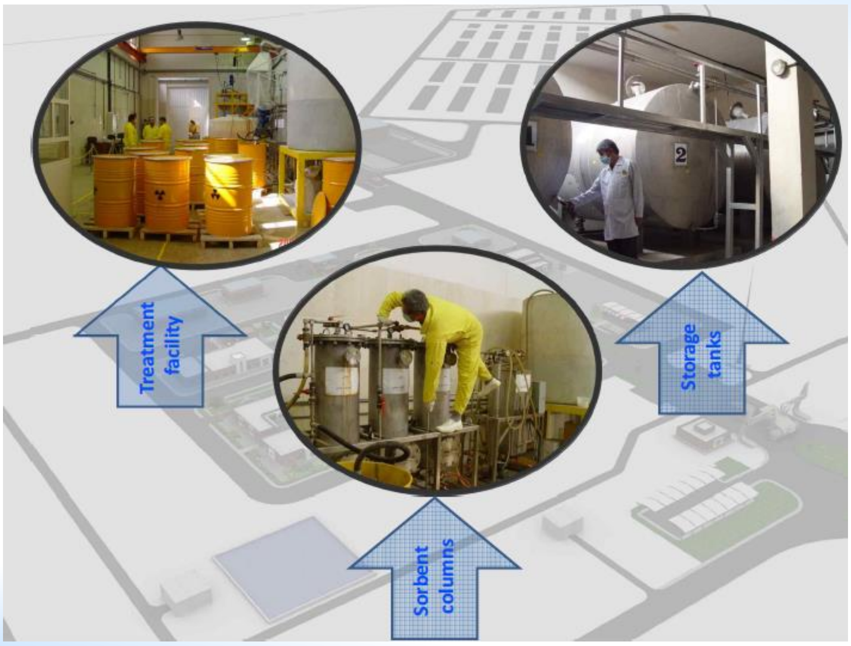
Status of main regulations (Regarding NORM)

- ✓ Basic Radiation Safety Standards (BRSS-1999);
- ✓ Regulations of radiation production in mining and mineral processing industries (INRA-RP-RE-110-00/44-0-Tir.1389)
- ✓ Iranian guidelines for the management of NORM.(under preparation)

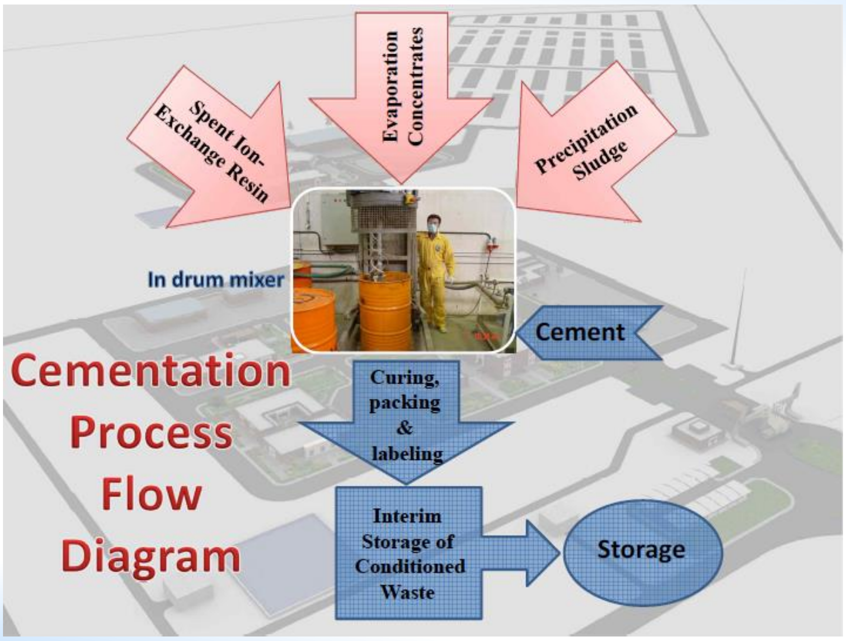
Treatment of Liquid Waste



Treatment of Liquid Waste

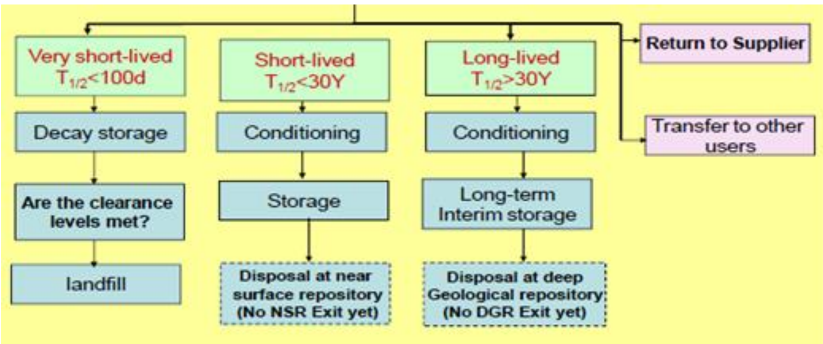


Cementation of Residue



Conditioning of Disused Sealed Sources

Conditioning of Disused Sealed Sources



Transportation of Institutional Radwaste

Waste Gathering & Transportation

- Solid waste transportation from medical and research centers
- Solid waste transportation from fuel cycle facilities
- Conditioned waste transportation
- Disused sealed source transportation

Safety & Radiation Protection

Main INWM Activities

- Safety control Liquid waste treatment system
- Daily monitoring and leakage control of material dispersion to environment
- Air sampling and radon determination
- Personnel training in the field of health physics and operation
- Measuring equipment calibration
- Personnel training in the field of transportation and safety aspect

CHALLENGES / IMPLEMENTATION

•Remaining these wastes has been a challenge and global growing issue, hence finding a suitable site for burial them is being deterioration because there are numerous factors and parameters involved. Besides, it is a complex, costing and time-consuming issue.

•It is necessary for burial sites to have some geological characteristics. Based on the IDOE Standards these sites should contain the following items:

CHALLENGES / METHODS / IMPLEMENTATION

- ✓ Suitable substrate of low permeability and high strength with minimal groundwater trend
- ✓ Homogeneous rock mass slope with low and stable hydraulic steep,
- ✓ Having a low vibration with low frequency
- ✓ Stay away from earthquake fault line
- ✓ Stay away from populated areas and protected areas and national reserves
- ✓ Stay away from lakes and rivers and groundwater discharge areas

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