3rd Semester Report

Semester Report 2019/2020 fall

By Tariq Hailat (hailat@caesar.elte.hu)

Doctoral School of Physics-ELTE

Supervisor: Balázs Madas, Radiation Biophysics Group, MTA Centre for Energy Research, Budapest, Hungary.

Ph.D Thesis topic: Characterization of radiation exposure and its biological effects at different spatial scales.

Place of research: MTA Centre for Energy Research, Budapest, Hungary

Introduction

In the middle of last year, we submitted a request to the doctoral school in order to modify the title of my thesis to include my research work in the field of gel dosimetry and to become this field as a part of my thesis. This is because I have good experience in this field and also I published some scientific papers in this field.

After this request was approved by the doctoral school, the title of my thesis became (Characterization of radiation exposure and its biological effects at different spatial scales) where this title includes experimental research in addition to Monte Carlo simulation.

Description of research work carried out in current semester

In this semester, I prepared some chemical samples in Jordan. These samples are used for medical purposes and they include Gelatin (300 Bloom porcine skin gelatin), Ferrous Ammonium Sulfate (FAS), Sulfuric Acid (SA) and Methylthymol Blue Sodium Salts (MTB).

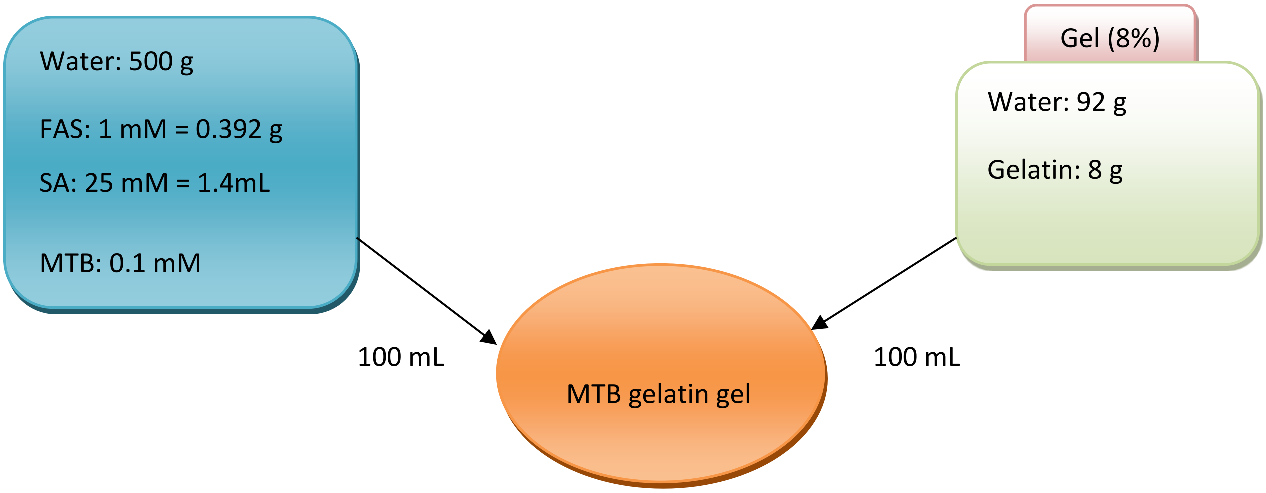

Figure1: Preparation method of 0.1 mM Fricke-MTB gelatin dosimeter.

The three stock solutions of SA, FAS and MTB were prepared and mixed separately and slowly in 500 g volumetric flasks of distilled water, kept at room temperature, meanwhile, 8% (w/v) gelatin was dissolved in 100 mL distilled water at room temperature and was left to hydrate for 10 min, and then the solution of gelatin-water was stirred and heated to 50 °C for 2 h under normal atmospheric pressure using a hot plate stirrer. After cooling the gelatin-water solution to approximately 30 °C, 100 mL stock solutions were added separately to the 100 mL gelatin hydrogel and mixing slowly for another 10 min (See Figure1). Finally, the solution was poured into 3 mL cuvette (see Figure2), and sealed using suitable covers and parafilm. The cuvette was stored in a refrigerator (10 °C) prior to irradiation.

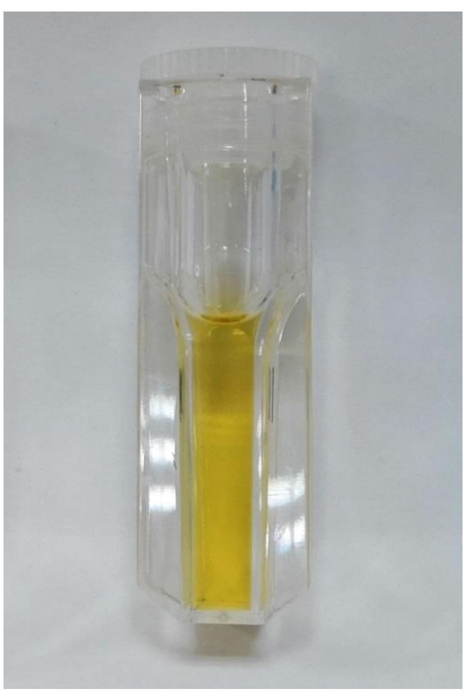

Figure2: A photograph of the unirradiated sample (Cuvette) of 0.1 mM Fricke-MTB gelatin dosimeter system.

Figure3: A photograph of the irradiated sample (Cuvette) of 0.1 mM Fricke-MTB gelatin dosimeter system by Am-243.

After that the MTB gel sample was injected by using a tracer (spike) 0.14 g of Am-243 that has activity 1.054 kBq/g. The color of MTB gel sample changed to become blue (see Figure 3) after injected by Am-243, this means that the MTB gel sample took a certain radiation dose. Then the MTB gel samples were investigated using Spectrophotometer.

The Fricke-MTB dosimeter shows a high sensitivity of the absorbance at 620 nm, which can be imaged with a red-light source (See Figure4).

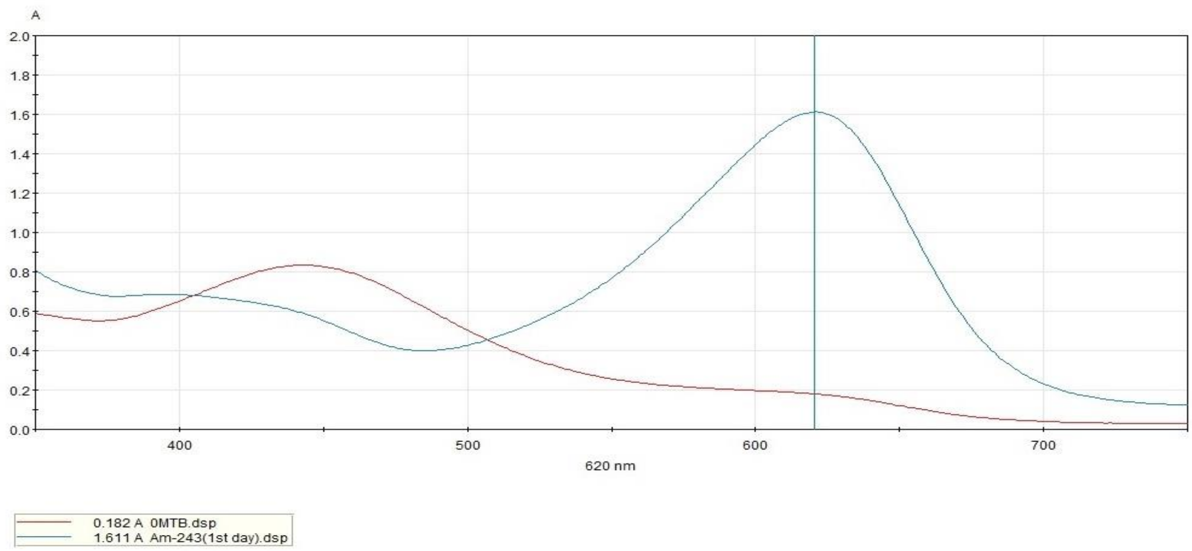

Figure4: The absorbance change of 0.1 mM MTB-Fricke dosimeter as a function of wavelength for different absorbed doses.

Continuing with what we started in Monte Carlo simulation, some of the tasks were completed and the results were obtained. Among these tasks, simulation was done for each of the following:

- A specific number of blood cells that placed in a plastic holder at a certain distance from a radioactive point source (Ra 223).
- A specific number of blood cells that placed in a circular plastic holder at a certain distance from a circular radioactive source that has the same radius of the cells holder (See Figure5). Some of the results were included for this simulation. For example, the plastic holder contains one thousands of blood cells at distance of 1 mm from the circular radioactive source. Also, one million of alpha particles decay from the source in random directions.

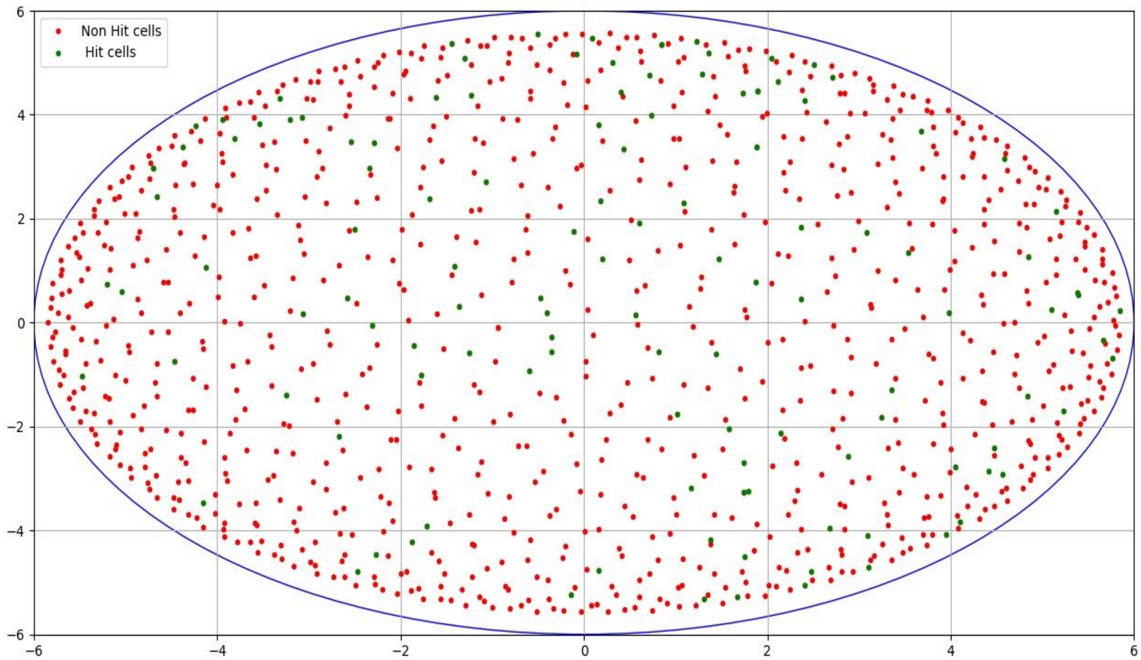

Figure5: One thousands of blood cells; green points (120 cells) represent hit cells by alpha particles and red points (880 cells) are non-hit.

Taple1: The Results that obtained from the Python code.

No. of hits (#) (k)	No. of cells (#) (f)	k*f	λ	Probability of hits	Total of cells*Probability of hits
0	880	0	0.126	0.88161	881.161
1	115	115		0.11108	111.08
2	4	8		0.00699	6.99
3	1	3		0.00029	0.29

X is the discrete random variable that represents the number of hits cells.

λ is the expected value (average) of X.

$$\lambda = \frac{Total\ of\ frequencies}{Total\ of\ cells} = \frac{\sum k * f}{1000}$$

The probability of observing k hits is

$$P(X = k) = \frac{\lambda^k e^{-\lambda}}{k!}$$

When we compare the number of cells at each hit with total of cells*Probability of hits (sixth column), we notice that the results follow the Poisson distribution (See Table1).

- Another task was done to check the relation between the activity concentrations with the dose rates, when the cell is placed in a homogenous activity of Americium source.

Publications

1- EYADEH, M. M., RABAEH, K. A., ALDWERI, F. M., AL-SHORMAN, M. Y., ALHEET, S. M., AWAD, S. I. & **HAILAT, T. F.** 2019. Nuclear magnetic resonance analysis of a chemically cross-linked ferrous–methylthymol blue–polyvinyl alcohol radiochromic gel dosimeter. *Applied Radiation and Isotopes,* 153**,** 108812.

Educational activities in current semester

In this semester, I registered one course (Imaging techniques in modern biology) in addition to the Guided Research Work. Also, I attended two courses:

- Macromolecules
- Data Models and Databases in Science

1- Imaging techniques in modern biology course

The course included detailed thematics about X-ray CT (computed tomography) scanner, MRI and fMRI (functional) magnetic resonance imaging, PET (positron emission tomography) and Sonography (medical ultrasound).

Dr. Bálint Szabó taught us the characteristics and functions of these devices and how to use them in medical imaging for patients.

Extra courses

1- **Macromolecules course**

The course included three parts:

- The first part is concerned with statistical properties of flexible polymers (Prof. Sándor Pekker)
- The second part is related to the conjugated polymers (Prof. Kürti Jenő)
- The third part is related to biological polymers (proteins) (Prof. Csaba Magyar)

2- **Data Models and Databases in Science course**

The course mainly focused on SQL language, where the course included a theoretical part and a practical part.

The theoretical part contained on many subjects such as;

Amdahl's laws, Storage systems, Redundant disk systems, Networks and Databases, Physical storage schemes, Indexes, GIS in MS SQL, RDBMS in the future and Consistency of distributed databases.

In the practical part, Dr. Laszlo Dobos explained many examples of SQL language, where we applied various exercises to this language in the computer lab.

Conferences in current semester

1- Hailat TF, Al-Bataina B, Madas BG *Measurement of radon and thoron concentration levels in Disi soil (in Jordan) using CR-39 detector* International Conference on Radiation Applications. 16-19 September, 2019 Belgrade, Serbia, p. 35. (**Oral presentation**)