EXPERIMENTAL STUDY REGARDING NEW METHODS OF RADIOACTIVE DECONTAMINATION AND CLEAN-UP FOR MATERIALS THAT WERE CONTAMINATED WITH HYDROGEN-3 USED IN RESEARCH LABORATORY

Diana CHIPER[1], Catalin Stelian TUŢĂ[1], George Gabriel BUBUEANU[1], Cristian POSTOLACHE[1]
Alexandra-Diana CHIPER[2], Ioana-Cristina CHIPER[2]

[1] Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH) Romania,
[2] Polytehnic University of Bucharest, Faculty of Automatic Control and Computers Romania

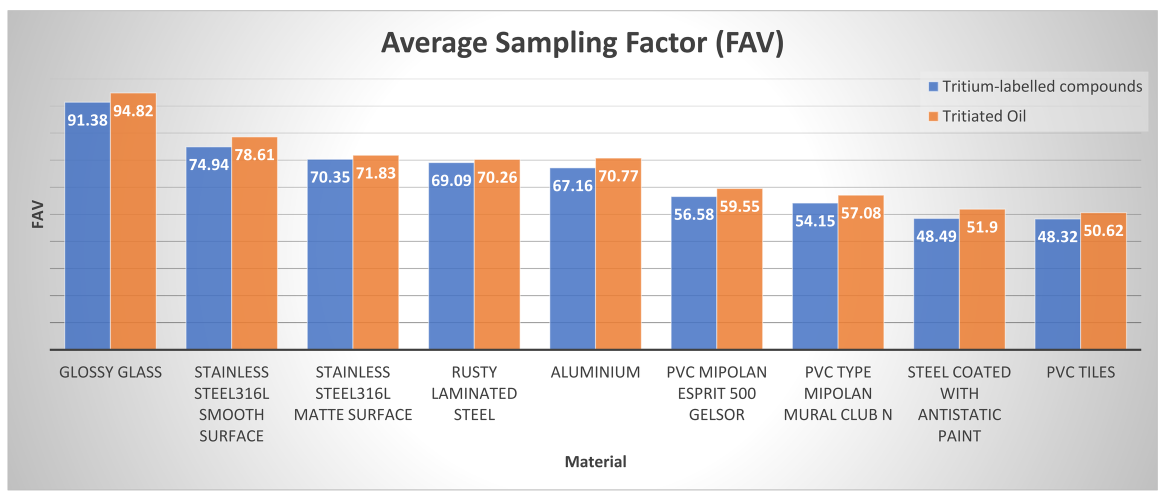
E-mail: dchiper@nipne.ro, catalin.tuta@nipne.ro, gbubueanu@nipne.ro, cristip@nipne.ro, alexandradiana.chiper@gmail.com, ioanacristina.chiper@gmail.com

INTRODUCTION

- The purpose of this present work consists of finding a more efficient and less expensive decontamination method for surfaces contaminated with Tritium-labelled compounds.
- In the experiments there were used the polymeric hydrogels, DeconGel type 1102 and type 1108.
- This paper presents the methods and facilities used, as well as the results obtained and their interpretation. All the experiments were conducted within Tritium Laboratory (TRITIULAB) from DRMR department from Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering (IFIN-HH).
- This paper aims to develop new methods and protocols of decontamination for Tritium laboratories facilities improving at the same time radiological security measures to meet EU requirements. In accordance with these requirements, we chose a polymeric hydrogel, DeconGel, because the method is easy, does not damage the surfaces and, at the same time, does not cause pollution, while the costs involved, and necessary storage space are minimal. After considering all these aspects, it was decided that DeconGel is a possibility with high chance of success for our research.
- The experiments are based on measurements realized on a certain number of materials (types of surfaces) that are often found in facilities specifically designed for radioactive research, which were afterwards gathered and interpreted. For each sample of materials, we made a comparison between the results obtained from the classic decontamination method (with wetted smears) and the one using the polymeric hydrogel.
- The paper will further develop, in a more detailed manner, the steps, utensils and chemical compounds used in the experiment.
- All the materials studied originate from the Radionuclides and Radiation Metrology Departament (DRMR)-NIPNE, TRITIULAB-NIPNE. The polymeric hydrogels were procured from CBI Polymers from USA.

RESULTS

Fig.3 – Average Sampling Factor



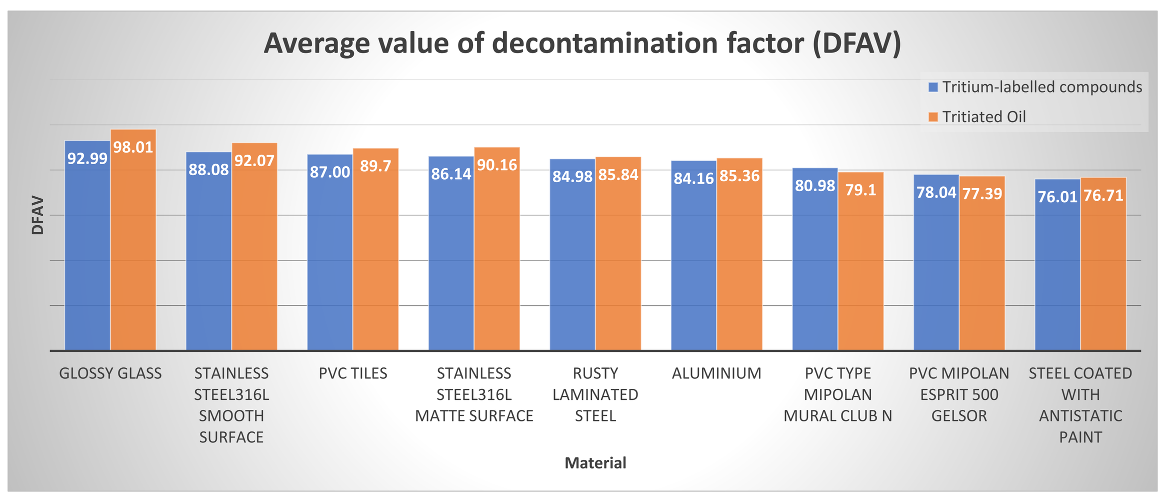


Fig.4 – Average Decontamination Factor

- The average values for the sampling factor are presented in Fig.3 for surfaces contaminated with ethanol solution of mixture of tritium-labelled compounds and Fig.4 for surfaces contaminated with tritiated oil.
- The maximum and minimum values are obtained for glossy glass and PVC tiles correspondingly in both situation.
- The average values for the sampling factor are between 91.38% and 48.32% for surfaces contaminated with tritium-labelled compounds and slightly higher vales for surfaces contaminated with tritiated oil between 94.82% and 50.62%, results that are more than satisfying.
- The average values for the decontamination factor are between 92.99% and 76.01% for surfaces contaminated with tritium-labelled compounds and slightly higher vales for surfaces contaminated with tritiated oil between 98.01% and 76.71%, results that are once again satisfying.
- The highest values were obtained again for the glossy glass, while the lowest vales were obtained for the steel coated with antistatic paint in both cases.

METHOD

- *New decontamination protocols for surfaces contaminated with tritium (^3H or T) were developed, by studying the decontamination factor for DeconGel 1108 and DeconGel 1102, in the case of different surfaces and contaminant types*
- In the experiment we used two types of contaminants: (1) ethanol solution of hydrophilic and hydrophobic tritium labelled compounds mixture and (2) tritiated oil from broken vacuum pumps from which the volatile component was removed.

SELECTION OF SURFACES

- *The following types of surfaces have been selected and prepared. Those surfaces are often found within TRITIULAB. From the selected surfaces, 10 x 10 cm samples were prepared (Fig 3).*
  - ✓ *type 316L austenitic stainless steel with a smooth surface;*
  - ✓ *type 316L austenitic stainless steel with a matte surface;*
  - ✓ *sheet laminated steel coated with antistatic paint (new false ceiling);*
  - ✓ *rusty laminated steel;*
  - ✓ *aluminium;*
  - ✓ *glossy glass;*
  - ✓ *PVC tiles (old false ceiling);*
  - ✓ *PVC Mipolan Esprit 500 GELSOR (pavement for laboratories and access halls);*
  - ✓ *PVC type Mipolan Mural Club N (PVC wallpaper from TRITIULAB);*

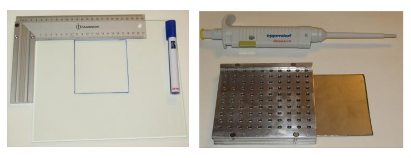


Fig 3 – Preparation of the surfaces

OBTAINING OF THE TRITIATED LABELLED COMPOUND SOLUTIONS

- A stock solution consisting of a tritiated organic compound mixture in ethanol solution was prepared.
- The radioactive concentration of stock solution has been determined using the Triple to Double Coincidence Ratio (TDCR) method at the Laboratory of Radionuclides Metrology

OBTAINING OF THE CONTAMINATED OILS

- The tritiated oil wastes were processed for volatile components removal (labile and volatile tritium – LVT).
- After the removal stage, the radioactive concentration of tritiated oil was determined by liquid scintillation technique.

THE SAMPLING FACTOR

- The RSC sampling factors were determined for each controlled contaminated surface. Determination of sampling factor was achieved by wiping the contaminated surface with smears made of extrudate polystyrene moistens in 50 L isopropyl alcohol, followed by activity measuring at LSC. The smears used were made of polystyrene materials because it has a good solubility in liquid scintillation cocktails, although it presents a lower sampling factor than desired due to its hydrophobic properties.
- The values of sampling factor (f) were obtained using equation:

$$f = 100 \times (SA / RCA)$$

where:

SA – activity determined at LSC [Bq]
RCA – (Real Conventional Activity) activity of the contaminant, controlled deposited onto analysed surface.

- For the rectification of the experimental values obtained in the determination of the residual activities (after application of the Decongel) it was used the average value of the sampling factor obtained for ten replicates.

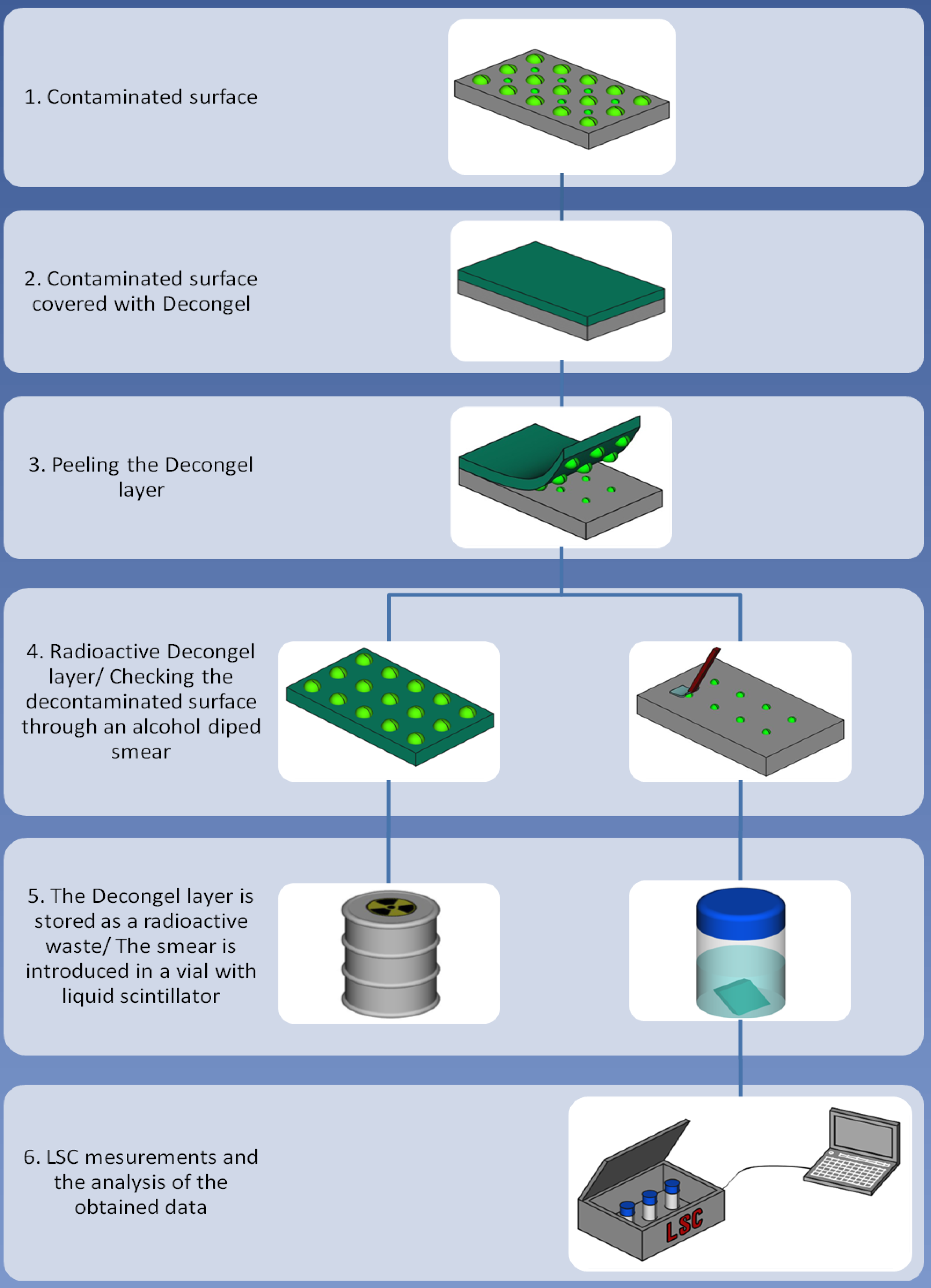


Fig. 1 – Method used for testing DeconGel in our experiments

RESIDUAL CONTAMINATION

- The residual RSC of the decontaminated surfaces with Decongel were determined by wiping using extruded polystyrene smears and their activity determined at LSC. The obtained values at LSC were rectified using predetermined average value of the sampling factor.
- The RSC was determined using the following protocol:
  - predetermination of the sampling factor for each surface;
  - determination of the RSC of sampling factors for surfaces with known sampling factor;
  - wiping the surface and smear's introduction in glass vials with liquid scintillator
  - determination of the sampled activity at LSC;
  - correlation between the sampled activity, the predetermined sampling factor and the total surface activity determination.

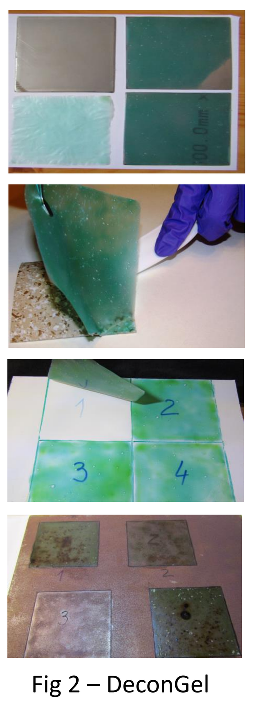


Fig 2 – DeconGel

DECONTAMINATION FACTOR

- The values of each decontamination factor (DF) were determined using next equation:

$$DF = 100 \times (RCA - RA) / RCA$$

respectively,

$$DF = 100 \times (RCA - (ALSC \times fav) / 100) / RCA$$

where:

RCA – activity of the contaminant, controlled deposited onto analysed surface [Bq]
RA - residual activity after treatment with Decongel [Bq]
ALSC – activity of the smear determined at LSC and
FAV – predetermined mean value of the sampling factor.

CONCLUSION

- The decontamination efficiency of the Decongel has been quantified as decontamination factor (DF), which represent the ratio between tritium activity incorporated in gels and total tritium activity deposited onto the analysed surface.
- Both types of Decongel were proved to be efficient in the decontamination process of different types of surfaces for specific contaminants type, the DF being in 85 and 99% range at one application for metallic and glass surfaces.
- For the steel coated with antistatic paint and MIPOLAN PVC surfaces, the obtained DF was lower (75-85%). These results can be explained by diffusion of tritiated compounds inside of the material surfaces with conversion in a quasi-fixed contamination.
- The decontamination factor of Decongel type 1108 for the analysed surfaces (contaminated with a mixture of tritium labelled compounds) can take values in the range of 76%-93%, while in the case of Decongel type 1102 the values of the decontamination factor for the analysed surfaces (contaminated with tritiated oil) can vary between 76% and 98%, results far greater than the ones obtained with the classical method of wet wiping.
- This suggests a greater efficiency of decontamination when using the Decongel comparing to the classic decontamination methods.

ACKNOWLEDGEMENTS

- The costs of this experiment are supported by the Romanian National Project-PN 09 37 02 06, PN 19 06 02 04, phase 9/2022 and phase 10/2022

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFRENCES

1. M.R.Ioan, C.Postolache, V.Fugaru, S.Bercea, A.Celarel, C.Cenusa, Rom. Rep. Phys., 71, 2019, p.202
2. C.Postolache, L.Matei, C.Tanase, G.Bubueanu, J. of Lab. Comp. and Radiopharm., 53, 2010, p.461-463
3. Razdolescu, A.C., Cassette, Ph., Applied Radiation and Isotopes, 60, 2004, p.493
4. A.Antohe, Sahagia, M., Cassette, Ph., Luca, A., Ioan, M.R., Rom. Rep. Phys., in press, 2019
5. A.Moanta, V.Fugaru, R.Trusca, M.Gheorghe, M.Coarna, I.Petre, Research regarding obtaining of the clinkers designed for performing cements with capacity of radiation attenuations, Romanian Journal of Materials 45 (1), 21-28 (2015).
6. Gurau, D. And Deju, R., Radioactive Decontamination Technique Used in Decommissioning of Nuclear Facilities, Rom. J. Phys. 59 (9-10), 912–919 (2014).